

Pathways to wellbeing: Residential nature, physical activity, and place-belongingness

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Abstract: Engagement with nature can nurture both individual wellbeing and just societies. However, with the global rise in urbanization, ecological degradation, and a profound physical and psychological disconnection from nature, understanding the links between residential nature and wellbeing is vital. The relationships between residential nature and wellbeing are complex, and gaps in our knowledge remain, for example, about the pathways involved in benefiting residents' wellbeing. In the current study, physical activity and place-belongingness are examined as two pathways mediating the benefits of residential outdoor spaces (recreation and hiking areas) on subjective wellbeing (affective, cognitive, and eudaimonic). Using path analysis, this study analyzed data from two consecutive waves of national wellbeing surveys in Norway (in 2020–2021) combined with register data (N = 35,079). Controlling for a host of confounders, two research questions were tested: 1) whether residential recreation and hiking areas relate to subjective wellbeing through physical activity and place-belongingness and 2) whether the strength of these pathways varies by age, gender, income, or urbanicity. The results of the path analyses widely affirmed these questions. Importantly, recreation areas and the place-belongingness pathway consistently showed the strongest relationships with subjective wellbeing. Moreover, older males in more rural areas appeared to experience stronger subjective wellbeing benefits from these pathways. These findings strengthen and advance the evidence base on how residential nature relates with wellbeing and grant insights for psychological science, urban planning, public health work, and outdoor education.

Keywords: instoration, urban greenspaces, parks, forests, structural equation modelling

1. Introduction

Ample evidence has shown that residential nature can benefit human mental health (Capaldi et al., 2015) and is regarded as a valuable source of public health (World Health Organization [WHO], 2016). However, with the global rise in urbanization, ecological degradation, and a profound physical and psychological disconnection from nature, understanding the links between residential nature and wellbeing has been increasingly actualised by modern challenges. Moreover, to guide effective public health strategies involving residential nature there is an urgent need to uncover the processes underlying the relationships between residential nature and wellbeing (Yang et al., 2021). The current study aims to strengthen and expand the evidence base on key processes and factors underlying the relationship between residential nature and wellbeing across Norway.

1.1 The relationships between residential nature and wellbeing

To better understand the dynamics between residential nature and wellbeing, a specification of both terms is necessary. On the one hand, the current study uses wellbeing to refer to subjective facets of the good life. Hence the focus is on subjective wellbeing. Subjective wellbeing is commonly associated with hedonia and eudaimonia. Hedonia refers to affective components such as happiness, pleasure, and the absence of discomfort, and cognitive components such as satisfaction with life. Eudaimonia refers to, for example, virtues, excellence, the development of potential, meaning in life, and positive mental functioning (Huta & Waterman, 2014). On the other hand, residential nature encompasses environments such as outdoor spaces with noticeable natural elements, from pristine or seminatural areas to urban green or blue spaces and including green infrastructure. When such spaces are close to residential areas, they provide settings for everyday nature experiences.

Beyond preventing numerous premature deaths (Barboza et al., 2021), extensive evidence has shown that residential nature universally benefits human health and wellbeing (Braubach et al., 2021; Houlden et al., 2018; Reyes-Riveros et al., 2021; WHO, 2016; Yang et al., 2021). The health and wellbeing benefits associated with residential nature are thought to result from a complex web of pathways, involving biopsychosocial mediators (Hartig et al., 2014; Lachowycz & Jones, 2013; Nieuwenhuijsen et al., 2017), which represent indirect processes linking the natural environment and wellbeing through intermediate variables. For example, Mensah et al. (2016) identified in their literature review that green spaces provide social, economic and environmental benefits which in turn improve wellbeing.

Explanations for the relationship between nature experiences and wellbeing include benefits associated to restoring attention (Kaplan, 1995), awe experiences (Joye & Bolderdijk, 2015), through the satisfaction of basic psychological needs (Yang et al., 2022), enhanced immune functioning (Kuo, 2015), among others. However, the specific processes linking residential nature to wellbeing still require research. Investigating indirect relationships is crucial to understanding how residential nature and wellbeing relate (Bonaiuto & Chiozza, 2024) and what are the strongest pathways.

