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Use mediates the relationship between access to private outdoor spaces and wellbeing, with age acting as a moderator

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Zusammenfassung

Aktuelle Studien haben gezeigt, dass privat nutzbare Freiräume mit dem Wohlbefinden zusammenhängen, wobei vermutet wird, dass die Nutzung dabei eine mediierende Rolle spielt. In dieser Arbeit wurde daher der Zusammenhang zwischen verschiedenen privat nutzbaren Freiraumtypen und dem Wohlbefinden der Bewohner*innen untersucht, sowie die Rolle der Nutzung als Mediator und die Rolle des Alters als Moderator. Dafür wurden Querschnittsdaten analysiert, die zwischen März 2021 und März 2023 im Rahmen der People and Nature Survey for England (PANS), einer für die englische Bevölkerung repräsentativen Umfrage, erhoben wurden. Für die Freiraumtypen, die Häufigkeit der Nutzung und das Alter wurden jeweils einzelne Items aus der PANS-Umfrage verwendet. Wohlbefinden wurde anhand der ONS4-Wohlbefindensskala operationalisiert, die evaluatives Wohlbefinden, eudämonisches Wohlbefinden, positiven und negativen Affekt misst. Moderationsanalysen ($N = 19.132$) und moderierte Mediationsanalysen ($N = 17.223$) wurden durchgeführt, um die Beziehungen zwischen Freiraumtyp, Nutzung, Alter und Wohlbefinden zu untersuchen. Dabei wurde für Einkommen, Hundebesitz, Gender, Gesundheit und Kinder im Haushalt kontrolliert. Jeder untersuchte Freiraumtyp stand in positivem Zusammenhang mit evaluativem und eudämonischem Wohlbefinden, sowie positivem Affekt. Private Gärten waren außerdem mit geringerem negativen Affekt verbunden und Gemeinschafts- und Schrebergärten mit höherem negativen Affekt. Alter moderierte die Beziehung zwischen Freiraumtyp und Nutzung, wobei ältere Menschen ihre privaten Gärten, Balkone, Innenhöfe und Terrassen am häufigsten nutzten. Dies deutet darauf hin, dass privat nutzbare Freiräume das Wohlbefinden der Bewohner*innen, insbesondere älterer Bewohner*innen, steigern könnten, und zeigt, wie wichtig die Einbeziehung dieser in die Stadtplanung und -politik ist. Darüber hinaus könnte eine häufigere Nutzung vorhandener privat nutzbarer Freiräume auch eine geeignete Maßnahme zur Steigerung des Wohlbefindens im Alltag sein.

Schlüsselwörter: privat nutzbare Freiräume, Gärten, Wohlbefinden, Alter, moderierte Mediationsanalyse

Abstract

Recent research has found that access to private outdoor spaces is related to wellbeing. A mediation by use in this relationship has been suggested but not yet researched. This thesis therefore examined access to different types of private outdoor spaces and the possible mechanisms underlying a relationship with wellbeing, including frequency of use and age. Cross-sectional data collected between March 2021 and March 2023 as part of the People and Nature Survey for England (PANS), a representative survey of the English population, was analysed. Individual items from the PANS were used for access, frequency of use and age. Wellbeing was operationalized using the ONS4 wellbeing scale, which measures evaluative wellbeing, eudemonic wellbeing, positive and negative affect. Moderation analyses ($N = 19,132$) and moderated mediation analyses ($N = 17,223$) were conducted to examine the relationship between access and wellbeing, use as a mediator and age as a moderator in this relationship. The analyses controlled for the covariates income, dog ownership, gender, health and children in the household. Access to any private outdoor space was positively associated with evaluative wellbeing, eudemonic wellbeing and positive affect, compared to no access. Private gardens were related to lower negative affect and shared gardens and allotments to higher negative affect. Age moderated the relationship between access and use, with older people using their private gardens, balconies, yards or patios most frequently. The relationship between access and wellbeing outcomes was partially mediated by use in the case of private gardens and fully mediated by use in the case of balconies, yards or patios. These findings suggest that access to private outdoor spaces could increase the wellbeing of residents, especially older residents, demonstrating the importance of including private outdoor spaces in urban planning and policy. In addition, more frequent use of existing private outdoor spaces could also be a suitable and simple measure to increase wellbeing in everyday life.

Keywords: private outdoor spaces, gardens, wellbeing, age, moderated mediation analysis

Use mediates the relationship between access to private outdoor spaces and wellbeing, with age acting as a moderator

It is well established that exposure to nature contributes to mental health (Bratman et al., 2019; Hartig et al., 2014) and wellbeing (MacKerron & Mourato, 2013; van den Bosch & Ode Sang, 2017). Potential pathways underlying these relationships are the restorative effect of nature contact on attention (Kaplan, 2001), reduced stress and negative affect, increased positive affect, better emotion regulation (Bratman et al., 2021), increased physical activity and social interactions (Gianfredi et al., 2021).

Most research focuses on public outdoor spaces, such as urban parks or street greenery (Beyer et al., 2014; Li et al., 2015; Markevych et al., 2017). However, as previous research has pointed out, private outdoor spaces also play an important role in expanding green infrastructure networks in cities (Ordóñez Barona et al., 2021).

Garden ownership has been linked to improved health indices (Brindley et al., 2018; Dennis & James, 2017) and mental wellbeing, increased physical activity and reduced social isolation (Howarth et al., 2020). Research on private gardens, also known as domestic, residential or home gardens, suggests that restorative quality may be positively related to biodiversity (Young et al., 2020), visual appeal and natural-looking aesthetics (Twedt et al., 2016).

There is evidence that gardening, an active way of experiencing nature, can promote relief from acute stress and the experience of a positive mood (Van Den Berg & Custers, 2011). Chalmin-Pui et al. (2021) found that frequent gardening (2-3 times a week) has the greatest health benefits compared to less frequent gardening. However, health benefits are not the main motivation for gardening. Instead, most people state that they garden for pleasure and enjoyment (Chalmin-Pui et al., 2021). Gardening in communal and allotment gardens is also associated with social benefits (van den Berg et al., 2010).

However, gardens not only provide restorative benefits but can also be a cause of stress. Young et al. (2020) found that garden-related stress and negative affect are higher in residential than in allotment gardeners and are negatively related to

restoration. This could be related to external pressure.

The lockdowns during the Covid-19 pandemic in particular have highlighted the importance of private outdoor spaces (Alhadedy & Gabr, 2022; Golzarpour et al., 2023; Mouratidis, 2021; Peters & Halleran, 2020; Pouso et al., 2021). High-quality private outdoor spaces that contribute to the wellbeing of residents can mitigate the negative effects of possible future lockdowns and are beneficial for daily life. Despite this, they are often not a priority for policy-makers and planners in the context of increasing urbanization and densification of cities (Haaland & van den Bosch, 2015).

Background

Wellbeing and mental health

The World Health Organization (WHO, 2021) describes wellbeing as a positive state that serves as a resource for daily life. It can be a description of both individuals and societies. In relation to societies, wellbeing means the extent to which they are resilient, build capacity to act and are prepared to overcome challenges.

Wellbeing is closely linked to mental health (Agteren & Iasiello, 2020; WHO, 2021), which is why some studies on mental health are also mentioned in the following chapters.

Private outdoor spaces and wellbeing

Private residential outdoor spaces can be defined as the space surrounding an individual's dwelling on their personal property, including front and back yards, porches, driveways, decks, and patios (Ordóñez Barona et al., 2021).

Recent research has found that access to private outdoor space is associated with better mental health and wellbeing and helped to mitigate the negative effects of lockdowns during the Covid-19 pandemic (Golzarpour et al., 2023; Mouratidis, 2021; Pouso et al., 2021). Alhadedy and Gabr (2022) conducted a survey among home residents and residential construction industry professionals in Cairo to assess features of home design during the pandemic. They identified access to private outdoor spaces as the third most important housing feature for the health and wellbeing of residents, after natural ventilation and natural light. Previous research suggested that post-pandemic

apartments should provide access to nature through balconies, among other things, to promote a healthy and restorative living environment (Peters & Halleran, 2020).

However, even before Covid-19, research found differences in the emotions of people with and without accessible outdoor spaces (Bratman et al., 2019), suggesting that the positive effect of these spaces is important even under normal circumstances.

Types of private outdoor spaces

There are different types of private outdoor spaces. Previous research has shown that different types of private outdoor spaces may not have the same impact on mental health and wellbeing.

Gardens (Golzarpour et al., 2023; Pouso et al., 2021) and patios (Pouso et al., 2021) are perceived as more beneficial than balconies (Golzarpour et al., 2023; Pouso et al., 2021) or yards (Golzarpour et al., 2023). One possible explanation is that private and communal gardens encourage gardening and physical activity which is beneficial for wellbeing (de Bell et al., 2020; Mouratidis, 2021). In general, active forms of nature exposure seem to have a more positive effect on wellbeing than passive forms of exposure (Pouso et al., 2021; van den Berg et al., 2010). However, opinions on shared gardens do not seem to be consistent (de Bell et al., 2020; Mouratidis, 2021; Pouso et al., 2021; Young et al., 2020).

Furthermore, aesthetic aspects are also important. For example, wild nature has a greater influence on wellbeing than domesticated nature. Even small spots of wild nature on a balcony, patio or roof garden could have a more positive impact than domesticated gardens (Allard-Poesi et al., 2022).

One aim of this thesis is to compare the effects of access to different types of private outdoor spaces on wellbeing. Even more interesting, however, is the question of which mechanisms underlie this relationship.

Use of private outdoor spaces as mediator

Research by Hartig et al. (2014) suggests that exposure to nature is linked to mental health and wellbeing in a number of ways, including air quality, physical activity, social contacts and stress reduction. Other studies confirmed physical activity

(A. Dzhambov et al., 2018; A. M. Dzhambov et al., 2018) and social cohesion (A. M. Dzhambov et al., 2018) as mediator between green spaces and mental health in adolescents. Furthermore, more frequent garden use is associated with greater mental health benefits (Chalmin-Pui et al., 2021; Corley et al., 2021), and de Bell et al. (2020) suggest that some of the benefits of garden access are explained by actual garden use.

Considering these findings, it can be assumed that the relationship between access to private outdoor space and wellbeing is mediated by how frequently individuals spend time in their private outdoor space.

Age as moderator

Age acts as a moderator for the relationship between allotment gardening and health and wellbeing. Older gardeners benefit more from allotment gardening, which could be related to the finding that they spent more of their time gardening and less on passive relaxation compared to younger gardeners (van den Berg et al., 2010).

Recent research also points to age-related aspects of the use and benefits of private outdoor spaces. Tabrizi et al. (2023) found that older people used private green spaces such as gardens and balconies throughout the pandemic and that this contact with nature correlates with improved mental health, among other benefits. Furthermore, Golzarpour et al. (2023) found that 5 to 18 year old children who have access to a garden have better health and wellbeing than those who have access to a yard or balcony. Access to a private garden was also associated with increased time outdoors for children (Olsen et al., 2022).

Considering these findings, age may act as a moderator of the relationship between access to and use of private outdoor space.

Covariates

Health is closely related to both exposure to nature (Grilli et al., 2020; Pietilä et al., 2015; Wang et al., 2024) and, by definition, wellbeing (Schramme, 2023; WHO, 2021), so health could act as a covariate in this thesis.