1.2 Physical activity and place-belongingness as pathways linking residential nature and subjective wellbeing

Physical activity is a widely recognised pathway linking nature and wellbeing (Beute et al., 2023; Li et al., 2023; Markevych et al., 2017; Marselle et al., 2021; Nieuwenhuijsen et al., 2017; Silva et al., 2018; van den Bogerd et al., 2020; Wang et al., 2023). The physical activity pathway has been extensively researched and the underlying relationships are well understood (Dzhambov et al., 2020; Hartig et al., 2014): Being outdoors tends to involve physical activity, and residential outdoor spaces are typically associated with more physically active residents (Juul & Nordbø, 2023; WHO, 2016; Yang et al., 2021); in turn, the beneficial role of being physically active during leisure time on wellbeing has been well documented, with effects varying according to activity type, frequency, duration, and intensity (Werneck et al., 2022; Wiese et al., 2018). There is also evidence pointing to additional wellbeing benefits of being physically active in green spaces (i.e., green exercise) compared to urban outdoor environments, such as anxiety, fatigue, positive affect, vigour, and depression (Wicks et al., 2022). Nonetheless, studies investigating physical activity as a mediator of greenspace benefits have yielded mixed results. These inconsistent findings may be due to differences in the greenspace and physical activity indicators used or the fact that proximity to greenspace does not necessarily imply its use (Markevych et al., 2017; Nieuwenhuijsen et al., 2017).

In addition to supporting physical activity, greenspaces can also foster social interactions. Social relations can result in beneficial outcomes such as knowing and respecting one's neighbours, safety, and being able to find help if needed. Such benefits are commonly referred to as social cohesion, which is another widely recognised indirect way in which greenspaces can promote residents' wellbeing (Hartig et al., 2014; Lachowycz & Jones, 2013; Markevych et al., 2017). It appears possible that at least some greenspace–wellbeing associations are mediated by social aspects in combination with physical activity. For example, the Relational Restoration Theory (Hartig, 2021) emphasises that person–environment transactions (e.g., being physically active outdoors) often occur in groups. The person, the partner or group sharing the experience, and the environment influence each other's relationships. Compared to “solo experiences” in nature, shared experiences can augment some aspects of the experience and its outcomes, such as motivation for physical activity, group cohesion, and wellbeing. Markevych et al. (2017) and Dzhambov et al. (2020) recommended that researchers should go beyond exploring physical activity as a mediator in isolation and instead study it in combination with other potential mediators such as social cohesion. Importantly, social cohesion can be considered an umbrella term encompassing many overlapping terms such as sense of community and belongingness. Although such terms are often used interchangeably with social cohesion, none fully captures the same nuances (Antonsich, 2010; Donald, 2022; Raman, 2014). Hence, the specific term and indicator used within the social dimension likely influence mediation findings (Hartig et al., 2014; Jennings & Bamkole, 2019; Markevych et al., 2017).

Multiple scholars consider belongingness a human need (Baumeister & Leary, 1995; Deci & Ryan, 2000; Maslow, 1954), and research has found that it has profound impacts on wellbeing (Allen et al., 2021). In this study, belonging is understood as a subjective feeling of being an integral part of the surrounding systems, including family, communities, cultural groups, and most importantly, physical places (Allen et al., 2021). Belonging denotes a personal and intimate feeling of being ‘at home’ in a place, comprising familiarity, comfort, security, and emotional attachment, which is well captured by Antonsich's (2010) term ‘place-belongingness’. Hence, an aspect characterising place-belongingness is that it integrates both social and natural aspects in a deep relational dimension. Place-belongingness is likely to mediate the residential nature–wellbeing relationship, given its associations with both residential outdoor spaces and wellbeing (Allen et al., 2021; Grau-Ruiz & Løvoll, 2024; Main, 2013; Peters et al., 2016; Plane & Klodawsky, 2013). Furthermore, place-belongingness is closely related to other recognised pathways linking the natural environment with wellbeing, such as place attachment, place identity, and sense of community (Friesinger et al., 2022; Hartig et al., 2014; Li et al., 2023; Markevych et al., 2017; Marselle et al., 2021).