Previous research has shown that income is related to access to and quality of natural environments and thus to the health and wellbeing benefits of these

environments (Mullin et al., 2018; Pham et al., 2012), leading to significant health inequities (Chen et al., 2024). A study in Germany has shown that it is not only the lack of green exposure through window views or a green yard that increases the likelihood of considering a residential relocation, but also the lack of a private outdoor space such as a balcony or a garden. The latter relationship is mediated by decreased life satisfaction (Kley & Dovbishchuk, 2021). This means that those who can afford it are more likely to have access to a private outdoor space and are more satisfied and therefore score higher on wellbeing. However, Allard-Poesi and Massu (2023) argue that access to different types of nature is only necessary for people with high financial strain to reach high levels of wellbeing, as opposed to people with little or no financial strain. They base this conclusion on the results of a necessary condition analysis (as proposed by Dul (2016)), which they conducted using data from 2,500 French urban residents to investigate whether nature near urban residences is necessary for and not only associated with wellbeing.

Two other demographic variables that could have an influence as covariates are gender and whether or not children live in the household. For example, Collins et al. (2023) found that the beneficial effects of private gardens on mental health vary by gender and age. Furthermore, parents who do not have access to a garden are more likely to consider residential relocation (Kley & Dovbishchuk, 2021), making it more likely that parents will have access to a garden if they can afford it. A study by Olsen et al. (2022) also found that the amount of time children spend outside in nature increases from 15 to 41 percent when private gardens are included, suggesting that access to gardens increases the children's use.

Another population group that spends more time outdoors is dog owners. Adult dog owners are visiting neighbourhood green spaces more frequently and are more likely to be physically active there than non-dog owners (Veitch et al., 2019; White et al., 2018). While there is no literature on the relationship between dog ownership and private outdoor spaces, access to and use of private outdoor spaces may differ, as gardens are more useable for dog owners than balconies, for example. In addition,

owning a dog is associated with higher wellbeing (Hardie et al., 2023).

To summarize, health, income, gender, children in the household and dog ownership could act as covariates for the relationship between access to and use of private outdoor spaces, age and wellbeing. There are certainly numerous other interesting possible covariates, but it is beyond the scope of this thesis to include them all.

Relevance

Researching how access to different types of private outdoor spaces affects wellbeing contributes to a better understanding of the relationship between physical environment and mental health and wellbeing. Including the use of private outdoor spaces as a mediator and age as a moderator can further explain the mechanisms underlying this relationship.

In addition to contributing to scientific knowledge in the fields of environmental psychology, urban planning and public health, findings could also provide evidence for policy-makers and urban planners on how to improve the wellbeing of residents.

Method

This thesis was designed as a secondary data analysis of the People and Nature Survey for England (PANS), which is based on a representative sample of English adults (Natural England, 2023). The data was analysed using moderation and moderated mediation analyses with access to a private outdoor space as the independent variable, wellbeing outcomes as the dependent variable, frequency of use of the private outdoor space as the mediator and age as the moderator. Income, dog ownership, health, gender and children in the household were included as covariates.

Hypotheses

Based on the literature presented above, the following hypotheses were derived.

Hypothesis 1. (H1): Access to a private outdoor space is positively related to wellbeing.

Hypothesis 2. (H2): Age moderates any relationship between access to a private outdoor space and wellbeing.

Hypothesis 3. (H3): Access to different types of private outdoor space is related to wellbeing.

Hypothesis 4. (H4): Access to different types of private outdoor space is related to use of private outdoor space.

Hypothesis 5. (H5): Use of private outdoor space is positively related to wellbeing.

Hypothesis 6. (H6): Use of private outdoor space mediates any relationship between access to different types of private outdoor space and wellbeing.

Hypothesis 7. (H7): Age moderates any relationship between access to different types of private outdoor space and use of private outdoor space.

Methodology

Due to the cross-sectional data used, this thesis was designed as a correlational study. It is a secondary data analysis of the PANS, an online self-assessment questionnaire. The PANS measures how people interact with and benefit from the natural environment and is used to inform government policy on environmental monitoring (Natural England, [2023](#)).

Sample

The PANS has a nationally representative sample for England and has been completed by around 25,000 adults per year since 2020. The data used in this thesis was collected between March 2021 and March 2023. Data from before this date was excluded due to Covid-19 lockdowns.

Of the 74,968 people in the PANS dataset, 28,255 had either no access to a private outdoor space or access to a shared garden or an allotment or access to a private garden or access to a balcony, yard or patio area, but not to more than one of these. Cases with missing values for wellbeing ($n = 4,499$) were excluded as were cases with missing values for use ($n = 3,705$) and income ($n = 79$). Due to the operationalization using mid-points, all cases in the non-binary gender category ($n = 42$) were also excluded. After excluding the cases with missing values for children in the household ($n = 798$), $N = 19,132$ ($M(\text{age}) = 51.7$, $SD(\text{age}) = 22.0$; 51.9% females, 48.1% males;

10.0% no access, 8.9% shared garden/allotment, 74.2% private garden, 6.9% balcony/yard/patio) complete cases remained for the moderation analysis. For the second part of the analysis the access category “no access” was excluded, leaving $N = 17,223$ ($M(\text{age}) = 52.6$, $SD(\text{age}) = 22.2$; 52.3% females, 47.7% males; 9.9% shared garden/allotment, 82.5% private garden, 7.7% balcony/yard/patio) complete cases for the moderated mediation analysis.

Previous research has shown that power analyses to indicate power for already observed outcomes are conceptually flawed and analytically misleading (Levine & Ensom, 2001; Zhang et al., 2019). As an illustration, however, a power analysis with Monte Carlo simulation for Hayes’ PROCESS model 7 (Xu et al., 2024) showed that a sample size of $N = 1,800$ would be required to detect small standardized regression coefficients in a moderated mediation analysis with a power of 95% and a statistical significance level of $\alpha = .05$. PROCESS is a regression path analysis modelling tool for mediation, moderation and moderated mediation models, with a single or multiple mediators or moderators.

Measures

All operationalized variables used in the analysis were self-rated items from the PANS, thus are subjective measures. Only complete cases were included and participants who responded with “Don’t know” or “Prefer not to say” to any question were excluded. In addition, all participants who took part in the survey during the Covid-19 lockdowns were excluded, as it would otherwise have been difficult to compare frequency of use.

Wellbeing

The dependent variable *wellbeing* was operationalized using the four questions on subjective wellbeing from the UK Office of National Statistics (ONS4; Tinkler, 2015). Four items were used to measure two trait scores with the items evaluative wellbeing “Overall, how satisfied are you with your life nowadays?” and eudemonic wellbeing “Overall, how worthwhile are the things you do in your life?”, as well as two state scores with the items positive affect “How happy were you feeling yesterday?” and

negative affect “How anxious were you feeling yesterday?”. Participants had to rate the items on a scale from 0 = “not at all” to 10 = “completely” (Natural England, 2023).

For the analyses, wellbeing was used as the sum of the items evaluative wellbeing, eudemonic wellbeing, positive affect and the inverted negative affect, but the four items were also used individually as respective independent variables. The mean inter-item correlation of the four items was $r = .53$ (evaluative wellbeing - eudemonic wellbeing: $r(19130) = .81$, $p < .001$; evaluative wellbeing - positive affect: $r(19130) = .80$, $p < .001$; evaluative wellbeing - negative affect: $r(19130) = -.26$, $p < .001$; eudemonic wellbeing - positive affect: $r(19130) = .76$, $p < .001$; eudemonic wellbeing - negative affect: $r(19130) = -.24$, $p < .001$; positive affect - negative affect: $r(19130) = -.34$, $p < .001$), the value for Cronbach's Alpha was $\alpha = .79$.

Access to private outdoor space

The independent variable *access to private outdoor space* was operationalized with an item that measured whether participants have access to private outdoor spaces and to what type of private outdoor spaces. Participants were asked whether or not they have access to a private garden, a shared garden, a private outdoor space but not a garden (balcony, yard, patio area) or an allotment at a council/community run site. It was possible to select multiple answer options (Natural England, 2023). For the sake of simplicity, only participants who selected without access or with access to only one of these types of private outdoor space (private garden, shared garden, balcony/yard/patio, allotment) were included in the analysis.

Initial moderated mediation regressions showed that access to a shared garden and access to an allotment did not differ significantly in any aspect of wellbeing, which is why these two were combined into a single category for the final analyses.

Use of private outdoor spaces

The mediator *use of private outdoor space* was operationalized by how frequently people use their private outdoor space. It was measured with the item “Thinking about the last 14 days, how often did you typically spend time in this garden or space?”. The answer options included “Every day”, “More than twice a week, but not every day”,

“Twice a week”, “Once a week”, “Once or twice in the last 14 days” and “Never” (Natural England, 2023).

For the analysis, this variable was recoded into an interval scaled variable indicating frequency of use in days per 14 days. This was done using mid-points, as mentioned by Williams (2020). The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) were used to test whether use can be treated as an interval scaled variable. Two linear regression models, one with use as an ordinal variable (AIC = 115963.2, BIC = 116071.7) and one with use as an interval scaled variable (AIC = 115987.7, BIC = 116065.2) were compared. While the AIC favoured use as an ordinal variable, the BIC favoured use as an interval scaled variable. Shmueli (2010) argues, that the BIC is better suited to model selection for explanation than the AIC, therefore it was assumed that use can be operationalized as an interval scaled variable for this thesis.

Age

The moderator *age* was measured with age groups. Participants were asked to choose which of the following age groups they belonged to: “16-24”, “25-39”, “40-54”, “55-65” or “65+” (Natural England, 2023).

As with the variable use of private outdoor space, age was recoded into an interval scaled variable using mid-points (Williams, 2020). “65+” is an open category, so 105 years was used as the upper limit to calculate a mid-point for this category. According to the Office for National Statistics (2023), there were only 610 people aged 105+ in 2022, which is negligible. While the AIC favoured age as an ordinal variable (AIC = 127644.3, BIC = 127848.6), the BIC favoured age as an interval scaled variable (AIC = 127647.9, BIC = 127758.0). Since the BIC is better suited to model selection for explanation, age was operationalized as an interval scaled variable for this thesis. (Shmueli, 2010).

Covariates

Income was measured with the item “Which of the following best describes your total annual household income before tax?” which offered the following answer options:

“£0–14,999”, “£15,000–19,999”, “£20,000–29,999”, “£30,000–39,999”, “£40,000–49,999” and “£50,000+” (Natural England, 2023). This variable was also recoded into an interval scaled variable using mid-points (Williams, 2020). “£50,000+” is an open category, thus no mid-point can be calculated. Therefore, the mid-point change for the previous two categories was used to set the mid-point for this category at £55,000. Here too, the AIC favoured income as an ordinal variable (AIC = 127643.7, BIC = 127785.1), while the BIC favoured income as an interval scaled variable (AIC = 127647.9, BIC = 127758.0). Since the BIC is better suited to model selection for explanation, income was operationalized as an interval scaled variable for this thesis. (Shmueli, 2010).

For the covariate *dog ownership*, the item “Do you have a dog in the household?” was used. The answer options were “yes” or “no” (Natural England, 2023).

Health was operationalized with the item “Would you say that, in general, your health is...” which was answered on a scale from 2 = “very good” to -2 = “very bad” (Natural England, 2023).

The covariate *gender* was measured with the question “What gender do you identify as?” with the three possible answers “male”, “female” and “in another way” (Natural England, 2023). The third category was excluded in order to simplify the analysis and because there were relatively few people in this category.

For the covariate *children in the household*, the item “How many children aged under 16 currently live in your household?” was used, which was answered with a number (Natural England, 2023). For the analysis, however, it was operationalized as a binary variable indicating whether or not children lived in the household, regardless of how many there were.

Analysis

To answer H1 and H2, a moderation analysis was conducted using Hayes’ PROCESS Model 1. The PROCESS macro for R was used, which applies ordinary least squares regression and provides unstandardized coefficients for all effects (Hayes, 2012; Hayes, 2017; R Core Team, 2023). The overall fit of the regression analysis was assessed

using R-squared statistics. All significant results were replicated by confidence intervals computed by bootstrapping with 10,000 samples, unless otherwise stated in the results section. Dummy variables were used in the analysis for the categorical variable access to private outdoor spaces, with “no access” as the reference category.

For H3, H4, H5, H6 and H7, a regression analysis was conducted with Hayes’ PROCESS Model 7 Moderated Mediation, also using the PROCESS macro for R. The category “no access” was excluded for the moderated mediation analysis, as it had zero variance in use of private outdoor spaces and non-zero variance is a necessary assumption for regressions. Instead, the category “access to a shared garden or an allotment” was used as reference category. The corresponding process models are shown in Figure 1. The moderator age was mean centred in all analyses.

The regression assumptions were checked and are reported in detail in Appendix A. All assumptions were fulfilled, except for homoscedasticity. Therefore, heteroscedasticity consistent standard errors (HC3; Davidson & MacKinnon, 1993) were used to calculate the confidence intervals.

Results

Descriptives

For the moderation analysis, the sample size was $N = 19,132$ ($M(\text{age}) = 51.7$, $SD(\text{age}) = 22.0$, 51.9% females, 48.1% males), with 10.0% of the sample having no access to a private outdoor space, 8.9% having access to a shared garden or an allotment, 74.2% having access to a private garden and 6.9% having access to a balcony, yard, patio or other private outdoor space that is not a garden. For the moderated mediation analysis, the sample size was $N = 17,223$ ($M(\text{age}) = 52.6$, $SD(\text{age}) = 22.2$, 52.3% females, 47.7% males), with 9.9% of the participants having access to a shared garden or an allotment, 82.5% having access to a private garden and 7.7% having access to a balcony, yard, or patio area. More detailed descriptive statistics for each access category can be found in Table 1.

Overall, people with access to a private garden had the highest mean scores for wellbeing and the lowest mean scores for negative affect. They also had the highest

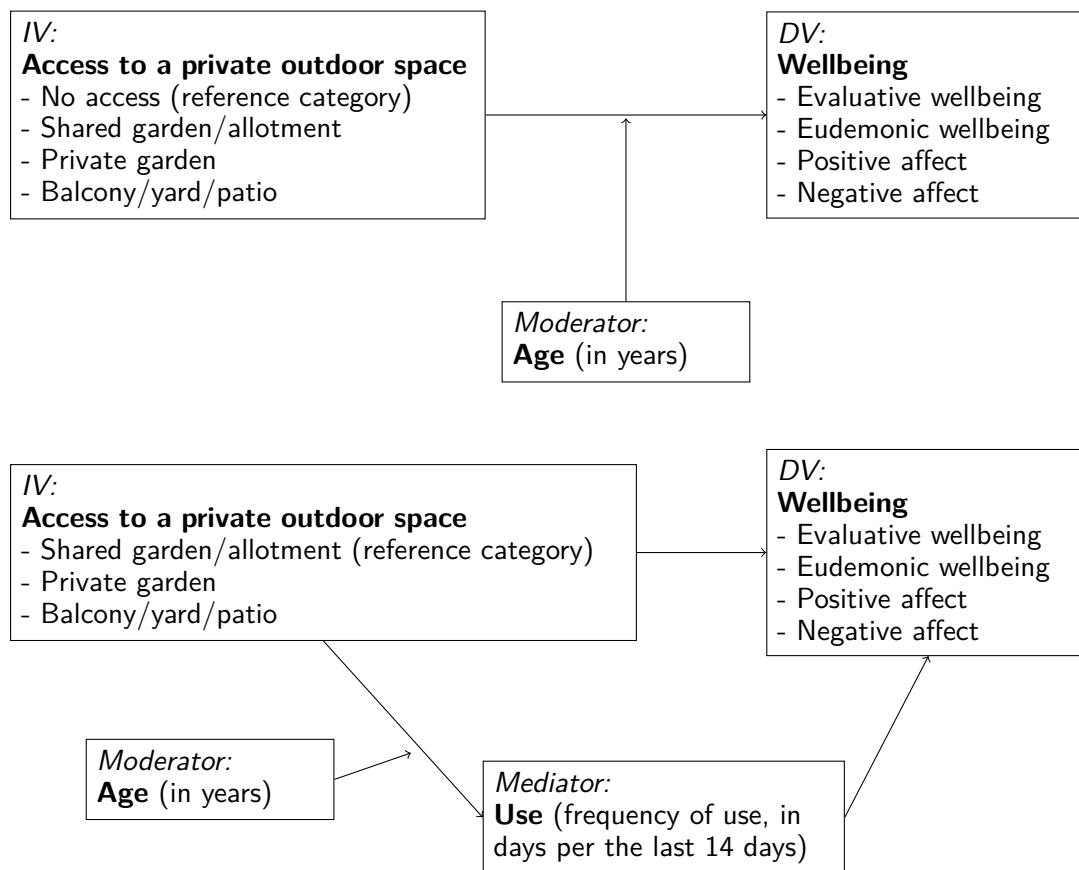


Figure 1

The process models of the moderation analysis (top) and the moderated mediation analysis (bottom).

Note. Following covariates are included in both process models: income, dog ownership, health, gender and children in the household.

mean scores for age, use and income and the highest percentage of dog ownership and female gender. Those with access to a shared garden had the highest mean scores for health and the highest percentage of children in the household. To adjust for potentially confounding effects, income, dog ownership, health, gender and children in the household were included as covariates in the analyses.

Moderation analysis

A moderation analysis was run to determine the relationship between access to a private outdoor space, age and wellbeing. In the moderation analysis conducted without covariates there was a significant direct effect for people with access to a shared

Table 1

Means and standard deviations, or frequency distributions of all variables per access category.

	no access	shared garden /allotment	private garden	balcony/yard /patio
n	1,909	1,700	14,201	1,322
Age, M (SD)	43.75 (19.05)	44.86 (21.98)	54.34 (21.91)	43.42 (20.58)
Wellbeing, M (SD)	23.64 (8.54)	25.30 (7.77)	27.34 (7.87)	24.86 (7.49)
Evaluative, M (SD)	5.68 (2.44)	6.44 (2.39)	6.74 (2.19)	6.23 (2.29)
Eudemonic, M (SD)	6.02 (2.55)	6.65 (2.41)	7.06 (2.26)	6.47 (2.30)
Positive affect, M (SD)	5.91 (2.57)	6.64 (2.46)	6.93 (2.36)	6.37 (2.42)
Negative affect, M (SD)	3.96 (3.08)	4.44 (3.20)	3.40 (3.08)	4.21 (2.97)
Use, M (SD)	0.00 (0.00)	5.28 (4.90)	7.36 (5.14)	5.77 (4.70)
Income, M (SD)	24,666 (16,112)	29,996 (17,005)	33,701 (16,527)	29,905 (16,765)
Dog ownership, % yes	12.0	30.0	30.8	28.4
Health, M (SD)	0.58 (0.90)	0.80 (0.87)	0.76 (0.83)	0.73 (0.82)
Gender, % female	48.1	45.5	53.5	48.2
Children, % yes	20.8	34.4	27.4	33.7

Note. N = 19,132 with “no access”, N = 17,223 without “no access” category; SD = Standard deviation; Variables have the following ranges: age (20-85), wellbeing (0-40), evaluative wellbeing (0-10), eudemonic wellbeing (0-10), positive affect (0-10), negative affect (0-10), use (0-14), income (7500-55000), health (-2-2); Binary variables have the following possible values: dog ownership (no/yes), gender (male/female), children in the household (no/yes).

garden or an allotment ($b = 1.43$, $SE = 0.29$, $t = 4.89$, $p < .001$), for people with access to a private garden ($b = 2.94$, $SE = 0.22$, $t = 13.53$, $p < .001$) and for people with access to a balcony, yard or patio area ($b = 1.21$, $SE = 0.30$, $t = 4.02$, $p < .001$) compared to people with no access. There was also a significant direct effect for age ($b = 0.07$, $SE = 0.01$, $t = 6.69$, $p < .001$). No interaction between access and age was significant, indicating that there was no moderation. The model explained $R^2 = 7.17\%$ ($F(7, 19124) = 222.56$, $p < .001$) of the relationship between access to private outdoor spaces and wellbeing.

When controlling for the covariates income, dog ownership, health, gender and children in the household there was only a significant direct effect for people with access to a private garden ($b = 1.52$, $p < .001$) and for age ($b = 0.10$, $p < .001$). No

interaction between access and age was significant, indicating that there was no moderation. The covariates income ($b < 0.01$, $p < .001$), health ($b = 4.03$, $p < .001$) and children in the household ($b = 0.25$, $p = .044$) were positively associated with wellbeing. Dog ownership ($b = -0.47$, $p < .001$) was negatively associated, and gender ($b = -0.04$, $p = .708$) had no significant relationship with wellbeing. For the full regression results see Table 2, for a visualization of the relationships see Figure 2.

To further clarify this relationship, four moderation analyses were conducted with each of the wellbeing subscales - evaluative wellbeing, eudemonic wellbeing, positive and negative affect - as the dependent variable. All relationships were tested with two-tailed tests.

The full results of these analyses are reported in Appendix B. Access to a shared garden or an allotment was positively related to evaluative wellbeing ($b = 0.29$, $p < .001$), eudemonic wellbeing ($b = 0.19$, $p = .009$), positive affect ($b = 0.30$, $p < .001$) and negative affect ($b = 0.42$, $p < .001$). Access to a private garden was positively related to evaluative wellbeing ($b = 0.43$, $p < .001$), eudemonic wellbeing ($b = 0.43$, $p < .001$), positive affect ($b = 0.43$, $p < .001$), and negatively related to negative affect ($b = -0.23$, $p = .002$). Access to a balcony/yard/patio area was positively related to

Table 2

Regression results for the moderation analysis, with wellbeing as DV, access as IV and age as moderator

Variable	b	SE	p
Reference (no access to a private outdoor space)	20.86	0.20	< .001
Shared garden or allotment	0.35	0.26	.086
Private garden	1.52	0.19	< .001
Balcony/yard/patio	0.43	0.27	.054
Age	0.10	0.01	< .001
Shared garden/allotment x Age	-0.01	0.01	.228
Private garden x Age	0.01	0.01	.123
Balcony/yard/patio x Age	< 0.01	0.01	.880
Income	< 0.01	< 0.01	< .001
Dog ownership	-0.47	0.11	< .001
Health	4.03	0.07	< .001
Gender	-0.04	0.10	.708
Children	0.25	0.12	.044

Note. $N = 19,132$. $R^2 = .28$, $F(12, 19119) = 564.22$, $p < .001$.

evaluative wellbeing ($b = 0.23$, $P = .001$), eudemonic wellbeing ($b = 0.15$, $p = .032$) and positive affect ($b = 0.21$, $p = .007$).

There was a negative interaction between access and age for the relationship between access to a shared garden or an allotment and evaluative wellbeing ($b = -0.01$, $p = .049$) as well as eudemonic wellbeing ($b = -0.01$, $p = .042$), which was strongest for small values of age and not significant for high values of age. There was also a positive interaction between access and age for the relationship between access to a private garden and positive affect ($b = 0.01$, $p = .043$), which was strongest for high values of age. No significant interaction was found between access to a balcony/yard/patio area and age.

Moderated mediation analysis

A moderated mediation regression was conducted to investigate use of private outdoor spaces as mediator for the relationship between access and wellbeing as well as age as moderator in the relationship between access and use. The reference category, access to a shared garden or an allotment, was compared to access to a private garden and to access to a balcony, yard, patio area or other private outdoor space that is not a garden. The inclusion of the covariates did not change the significance. Therefore, only the results of the regression with covariates are reported below.