The biophilia hypothesis (Kellert & Wilson, 1993) and nature connectedness (Mayer et al., 2009) could help in explaining the associations between residential nature, place-belongingness, and wellbeing. The biophilia hypothesis (Kellert & Wilson, 1993) proposes that since human beings are animals who evolved in close contact with other living beings and their rhythms, a deep interconnectedness with the more-than-human world inhabits our minds and emotions. According to this hypothesis, humans have an intrinsic inherited emotional affinity to nature. Since nature has been our home for most of our history, residential nature could elicit feelings of place-belongingness. Leaving aside biophilia's debated genetic bases (Gunnarsson & Hedblom, 2023), research has shown that nature connectedness, meaning a feeling of belongingness to the natural world (Mayer et al., 2009), is an important mediator of the benefits of nature proximity and exposure for wellbeing (Baceviciene & Jankauskiene, 2022; Jenkins et al., 2022; Mayer et al., 2009). In the context of analysing nature-based solutions, Bonaiuto & Alves (2024, p. 316) argue

that special attention should be given to instoration¹ and those pathways to wellbeing that develop a relational dimension entailing both human and non-human beings. Hence, testing whether place-belongingness mediates the relationship between residential nature and wellbeing is warranted, as we are unaware of any study that has done so yet.

Exploring the place-belongingness pathway together with physical activity is particularly relevant because these potential pathways could be interconnected. Research has shown that an individual's sense of belonging to their local community relates to increased physical activity (Yip et al., 2016). As place-belongingness is assigned practical meanings and feelings of familiarity with the environment, safety, being accepted, emotional attachments, and empowerment (Mohseni et al., 2024), it is likely that such meanings and feelings favour the likelihood that individuals take advantage of the local opportunities to engage in physical activity (Yip et al., 2016). Moreover, hobbies, lifestyle, and other cultural factors like values, skills, and rituals are elements known to contribute to place-belongingness (Mohseni et al., 2024). Hence, year-round traditions such as the Norwegian "søndagstur" (i.e., the Sunday's trip) could bind together green exercise with a development of place-belongingness. In sum, simultaneously studying physical activity and place-belongingness as pathways linking residential nature and wellbeing could provide valuable knowledge about two parallel indirect ways through which nearby natural environments might benefit residents' wellbeing. If confirmed, such an analysis could inform our knowledge of the relative strength of these two pathways after controlling for each other, as well as whether these two pathways could be interconnected.

1.3 Moderators of the relationships between residential nature and wellbeing

The strength of the pathways linking residential nature with wellbeing likely varies across social groups and contexts. Factors such as the characteristics of the natural environment, residents, and contextual settings are theorised to influence these relationships (Hartig et al., 2014; Lachowycz & Jones, 2013; Nieuwenhuijsen et al., 2017). Analytically, these factors may operate as moderators of the relationship between residential nature and wellbeing (Bonaiuto & Chiozza, 2024).

Lachowycz and Jones (2013) proposed that the relationship between the natural environment and wellbeing is moderated by factors including age, economic status, gender, and urbanicity. Age is a key factor in physical activity and health and influences outdoor engagement, with younger and older adults being more sensitive to nature access than middle-aged adults. The moderating role of economic status is also relatively well established, with those in weaker economic positions potentially benefiting most, making greenspaces equigenic (Geary et al., 2023; Lachowycz & Jones, 2013; Markevych et al., 2017; WHO, 2016). However, a nationwide study in Austria found that the effect of reducing wellbeing inequalities arises from actual visits to outdoor spaces, implying that merely having a green environment nearby may not be sufficient (Fian et al., 2024). Gender shapes environmental perceptions and use, but findings on its moderating role are mixed, highlighting the need for further research (Lachowycz & Jones, 2013; Markevych et al., 2017; Nieuwenhuijsen et al., 2017). Evidence on urbanicity as a moderator is also inconsistent (Markevych et al., 2017), likely due to its multifaceted nature and varying definitions, computation, and standardisation. For example, national statistical institutions

¹ Instoration refers to processes involving the building of human capacities (e.g., encouraging physical activity and facilitating social cohesion). Instoration contrasts with processes that rely on preventing health risks (e.g., air pollution) or a previous condition of resource depletion (e.g., stress or attention) (Bonaiuto & Alves, 2024).

implement changes in their definitions and classifications of urbanicity/centrality². Hence, more research is needed to clarify urbanicity's role as a moderator in the relationships between residential nature and wellbeing (Jennings & Bamkole, 2019; Lachowycz & Jones, 2013; Markevych et al., 2017).