For the a-path from access to a private garden to use there was a significant direct effect, $b = 2.21$, $p < .001$, and a significant interaction between access and age, $b = 0.06$, $p < .001$. The conditional effect from access on use was the strongest for high values (+ 1 SD) of age, $b = 3.51$, $p < .001$, it was weaker but still significant for medium values (M) of age, $b = 2.21$, $p < .001$, and for small values (- 1 SD) of age, $b = 0.91$, $p < .001$. From access to a balcony/yard/patio area to use there was also a significant direct effect, $b = 0.89$, $p < .001$, and a significant interaction between access and age, $b = 0.04$, $p < .001$. The conditional effect from access on use was the strongest for high values (+ 1 SD) of age, $b = 1.67$, $p < .001$, it was weaker but still significant for medium values (M) of age, $b = 0.89$, $p < .001$, but not significant for small values (- 1 SD) of age, $b = 0.11$, $p = .579$. The moderation by age explained $\Delta R^2 = 0.58\%$ of the

variance in the model, the simple slopes of the interaction are shown in Figure 2. The covariates dog ownership ($b = 2.03$, $p < .001$), health ($b = 0.77$, $p < .001$) and children in the household ($b = 0.62$, $p < .001$) were positively associated with use. Gender ($b = -0.45$, $p < .001$) was negatively associated, and income ($b < 0.01$, $p = .231$) had no significant relationship with use.

The b-path from use to wellbeing was significant, $b = 0.14$, $p < .001$. The direct effect from access to a private garden to wellbeing was significant, too, $b = 1.61$, $p < .001$. The direct effect from access to a balcony/yard/patio to wellbeing was not significant, $b = -0.29$, $p = .251$. The direct effect explained $\Delta R^2 = 0.68\%$ of the variance in the model. The covariates income ($b < 0.01$, $p < .001$) and health ($b = 3.77$, $p < .001$) were positively associated with wellbeing. Dog ownership ($b = -1.23$, $p < .001$) and children in the household ($b = -1.88$, $p < .001$) were negatively associated, and gender ($b = 0.03$, $p = .754$) had no significant relationship with wellbeing.

The index of moderated mediation for access to a private garden was significant, $b = 0.008$, 95% percentile CI [0.006, 0.010], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.49$, 95% percentile CI [0.40, 0.59], it was weaker but still significant for medium values (M) of age, $b = 0.31$, CI [0.25, 0.37] and for small values (- 1 SD) of age, $b = 0.13$, CI [0.09, 0.17]. The index of moderated mediation for access to a balcony/yard/patio was also significant, $b = 0.005$, 95% percentile CI [0.003, 0.007], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.23$, 95% percentile CI [0.14, 0.33], it was weaker but still significant for medium values (M) of age, $b = 0.12$, CI [0.07, 0.18] but not significant for small values (- 1 SD) of age, $b = 0.02$, CI [-0.04, 0.07]. For the full regression results of the moderated mediation see Table 3, for a visualization of the relationships see Figure 2.

As with the moderation analysis, four further moderated mediation analyses were conducted with each of the wellbeing subscales - evaluative wellbeing, eudemonic wellbeing, positive and negative affect - as the dependent variable. All relationships

Table 3

Regression results for the a-path from access to use and for the b-path from use to wellbeing

Variable	Model a-path			Model b/c'-path		
	b	E	p	b	SE	p
Reference						
(shared garden or allotment)	3.84	0.15	< .001	21.34	0.22	< .001
Private garden	2.21	0.13	< .001	1.61	0.18	< .001
Balcony/yard/patio	0.89	0.19	< .001	-0.29	0.25	.251
Age	-0.02	0.01	.002			
Private garden x Age	0.06	0.01	< .001			
Balcony/etc. x Age	0.04	0.01	< .001			
Use				0.14	0.01	< .001
Income	< 0.01	< 0.01	.231	< 0.01	< 0.01	< .001
Dog ownership	2.03	0.08	< .001	-1.23	0.12	< .001
Health	0.77	0.05	< .001	3.77	0.07	< .001
Gender	-0.45	0.08	< .001	0.03	0.11	.754
Children	0.62	0.09	< .001	-1.88	0.12	< .001

Note. N = 17,223. Model for the a-path $R^2 = .09$, $F(10, 17212) = 183.15$, $p < .001$, Model for b-path and c'-path $R^2 = .21$, $F(8, 17214) = 493.91$, $p < .001$.

were tested with two-tailed tests.

The a-path is the same for all wellbeing outcomes. The b- and c'-paths are reported in full in Appendix B. Access to a private garden was positively related to evaluative wellbeing ($b = 0.17$, $p = .001$), eudemonic wellbeing ($b = 0.28$, $p < .001$) and positive affect ($b = 0.17$, $p = .003$), and it was negatively related to negative affect ($b = -0.99$, $p < .001$). Access to a balcony/yard/patio area was negatively related to evaluative wellbeing ($b = -0.16$, $p = .032$), positive affect ($b = -0.22$, $p = .006$) and negative affect ($b = -0.24$, $p = .026$), and use was positively related to all subscales of wellbeing - evaluative wellbeing ($b = 0.05$, $p < .001$), eudemonic wellbeing ($b = 0.05$, $p < .001$), positive affect ($b = 0.05$, $p < .001$) and negative affect ($b = 0.01$, $p = .014$). The index of moderated mediation was significant for both access to a private garden and access to a balcony, yard or patio area for all wellbeing outcomes.

Discussion

The aim of this thesis was to investigate the relationship between access to different types of private outdoor spaces and wellbeing, the mediating role of use and the moderating role of age in this relationship.

Results related to the hypotheses

There is evidence that access to a private outdoor space is positively related to wellbeing (H1). Without controlling for covariates, access to any type of private outdoor space is associated with higher wellbeing than no access. Controlling for covariates, only access to a private garden is significantly related to higher wellbeing, suggesting that the effects of access to a shared garden or an allotment and access to a balcony, yard or patio on wellbeing are better explained by high income, not owning a dog, good health and having children in the household. Looking at the wellbeing subscales, there are still significant relationships. Access to any type of private outdoor space is positively related to evaluative wellbeing, eudemonic wellbeing and positive affect. Access to a shared garden or an allotment is associated with higher negative affect, while access to a private garden is associated with lower negative affect.

Contrary to the assumption, age does not moderate any relationship between access to a private outdoor space and wellbeing (H2). However, it does moderate the relationship between access to a shared garden or an allotment and evaluative wellbeing and eudemonic wellbeing. Age also moderates the relationship between access to a private garden and positive affect, with older people benefiting most from their shared gardens, allotments and private gardens.

Compared to access to a shared garden or an allotment, access to a private garden is positively associated with wellbeing, while access to a balcony, yard or patio shows no significant difference (H3). Private gardens are also associated with higher evaluative wellbeing, eudemonic wellbeing and positive affect and lower negative affect. Balconies, yards and patios are associated with lower evaluative wellbeing and positive affect, but also lower negative affect, compared to shared gardens.

Access to different types of private outdoor space is related to its use (H4). Private gardens as well as balconies, yards or patios are used more frequently than shared gardens or allotments.

Age acts as a moderator in both of these relationships (H7), with older people using their private gardens, balconies, yards and patios more frequently. Only young

people with access to a balcony, yard, or patio do not differ significantly from people with access to a shared garden or an allotment.

As assumed, use of private outdoor space is positively related to wellbeing (H5). It is also positively related to evaluative and eudemonic wellbeing as well as positive and negative affect.

Use partially mediates the relationship between access to a private garden and wellbeing and fully mediates the relationship between access to a balcony, yard or patio area and wellbeing (H6). Thus, in the case of balconies, yards and patios, wellbeing benefits are fully explained by frequency of use. Furthermore, there is evidence for a moderated mediation for both types of access, except for young people with access to balconies, yards or patios. The same pattern was also found for evaluative wellbeing, eudemonic wellbeing, positive and negative affect.

Integration with literature

The results of this thesis support the findings of previous research that access to private outdoor space is positively associated with wellbeing outcomes (Golzarpour et al., 2023; Howarth et al., 2020; Mouratidis, 2021; Pouso et al., 2021) and that different types of private outdoor space are not all equally beneficial (Golzarpour et al., 2023; Pouso et al., 2021).

Previous research found that gardens are perceived as more beneficial than balconies or yards (Golzarpour et al., 2023; Pouso et al., 2021). This is partly consistent with the findings of this thesis. Balconies, yards and patios do not differ from shared gardens and allotments in terms of wellbeing, while private gardens are associated with higher wellbeing. However, balconies, yards and patios are associated with lower evaluative wellbeing and positive affect than shared gardens or allotments, but also with lower negative affect. As balcony, yard and patio areas were combined into one single category, differences between these types, as found in a previous study, (Pouso et al., 2021) could not be investigated in this thesis.

The results of previous studies on shared gardens are not consistent. For example, de Bell et al. (2020) found that having access to a communal garden is

associated with poorer health than not having access to a garden, while Corley et al. (2021) suggests that both private and communal outdoor spaces promote wellbeing. This is reflected in the results of this thesis, as access to a shared garden or an allotment is positively associated with all subscales of wellbeing, even negative affect. Private gardens, on the other hand, are the only type of private outdoor space that is associated with lower negative affect compared to no access. This is in contrast to the findings of Young et al. (2020), who found that negative affect is higher in private gardeners than allotment gardeners. However, the finding of Pouso et al. (2021) that the mental health benefits are less positive for shared outdoor spaces compared to private gardens is consistent with the findings of this thesis.

The suggestion by de Bell et al. (2020) that some benefits of garden access are explained by actual garden use is supported by the results of this thesis. Use of private gardens partially mediates the relationship between access and wellbeing. This is also consistent with research by Chalmin-Pui et al. (2021) and Corley et al. (2021). The mediating role of use can even be extended to other private outdoor spaces such as balconies, yards and patios, where it fully explains the relationship between access and wellbeing.

In this thesis, no moderating effect of age was found on the relationship between access to a private outdoor space and wellbeing. However, older people benefit more from access to a garden in terms of wellbeing trait measures and positive affect. In addition, older people spend more time in their private garden, balcony, yard or patio and therefore benefit more from access to these spaces. This is consistent with previous research showing that the use of private green spaces such as gardens and balconies correlates with improved mental health in older people (Tabrizi et al., 2023) and that older gardeners benefit more than younger gardeners from allotment gardening (van den Berg et al., 2010).

Strengths, limitations and future directions

The strengths of this thesis lie in the large sample size and the use of the PANS dataset, which consists of a nationally representative sample for England.

However, as cross-sectional data was used, no causal conclusions can be drawn. Furthermore, the direction of the relationships may not be as expected. For example, it could be that participants with higher wellbeing scores are more likely to spend time in their private outdoor space and not vice versa. In addition, only self-reported data was used. Participants may have inaccurately recalled or estimated the amount of time they spent in their private outdoor space. The use of secondary data also comes with some limitations. The PANS focuses on measuring different types of gardens, but does not differentiate between types of private outdoor spaces other than gardens. However, a balcony and a patio could differ in their relationship with wellbeing. Furthermore, the variables use, age and income were treated as interval scaled variables in the analysis, although they were not collected as such.

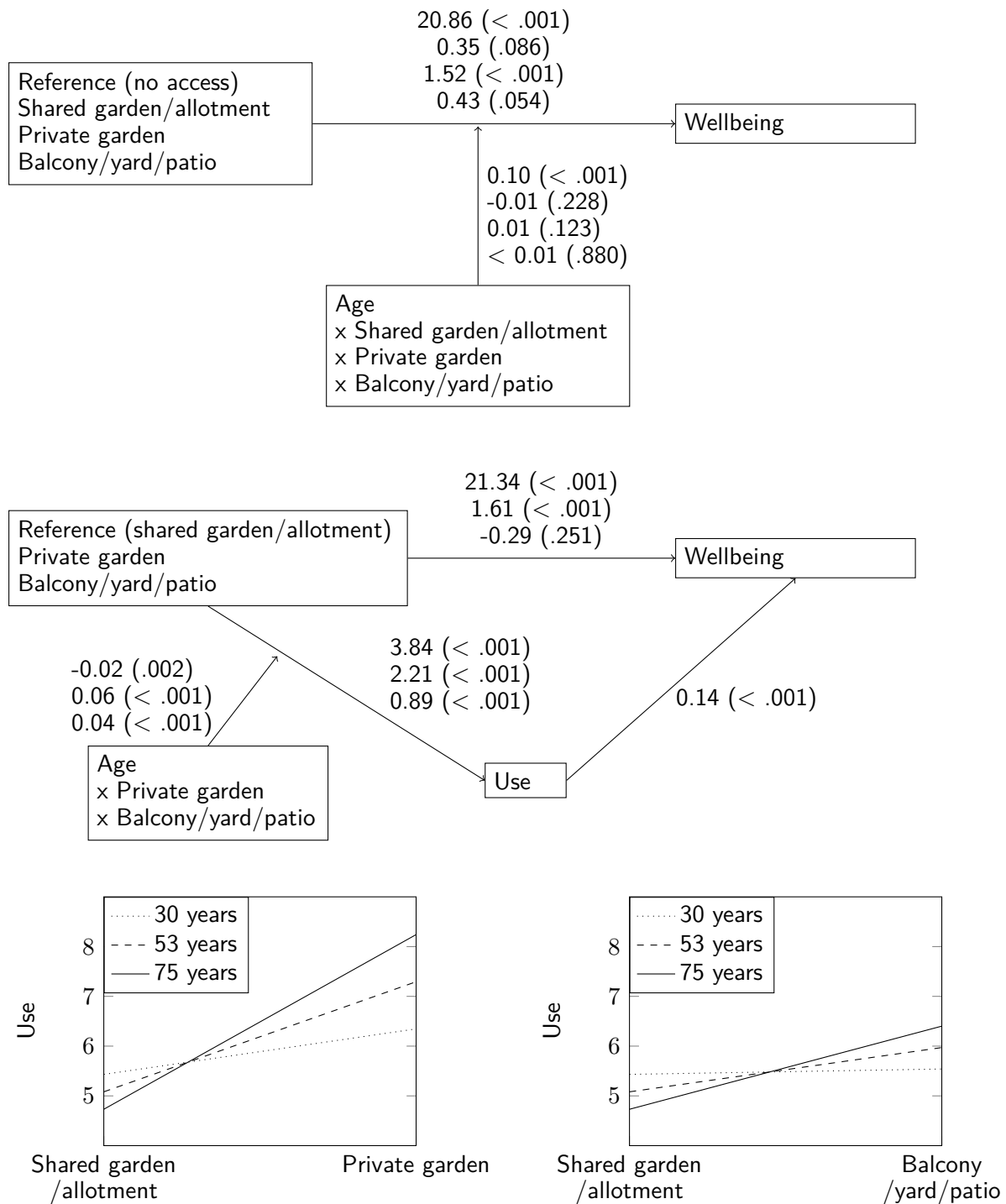
Considering these limitations, future research should further investigate the causality of the relationships in the models used in this thesis. Future studies should also take into account the mixed results on shared gardens and further investigate the relationship with negative affect, for example, what role privacy and social aspects play in this context. Furthermore, previous research suggests that active forms of nature exposure have a more positive effect on wellbeing than passive forms (Pouso et al., 2021; van den Berg et al., 2010). Future research should therefore include specific activities such as gardening or passive relaxation.

Conclusion

This thesis demonstrates the link between access to and use of different types of private outdoor spaces, age and wellbeing outcomes. Access to any type of private outdoor space is associated with greater trait measures of wellbeing and positive affect. Access to a private garden is related to lower negative affect, while access to a shared garden or an allotment is related to higher negative affect compared to no access. People who spend more time in their private garden, balcony, yard or patio might experience greater wellbeing, but also greater negative affect. For private outdoor spaces that are not gardens, such as balconies, yards and patios, the analysis even showed a full mediation, suggesting that the wellbeing benefits are fully explained by the frequency of

use. The findings also suggest that older people use their private gardens, balconies, yards and patios more frequently and thus derive greater benefits for their wellbeing.

These findings contribute to a deeper understanding of how the physical environment is related to wellbeing. They demonstrate the importance of considering different types of private outdoor spaces in urban planning and public health policies in order to promote public mental health, especially for older people. In particular, providing access to gardens might promote the wellbeing of residents in their daily lives and thus contribute to building a resilient society. But even for those who already have access to a private outdoor space, interventions aimed at spending more time in these spaces could improve wellbeing. This is especially true for private outdoor spaces that are not gardens, such as balconies, yards and patios.

**Figure 2**

The unstandardized regression coefficient and the significance in parentheses for each relationship in the moderation (top) and the moderated mediation analysis (centre) with wellbeing as DV; and simple slopes for the interaction of the moderated mediation analysis (bottom).

Note. Following covariates are included in both process models: income, dog ownership, health, gender and children in the household.

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Appendix A

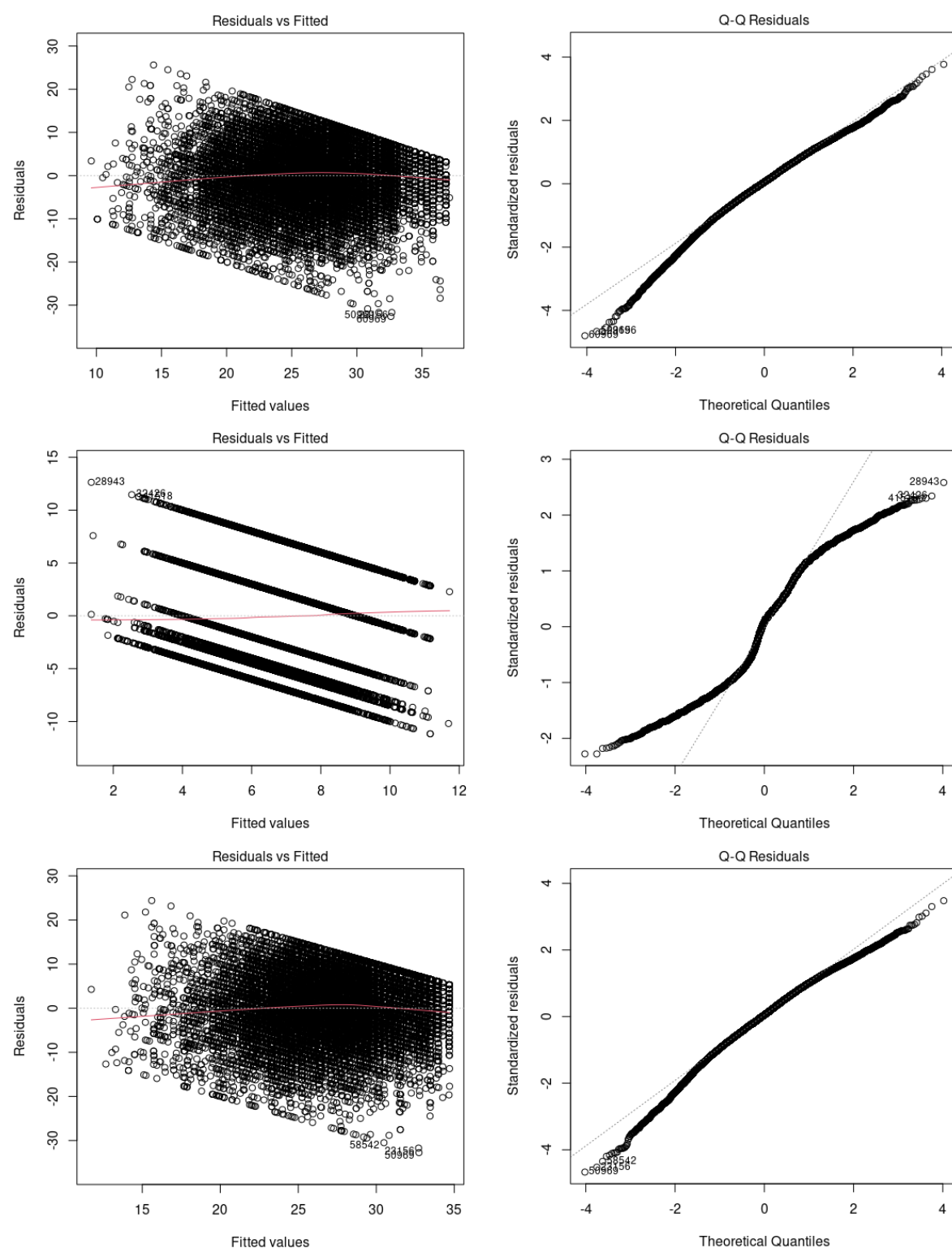
Regression assumptions

The assumption tests were carried out for three regression models: the moderation analysis, the a-path and the b/c'-path of the moderated mediation analysis.

To check linearity, a residual vs. fitted plot was used for each model, as shown on the left-hand side in Figure A1. The red line indicates that the linearity assumption was met for all three models. This was confirmed by the Rainbow test for the moderation analysis ($\text{Rain}(9566, 9553) = 1.00$; $p = .436$), the a-path ($\text{Rain}(8612, 8600) = 1.01$; $p = .353$) and the b/c'-path of the moderated mediation analysis ($\text{Rain}(8612, 8602) = 1.01$; $p = .309$). The residual vs. fitted plots also show that the homoscedasticity assumption was not met. Thus, robust standard errors for heteroscedasticity HC3 were used in the analyses.

To check the normality of the residuals, a normal quantile plot was used for each of the three models, as shown on the right-hand side in Figure A1. However, since bootstrapping was used in the analysis, normality was not a necessary assumption. Excluding the interaction term, the highest variance inflation factor in all three models was $\text{VIF} = 1.69$, which indicates that multicollinearity was not a problem. The Durbin-Watson-Test showed that the assumption of uncorrelated residuals was also met, with D-W statistic values between 1.82 and 1.97. Outliers are shown in Figure A2 as studentized residuals, but no outliers have been excluded from the analyses.

In addition, the distribution of all variables in both statistical samples was similar to that in the full sample of the PANS dataset, indicating that the exclusion of participants did not lead to a systematic bias.

**Figure A1**

Residual vs. fitted plots (left) and normal quantile plots (right) for the moderation analysis (top), the a-path (centre) and the b/c'-path of the moderated mediation analysis (bottom).