It is also unlikely that all types of outdoor spaces relate to wellbeing in the same way. Lachowycz and Jones (2013) suggest that greenspace type can moderate the nature–wellbeing relationship, as features such as amenities may influence the health value of nature. In previous research, different greenspace types, such as parks and forests, have shown beneficial associations with mental health individually, but comparisons between them yielded mixed results. This inconsistency may arise from interactions between varying greenspace qualities and sociodemographic factors (Beute et al., 2023; Braubach et al., 2021). As noted by Lachowycz and Jones (2013), certain associations may apply only to specific groups and greenspace types, highlighting the benefit of treating outdoor space types as distinct exposures. This approach allows for increased nuance and yields more refined knowledge.

1.4 Focus and scope of the current study

The current study aims to address gaps identified in our research review; specifically, we examined the relationships between residential nature and wellbeing with a focus on two pathways: the well-established pathway of physical activity and the potentially overlooked one of place-belongingness. These pathways were examined in the context of recreation areas and hiking areas—two types of outdoor spaces in Norway whose mental health benefits warrant exploration (Beute et al., 2023). Additionally, age, gender, income, and urbanicity were explored as potential moderators of these pathways, recognising their role in shaping individuals' interactions with residential nature (Lachowycz & Jones, 2013). By including these moderators as control variables, we aimed to uncover nuanced interactions and enhance the precision of our findings. To achieve these objectives, path analysis was used within a structural equation modelling framework to analyse two nationally representative Norwegian samples obtained in consecutive years (2020–2021, N = 35,079). In sum, based on the context provided, this research investigated multiple relationships with a focus on two research questions:

- 1) Do residential outdoor spaces relate to subjective wellbeing through physical activity and place-belongingness?
- 2) Does the strength of these pathways vary by age, gender, income, or urbanicity?

We hypothesised affirmative answers to these broad research questions and aimed to determine if, and then how, physical activity and place-belongingness mediate the subjective wellbeing benefits of residential outdoor spaces, the relative strength of these pathways, and which of these paths are moderated by the selected factors.

2. Methods

2.1 Norway as a study area

Norway is a north-western European country with approximately 5.5 million people and a total land area of 323,779 km². Approximately 84% of Norwegian residents live in urban areas (municipalities with 10,000+ inhabitants); and yet, built-up areas account for just 1.7% of the total

² The case of Statistics Norway (2020) is useful to illustrate this complexity, which previously considered urbanicity/centrality a reflection of the municipality's location and size but changed its classification in 2018. Urbanicity now integrates the municipality's functions as a regional centre as well as proximity to the regional centre, workplaces, and other services.

land area (of which 3.5% is agricultural land). Norway thus has a vast and diverse array of natural environments, of which forests predominate (37.8%) (Statistics Norway, 2024a, 2024b). Norway offers a compelling case to examine the relationships between outdoor spaces and residents' wellbeing. Norway is consistently ranked among the 10 happiest countries worldwide (Martela et al., 2020) and is well-known for its abundant and easily accessible nature and the 'right to roam'. Moreover, there is an active culture in Norway that emphasises the value of outdoor engagement as exemplified by the fact that outdoor activities were practised by 97% of the inhabitants (16+ years old) in 2021 (Statistics Norway, 2021).

2.2 Study design, participants, and procedures

Datasets from the Quality-of-Life 2020–21 surveys were utilised (Statistics Norway, 2023a, 2023b). Statistics Norway conducted two waves of digital surveys on March 9–29, 2020 and March 8–28, 2021. A nationally representative sample of 80,000 Norwegian residents aged 18+ was selected through the Norwegian population register. These residents were invited via emails, letters, and text messages to participate in the wellbeing surveys. Consent was obtained to use participant's responses and linked register data for research. Residents with higher education, those aged 45–66, and those with a Norwegian background were overrepresented (Pettersen & Støren, 2020, 2021). The used datasets (Statistics Norway, 2023a, 2023b) were obtained from the Norwegian Agency for Shared Services in Education and Research (SIKT). These contained anonymised data from 35,095 respondents (17,534 from 2020). All procedures were performed in compliance with the relevant laws and institutional guidelines and approved by the appropriate institutional committee.

2.3 Measures

2.3.1 Exposure to outdoor spaces

Two types of local public outdoor space³ were included in the national Quality-of-Life surveys during the 2019–2021 period: play and recreation areas (for simplicity, 'recreation areas') and hiking areas. The Norwegian Environment Agency (2014) defines hiking areas as being covered by vegetation, larger than 200,000 m², and found within 500 metres of residences, schools, and kindergartens. Recreation areas are smaller than hiking areas, can be managed to a greater degree, for example, by incorporating more infrastructure, and are closer to residences (within 200 metres). Figure 1 shows two areas that have been categorised based on these distinctions.

Participants in the Quality-of-Life surveys were asked to think about their place of residence and nearby environment. Exposure to local outdoor spaces was assessed using two indicators: whether there was an area that could be used for play or recreation within 200 metres of their residence and whether there were hiking areas within 500 metres of their residence (both with 'yes' or 'no' answers). To increase nuance in analyses and results, the outdoor spaces–wellbeing relationships were analysed by treating recreation and hiking areas as distinct exposures.

It has been generally proposed that the relationship between the natural environment and wellbeing is mediated by contact with nature (Hartig et al., 2014; Lachowycz & Jones, 2013). Contact with nature is not understood in a narrow sense (e.g., hiking, skiing, cycling), but more broadly as including other types of daily-life interactions with the natural environment (e.g.,

³ The current study authors refer to these spaces and areas using translated terms that closely correspond with the terms used in their original language. In international research reviews (e.g., Beute et al., 2023; Braubach et al., 2021), other equivalent terms included: urban green spaces (outdoor spaces), parks (recreation areas), and forests (hiking areas).

sensing, commuting, resting). Although proximity does not imply contact with nature, it is commonly assumed to facilitate it (Lachowycz & Jones, 2013, p. 64). Living close to nature in Norway can be considered a reasonable proxy for contact with nature. According to Statistics Norway (2021), 93% of residents (16+ years old) participated in outdoor activities in parks close to home (87% did so monthly or more frequently), and 79% participated in hikes of under three hours (64% did so monthly or more frequently). Approximately 2% of Norwegian residents did not visit such areas at all (Fongar et al., 2019).

Figure 1. *Examples of outdoor spaces: Hiking areas (above) and recreation areas (below)*



2.3.2 Physical activity

Participants were asked to think about their everyday lives and leisure time. The item ‘approximately how often do you do the following in your leisure time: exercising or being physically active so that you become breathless or sweaty’ was used to assess physical activity corresponding to brisk physical activity. This item had six response levels: daily, weekly but not daily, monthly but not weekly, a few times a year, more rarely, and never.

2.3.3 Place-belongingness

In the same block of questions concerning the residential area and nearby environment, the survey respondents reported the extent to which they feel that they belong in the place where they live. This was marked on a Likert scale where 0 = ‘no belongingness’ and 10 = ‘strong belongingness’.

2.3.4 Subjective wellbeing

Subjective wellbeing was measured using a set of recommended wellbeing measures for national public health surveys in Norway (Nes et al., 2018). The measures represented three dimensions of wellbeing: affective, cognitive, and eudaimonic. In the current study, the affective dimension was assessed with a measure of affect balance, integrating information on the degree to which the respondent had experienced positive (happy, engaged/interested, and relaxed, Chronbach’s alpha = .78) and negative (worried, sad, irritated, lonely, anxious, and stressed, Chronbach’s alpha = .87) emotions in the previous week scored on a –10 to +10-point Likert scale. The cognitive dimension was assessed using the average score on the Satisfaction with Life Scale (Diener et al., 1985) comprising five items on a 1–7-point Likert scale (Chronbach’s alpha = .90). To assess the eudaimonic dimension, two averaged items concerning meaning in life were used. One was the Organisation for Economic Cooperation and Development’s (OECD) question on experiencing life as meaningful (OECD, 2013), and the second was Erik Nord’s question on experiencing life as rich (Nes et al., 2018). Those two items together indicate the degree to which life is perceived as meaningful, substantial, and rewarding on a 0–10-point Likert scale and showed acceptable reliability (Spearman–Brown estimate = .87). For all the scales, higher scores indicate greater subjective wellbeing. A similar overall subjective wellbeing measure including only three items (general happiness, satisfaction with life, and sense of meaningfulness in life) was validated by Vederhus et al. (2021).