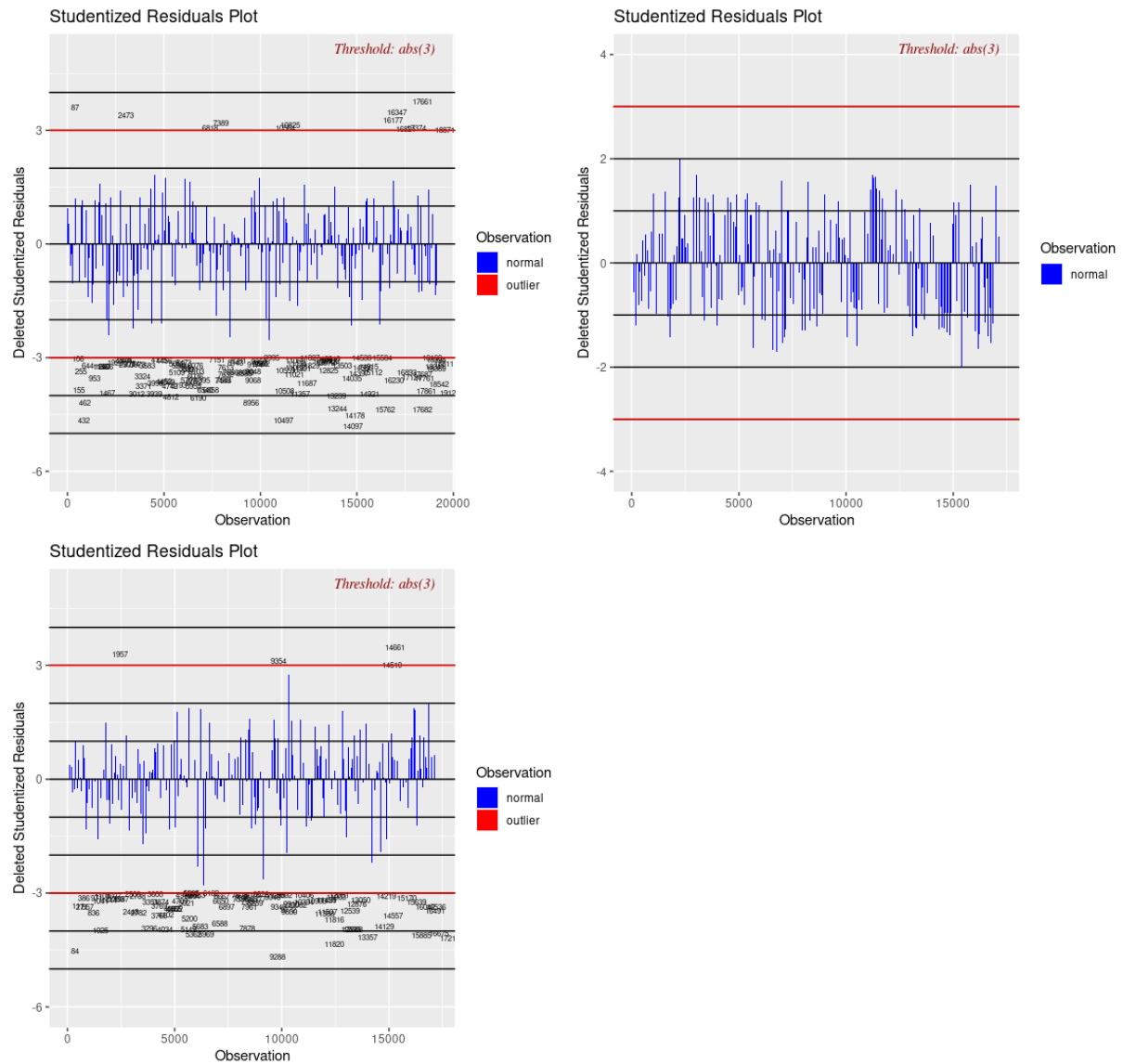


Figure A2

Studentized residual plots showing the outliers in the moderation analysis (top left), the a-path (top right) and the b/c'-path of the moderated mediation analysis (bottom).

Appendix B

Regression results for wellbeing subscales

Evaluative wellbeing

A moderation analysis was run to determine the relationship between access to a private outdoor space, age and evaluative wellbeing. The interaction between access to a shared garden or an allotment and age was significant compared to no access, indicating that the relationship between access to a shared garden or an allotment and evaluative wellbeing was moderated by age. The simple slope was strongest for small values (-1 SD) of age ($b = 0.43$, $SE = 0.09$, $t = 5.04$, $p < .001$) but also significant for medium values (M) of age ($b = 0.29$, $SE = 0.07$, $t = 3.87$, $p = .001$), however not significant for high values (+ 1 SD) of age ($b = 0.14$, $SE = 0.12$, $t = 1.16$, $p = .246$). An additional $\Delta R^2 = 0.10\%$ ($F(3, 19119) = 7.39$, $p < .001$) of the variance was explained by the moderation. For the full regression results see Table B1, for a visualization of the relationships see Figure B1.

A moderated mediation analysis was conducted to investigate use of private outdoor spaces as mediator for the relationship between access and evaluative wellbeing as well as age as moderator in the relationship between access and use. The reference

Table B1

Regression results for the moderation analysis, with evaluative wellbeing as DV, access to a private outdoor space as IV and age as moderator

Variable	b	SE	p
Reference (no access to a private outdoor space)	4.62	0.06	< .001
Shared garden or allotment	0.29	0.07	< .001
Private garden	0.43	0.05	< .001
Balcony/yard/patio	0.23	0.08	.001
Age	0.02	< 0.01	< .001
Shared garden/allotment x Age	-0.01	< 0.01	.049
Private garden x Age	< 0.01	< 0.01	.101
Balcony/yard/patio x Age	> -0.01	< 0.01	.961
Income	< 0.01	< 0.01	< .001
Dog ownership	0.09	0.03	.006
Health	1.23	0.02	< .001
Gender	0.03	0.03	.220
Children	0.26	0.04	< .001

Note. $N = 19,132$. $R^2 = .29$, $F(12, 19119) = 550.18$, $p < .001$.

category was access to a shared garden or an allotment. As the a-path is the same for all wellbeing outcomes, the details of the moderation are only reported once, in section [Results](#).

The index of moderated mediation for access to a private garden was significant, $b = 0.003$, 95% percentile CI [0.002, 0.004], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.17$, 95% percentile CI [0.14, 0.20], it was weaker but still significant for medium values (M) of age, $b = 0.11$, CI [0.09, 0.12] and for small values (- 1 SD) of age, $b = 0.04$, CI [0.03, 0.06]. The index of moderated mediation for access to a balcony/yard/patio was significant, $b = 0.002$, 95% percentile CI [0.001, 0.003], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.08$, 95% percentile CI [0.05, 0.11], it was weaker but still significant for medium values (M) of age, $b = 0.04$, CI [0.02, 0.06] but not significant for small values (- 1 SD) of age, $b = 0.01$, CI [-0.01, 0.02]. For the full regression results of the moderated mediation see Table [B2](#), for a visualization of the relationships see Figure [B1](#).

Eudemonic wellbeing

To determine the relationship between access to a private outdoor space, age and eudemonic wellbeing a moderation analysis was conducted. The interaction between access to a shared garden or an allotment and age was significant compared to no access. This indicates that the relationship between access to a shared garden or an allotment and eudemonic wellbeing was moderated by age. The simple slope was strongest for small values (-1 SD) of age ($b = 0.35$, $SE = 0.09$, $t = 3.86$, $p < .001$) but also significant for medium values (M) of age ($b = 0.19$, $SE = 0.08$, $t = 2.40$, $p = .017$), however not significant for high values (+ 1 SD) of age ($b = 0.03$, $SE = 0.13$, $t = 0.21$, $p = .832$). An additional $\Delta R^2 = 0.06\%$ ($F(3, 19119) = 4.38$, $p = .004$) of the variance was explained by the moderation. For the full regression results see Table [B3](#), for a visualization of the relationships see Figure [B2](#).

A moderated mediation analysis was conducted to investigate use of private

outdoor spaces as mediator for the relationship between access and eudemonic wellbeing as well as age as moderator in the relationship between access and use. The reference category was access to a shared garden or an allotment. As the a-path is the same for all wellbeing outcomes, the details of the moderation are only reported once, in section [Results](#).

The index of moderated mediation for access to a private garden was significant, $b = 0.003$, 95% percentile CI [0.002, 0.004], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.18$, 95% percentile CI [0.15, 0.21], it was weaker but still significant for medium values (M) of age, $b = 0.11$, CI [0.10, 0.13] and for small values (- 1 SD) of age, $b = 0.05$, CI [0.03, 0.06]. The index of moderated mediation for access to a balcony/yard/patio was significant, $b = 0.002$, 95% percentile CI [0.001, 0.003], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.09$, 95% percentile CI [0.05, 0.12], it was weaker but still significant for medium values (M) of age, $b = 0.05$, CI [0.03, 0.07]

Table B2

Regression results for the a-path from access to use and for the b-path from use to evaluative wellbeing

Variable	Model a-path			Model b/c'-path		
	b	SE	p	b	SE	p
Reference (shared garden or allotment)	3.84	0.15	< .001	4.88	0.06	< .001
Private garden	2.21	0.13	< .001	0.17	0.05	.001
Balcony/yard/patio	0.89	0.19	< .001	-0.16	0.08	.032
Age	-0.02	0.01	.002			
Private garden x Age	0.06	0.01	< .001			
Balcony/etc. x Age	0.04	0.01	< .001			
Use				0.05	< 0.01	< .001
Income	< 0.01	< 0.01	.231	< 0.01	< 0.01	< .001
Dog ownership	2.03	0.08	< .001	-0.10	0.03	.003
Health	0.77	0.05	< .001	1.16	0.02	< .001
Gender	-0.45	0.08	< .001	0.04	0.03	.154
Children	0.62	0.09	< .001	-0.17	0.03	< .001

Note. N = 17,223. Model for the a-path $R^2 = .09$, $F(10, 17212) = 183.15$, $p < .001$, Model for b-path and c'-path $R^2 = .25$, $F(8, 17214) = 588.59$, $p < .001$; The direct effect explained $\Delta R^2 = 0.19\%$ of the variance in the model.

but not significant for small values (-1 SD) of age, $b = 0.01$, CI $[-0.01, 0.03]$. For the full regression results of the moderated mediation see Table B4, for a visualization of the relationships see Figure B2. Only when using the bootstrapping method was there a significant direct effect on wellbeing for people with access to a balcony/yard/patio area ($b = -0.15$, 95% percentile CI $[-0.302, -0.005]$).

Positive affect

A moderation analysis was run to determine the relationship between access to a private outdoor space, age and positive affect. The interaction between access to a private garden and age was significant compared to no access. This indicates that the relationship between access to a private garden and positive affect was moderated by age. The simple slope was strongest for high values (-1 SD) of age ($b = 0.56$, $SE = 0.10$, $t = 5.68$, $p < .001$) but also significant for medium values (M) of age ($b = 0.43$, $SE = 0.06$, $t = 7.21$, $p < .001$) and small values ($+1$ SD) of age ($b = 0.30$, $SE = 0.07$, $t = 4.11$, $p < .001$). An additional $\Delta R^2 = 0.09\%$ ($F(3, 19119) = 6.94$, $p < .001$) of the variance was explained by the moderation. For the full regression results see Table B5, for a visualization of the relationships see Figure B3.

A moderated mediation analysis was conducted to investigate use of private

Table B3

Regression results for the moderation analysis, with eudemonic wellbeing as DV, access to a private outdoor space as IV and age as moderator

Variable	b	SE	p
Reference (no access to a private outdoor space)	5.05	0.06	< .001
Shared garden or allotment	0.19	0.08	.009
Private garden	0.43	0.06	< .001
Balcony/yard/patio	0.15	0.08	.032
Age	0.02	< 0.01	< .001
Shared garden/allotment x Age	-0.01	< 0.01	.042
Private garden x Age	< 0.01	< 0.01	.486
Balcony/yard/patio x Age	> -0.01	< 0.01	.862
Income	< 0.01	< 0.01	< .001
Dog ownership	0.04	0.03	.229
Health	1.12	0.02	< .001
Gender	0.12	0.03	< .001
Children	0.36	0.04	< .001

Note. $N = 19,132$. $R^2 = .24$, $F(12, 19119) = 412.67$, $p < .001$.

outdoor spaces as mediator for the relationship between access and positive affect as well as age as moderator in the relationship between access and use. The reference category was access to a shared garden or an allotment. As the a-path is the same for all wellbeing outcomes, the details of the moderation are only reported once, in section [Results](#).

The index of moderated mediation for access to a private garden was significant, $b = 0.003$, 95% percentile CI [0.002, 0.004], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.18$, 95% percentile CI [0.15, 0.21], it was weaker but still significant for medium values (M) of age, $b = 0.11$, CI [0.09, 0.13] and for small values (- 1 SD) of age, $b = 0.05$, CI [0.03, 0.06]. The index of moderated mediation for access to a balcony/yard/patio was significant, $b = 0.002$, 95% percentile CI [0.001, 0.003], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.09$, 95% percentile CI [0.05, 0.12], it was weaker but still significant for medium values (M) of age, $b = 0.05$, CI [0.03, 0.07]

Table B4

Regression results for the a-path from access to use and for the b-path from use to eudemonic wellbeing

Variable	Model a-path			Model b/c'-path		
	b	SE	p	b	SE	p
Reference (shared garden or allotment)	3.84	0.15	< .001	5.20	0.07	< .001
Private garden	2.21	0.13	< .001	0.28	0.06	< .001
Balcony/yard/patio	0.89	0.19	< .001	-0.15	0.08	.051
Age	-0.02	0.01	.002			
Private garden x Age	0.06	0.01	< .001			
Balcony/etc. x Age	0.04	0.01	< .001			
Use				0.05	< 0.01	< .001
Income	< 0.01	< 0.01	.231	< 0.01	< 0.01	< .001
Dog ownership	2.03	0.08	< .001	-0.16	0.04	< .001
Health	0.77	0.05	< .001	1.05	0.02	< .001
Gender	-0.45	0.08	< .001	0.13	0.03	< .001
Children	0.62	0.09	< .001	-0.09	0.04	.011

Note. N = 17,223. Model for the a-path $R^2 = .09$, $F(10, 17212) = 183.15$, $p < .001$, Model for b-path and c'-path $R^2 = .20$, $F(8, 17214) = 430.86$, $p < .001$; The direct effect explained $\Delta R^2 = 0.34\%$ of the variance in the model.

but not significant for small values (-1 SD) of age, $b = 0.01$, CI $[-0.01, 0.03]$. For the full regression results of the moderated mediation see Table B6, for a visualization of the relationships see Figure B3.

Negative affect

To determine the relationship between access to a private outdoor space, age and negative affect a moderation analysis was conducted. No interaction between access and age was significant compared to no access, indicating that there was no moderation. For the full regression results see Table B7, for a visualization of the relationships see Figure B4.

A moderated mediation analysis was conducted to investigate use of private outdoor spaces as mediator for the relationship between access and negative affect as well as age as moderator in the relationship between access and use. The reference category was access to a shared garden or an allotment. As the a-path is the same for all wellbeing outcomes, the details of the moderation are only reported once, in section Results.

The index of moderated mediation for access to a private garden was significant, $b = 0.001$, 95% percentile CI $[< 0.001, 0.001]$, providing evidence for a moderated

Table B5

Regression results for the moderation analysis, with positive affect as DV, access to a private outdoor space as IV and age as moderator

Variable	b	SE	p
Reference (no access to a private outdoor space)	5.03	0.06	< .001
Shared garden or allotment	0.30	0.08	< .001
Private garden	0.43	0.06	< .001
Balcony/yard/patio	0.21	0.08	.007
Age	0.02	< 0.01	< .001
Shared garden/allotment x Age	-0.01	< 0.01	.156
Private garden x Age	0.01	< 0.01	.043
Balcony/yard/patio x Age	< 0.01	< 0.01	.521
Income	< 0.01	< 0.01	< .001
Dog ownership	0.02	0.04	.573
Health	1.15	0.02	< .001
Gender	-0.07	0.03	.023
Children	0.21	0.04	< .001

Note. $N = 19,132$. $R^2 = .23$, $F(12, 19119) = 423.49$, $p < .001$.

Table B6

Regression results for the a-path from access to use and for the b-path from use to positive affect

Variable	Model a-path			Model b/c'-path		
	b	SE	p	b	SE	p
Reference						
(shared garden or allotment)	3.84	0.15	< .001	5.31	0.07	< .001
Private garden	2.21	0.13	< .001	0.17	0.06	.003
Balcony/yard/patio	0.89	0.19	< .001	-0.22	0.08	.006
Age	-0.02	0.01	.002			
Private garden x Age	0.06	0.01	< .001			
Balcony/etc. x Age	0.04	0.01	< .001			
Use				0.05	< 0.01	< .001
Income	< 0.01	< 0.01	.231	< 0.01	< 0.01	< .001
Dog ownership	2.03	0.08	< .001	-0.20	0.04	< .001
Health	0.77	0.05	< .001	1.09	0.02	< .001
Gender	-0.45	0.08	< .001	-0.06	0.03	.094
Children	0.62	0.09	< .001	-0.26	0.04	< .001

Note. N = 17,223. Model for the a-path $R^2 = .09$, $F(10, 17212) = 183.15$, $p < .001$, Model for b-path and c'-path $R^2 = .19$, $F(8, 17214) = 438.90$, $p < .001$; The direct effect explained $\Delta R^2 = 0.21\%$ of the variance in the model.

mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.04$, 95% percentile CI [0.01, 0.07], it was weaker but still significant for medium values (M) of age, $b = 0.02$, CI [< 0.01 , 0.05] and for small values (- 1 SD) of age, $b = 0.01$, CI [< 0.01 , 0.02]. The index of moderated mediation for access to a balcony/yard/patio was significant, $b < 0.001$, 95% percentile CI [< 0.001 , 0.001], providing evidence for a moderated mediation. The conditional indirect effect for high values (+ 1 SD) of age was the strongest, $b = 0.02$, 95% percentile CI [< 0.01 , 0.04], it was weaker but still significant for medium values (M) of age, $b = 0.01$, CI [< 0.01 , 0.02] but not significant for small values (- 1 SD) of age, $b < 0.01$, CI [> -0.01 , 0.01]. For the full regression results of the moderated mediation see Table B8, for a visualization of the relationships see Figure B4.

Table B7

Regression results for the moderation analysis, with negative affect as DV, access to a private outdoor space as IV and age as moderator

Variable	b	SE	p
Reference (no access to a private outdoor space)	3.83	0.08	< .001
Shared garden or allotment	0.42	0.10	< .001
Private garden	-0.23	0.08	.002
Balcony/yard/patio	0.16	0.11	.076
Age	-0.03	< 0.01	< .001
Shared garden/allotment x Age	-0.01	< 0.01	.273
Private garden x Age	> -0.01	< 0.01	.590
Balcony/yard/patio x Age	> -0.01	0.01	.980
Income	> -0.01	< 0.01	.009
Dog ownership	0.62	0.05	< .001
Health	-0.53	0.03	< .001
Gender	0.12	0.04	.004
Children	0.59	0.06	< .001

Note. N = 19,132. $R^2 = .13$, $F(12, 19119) = 251.43$, $p < .001$.

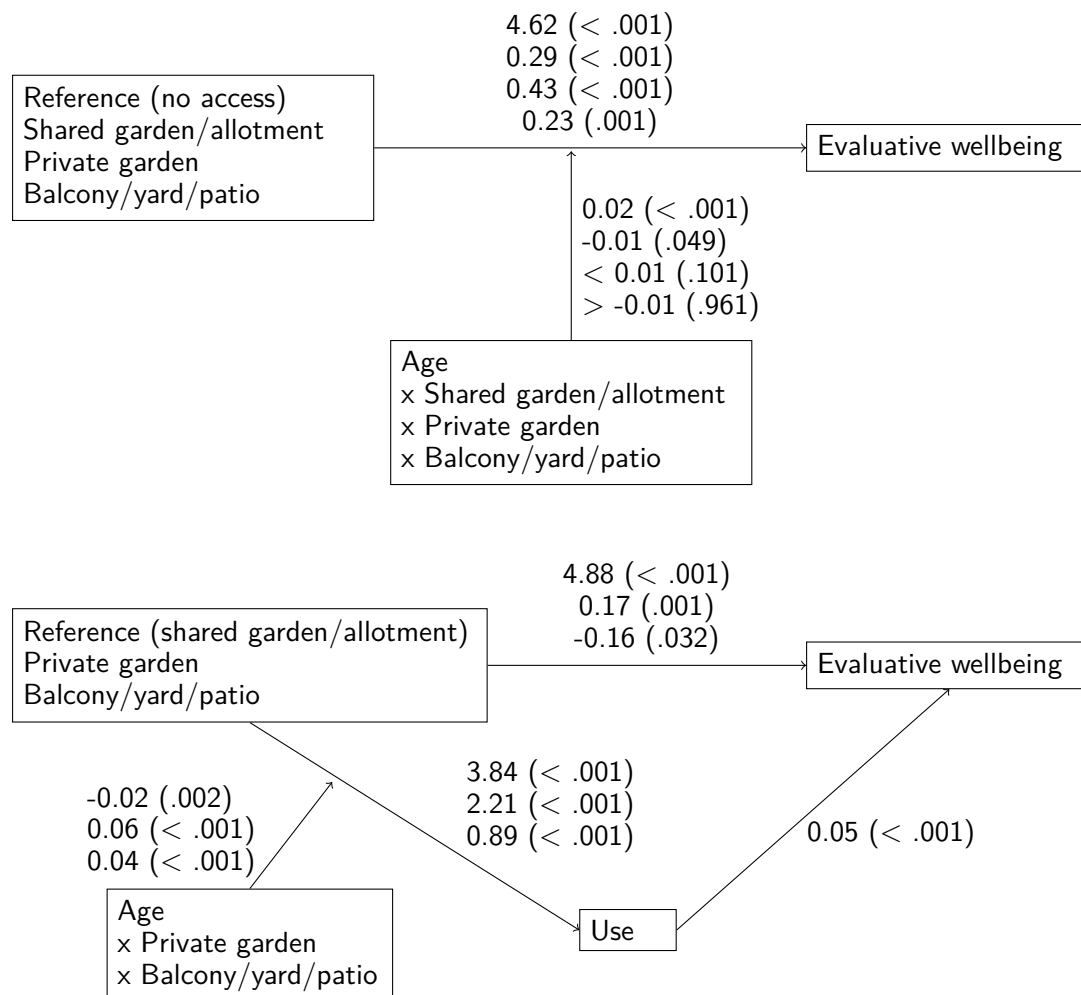
Table B8

Regression results for the a-path from access to use and for the b-path from use to negative affect

Variable	Model a-path			Model b/c'-path		
	b	SE	p	b	SE	p
Reference						
(shared garden or allotment)	3.84	0.15	< .001	4.05	0.09	< .001
Private garden	2.21	0.13	< .001	-0.99	0.08	< .001
Balcony/yard/patio	0.89	0.19	< .001	-0.24	0.11	.026
Age	-0.02	0.01	.002			
Private garden x Age	0.06	0.01	< .001			
Balcony/etc. x Age	0.04	0.01	< .001			
Use				0.01	< 0.01	.014
Income	< 0.01	< 0.01	.231	> -0.01	< 0.01	.383
Dog ownership	2.03	0.08	< .001	0.78	0.05	< .001
Health	0.77	0.05	< .001	-0.46	0.03	< .001
Gender	-0.45	0.08	< .001	0.08	0.05	.070
Children	0.62	0.09	< .001	1.36	0.05	< .001