2.3.5 Control variables

Control variables included the year of the survey (2020 or 2021), immigration background (from the national register: Norwegian background, second- and first-generation immigrants), legal gender (i.e., sex, from the national register: male or female), sexual orientation (heterosexual or non-heterosexual), age (from the national register: in years, continuous), education level (from the national register: secondary education, below, and over), the national standard for the urbanicity of the municipality (from the national register: six levels, from the highest to lowest centrality), income (from the national register: household income in quartiles), and whether the respondent was employed, lived with a spouse or partner, and owned their own house.

2.4 Statistical analyses

SPSS for Windows (Version 29.0) was used to prepare the data, which involved screening datasets for monotonic response patterns (removing 16 cases), outliers, and distribution

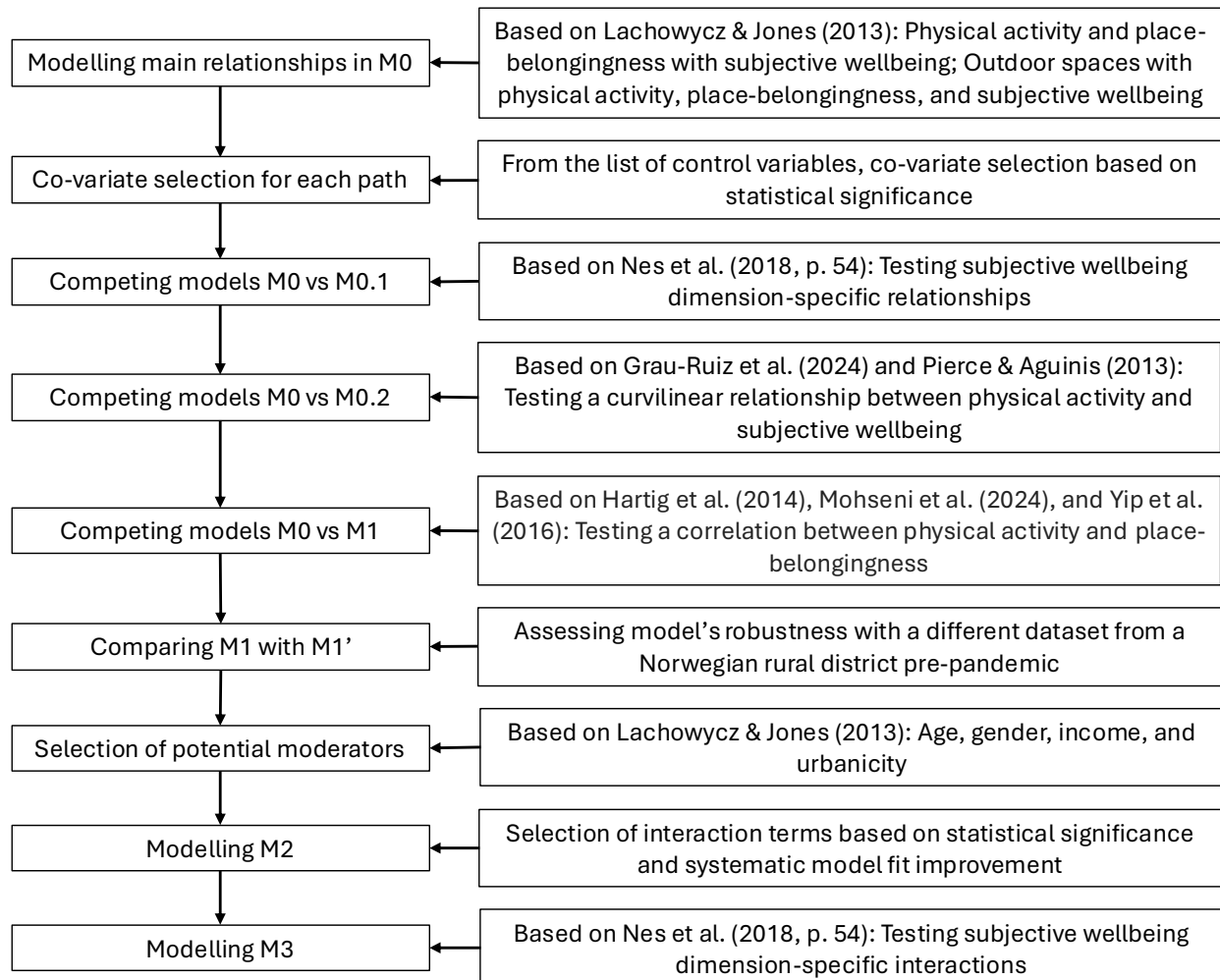
normality; recoding and computing study variables; and pooling the datasets. Missing data were low, being highest for education level (2.5%). Missing data for education level correlated with immigration background (.38, $p > .001$) and were considered missing at random (MAR). Missing data were treated with listwise deletion. Preliminary linear regression analyses ($p \leq .05$) assisted in selecting control variables for each relationship. Analyses were conducted using R version 4.3.2 (R Core Team, 2023) and the *lavaan* package. Path models were specified on the basis of a theory-driven initial model, and several alternative specifications were evaluated. Model selection followed established SEM practice and relied on multiple fit indices, including χ^2 (and its associated p -value), CFI, TLI, RMSEA, SRMR, and BIC. All variables were standardized to facilitate the interpretation and comparability of parameter estimates. Because some variables exhibited deviations from multivariate normality, parameter estimation was performed using Maximum Likelihood with robust standard errors (MLR), which provides consistent estimates and adjusted fit statistics under non-normality.