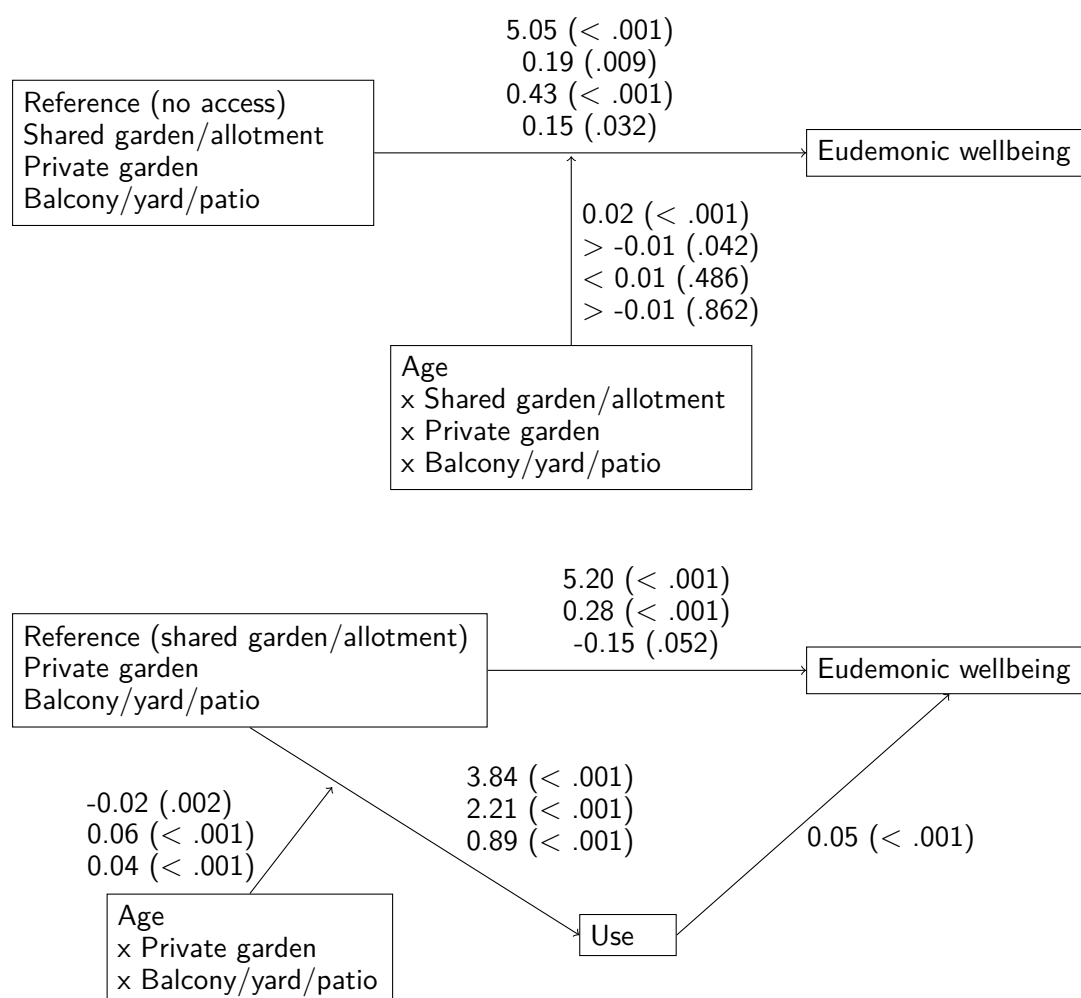
Note. N = 17,223. Model for the a-path $R^2 = .09$, $F(10, 17212) = 183.15$, $p < .001$,

Model for b-path and c'-path $R^2 = .08$, $F(8, 17214) = 193.14$, $p < .001$; The direct effect explained $\Delta R^2 = 1.15\%$ of the variance in the model.

**Figure B1**

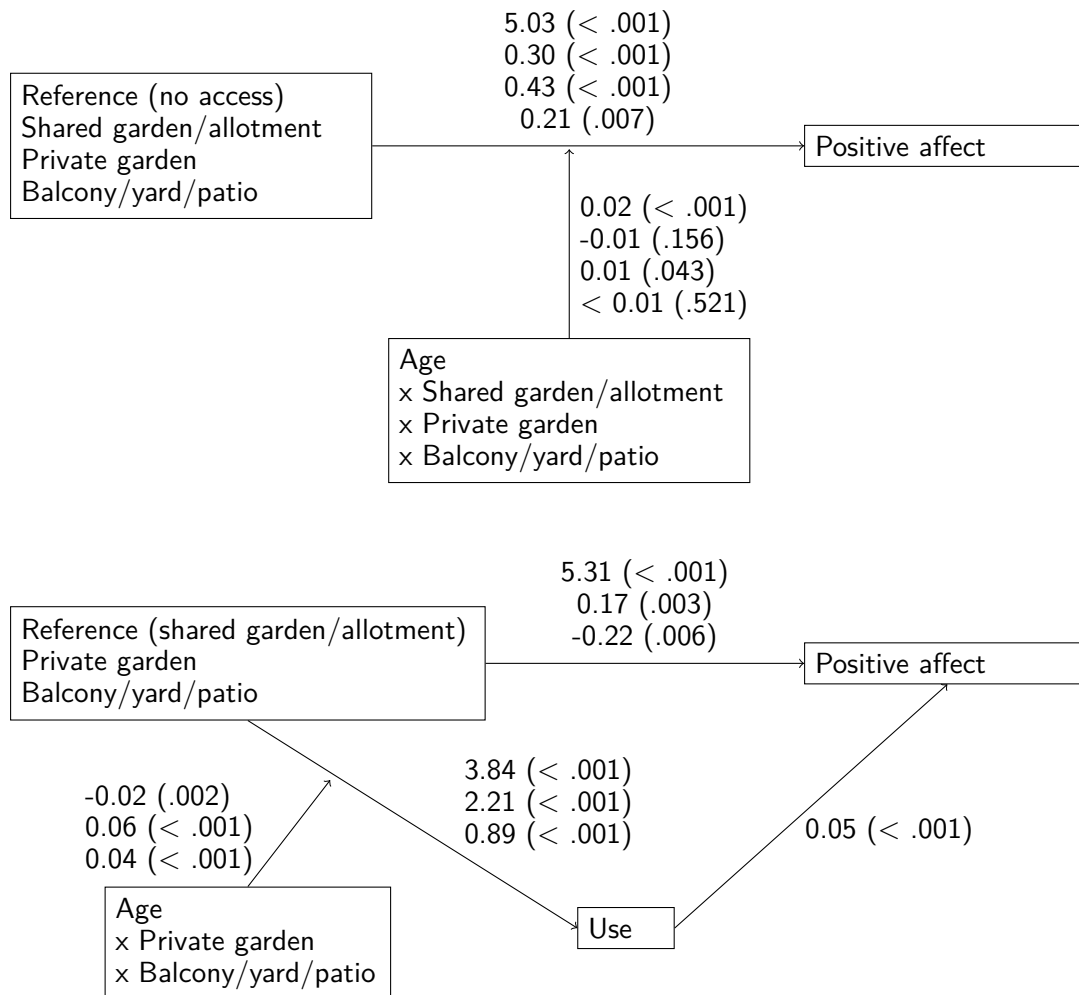
The unstandardized regression coefficient and the significance in parentheses for each relationship in the moderation (top) and the moderated mediation analysis (bottom) with evaluative wellbeing as DV.

Note. Following covariates are included in both the moderation and the moderated mediation analysis: income, dog ownership, health, gender and children in the household.

**Figure B2**

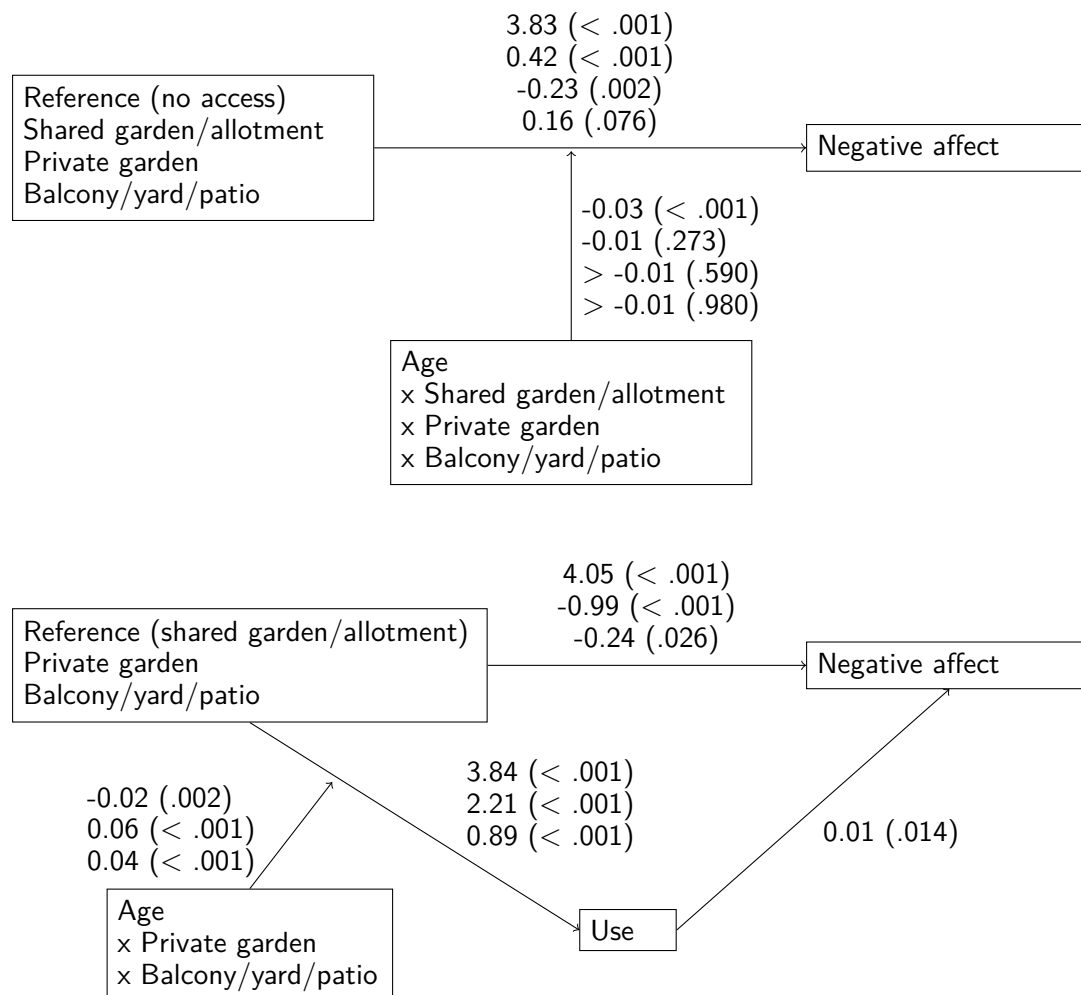
The unstandardized regression coefficient and the significance in parentheses for each relationship in the moderation (top) and the moderated mediation analysis (bottom) with eudemonic wellbeing as DV.

Note. Following covariates are included in both the moderation and the moderated mediation analysis: income, dog ownership, health, gender and children in the household.

**Figure B3**

The unstandardized regression coefficient and the significance in parentheses for each relationship in the moderation (top) and the moderated mediation analysis (bottom) with positive affect as DV.

Note. Following covariates are included in both the moderation and the moderated mediation analysis: income, dog ownership, health, gender and children in the household.

**Figure B4**

The unstandardized regression coefficient and the significance in parentheses for each relationship in the moderation (top) and the moderated mediation analysis (bottom) with negative affect as DV.

Note. Following covariates are included in both the moderation and the moderated mediation analysis: income, dog ownership, health, gender and children in the household.