In line with the theoretical framework of Lachowycz and Jones (2013), the initial model included paths from physical activity and place-belongingness towards subjective wellbeing and from both types of outdoor space towards physical activity, place-belongingness, and subjective wellbeing. These paths were simultaneously controlled by the control variables identified in the previous analysis stage with linear regression, whereas age, gender, income, and urbanicity were always included. Some preliminary considerations when specifying the initial model included modelling subjective wellbeing either as an averaged score or, based on Nes et al. (2018, p. 54), as three separate dimensions (affective, cognitive, and eudaimonic); testing for a quadratic effect in the path from physical activity towards subjective wellbeing (Grau-Ruiz et al., 2024, Pierce & Aguinis, 2013); and testing a correlation between physical activity and place-belongingness (Hartig et al., 2014; Mohseni et al., 2024; Yip et al., 2016). Model 1 (M1) provided the best fit and greater parsimony by using subjective wellbeing as an averaged outcome, modelling the physical activity variable continuously and linearly, and incorporating a correlation between physical activity and place-belongingness. Next, interactions with age, gender, income, and urbanicity were tested in every path (presented in the appendix). Ultimately a second model (M2) was created that included all the interaction terms that had individually led to improved model fit.

As some identified interactions concerned paths towards subjective wellbeing, a last model (M3) was created to examine whether the interactions were sensitive to the specific subjective wellbeing dimension (Nes et al., 2018, p. 54). Reliably estimating M3 (our most complex model) required a sample of 1,280 observations (Gelman, 2018); hence, the sample size was sufficient. Indirect and total effects of outdoor spaces on subjective wellbeing were estimated following SEM standard mediation procedures (Dzhambov et al., 2020). To obtain robust inferences for the indirect pathways, 95% confidence intervals were computed using nonparametric bootstrapping with 5,000 resamples, yielding percentile-based confidence bounds. To assess the model's robustness, a similar model to M1 was tested with additional data ($N = 2,124$) from Statistics Norway (2022), focusing on a specific rural Norwegian district called Hallingdal in 2019 (i.e., pre-pandemic). This follow-up model (M1') is presented in the appendix. A flowchart summarising the analyses is provided in Figure 2. Upon completing the statistical analyses, additional model diagnostics were performed. Inspection of the correlation matrix and Variance Inflation Factors (VIF) indicated no evidence of multicollinearity; all intercorrelations were modest and all VIF values were well below commonly used thresholds. Standardized residuals and modification indices were examined to evaluate potential areas of model misfit beyond the global fit statistics. The largest standardized residuals were modest (approximately -2.5), indicating no substantial discrepancies between the observed and model-implied covariance structure. Likewise, no

modification indices exceeded 10, suggesting that no theoretically meaningful or statistically warranted adjustments to the model were indicated.

Figure 2. Flowchart of the analysis



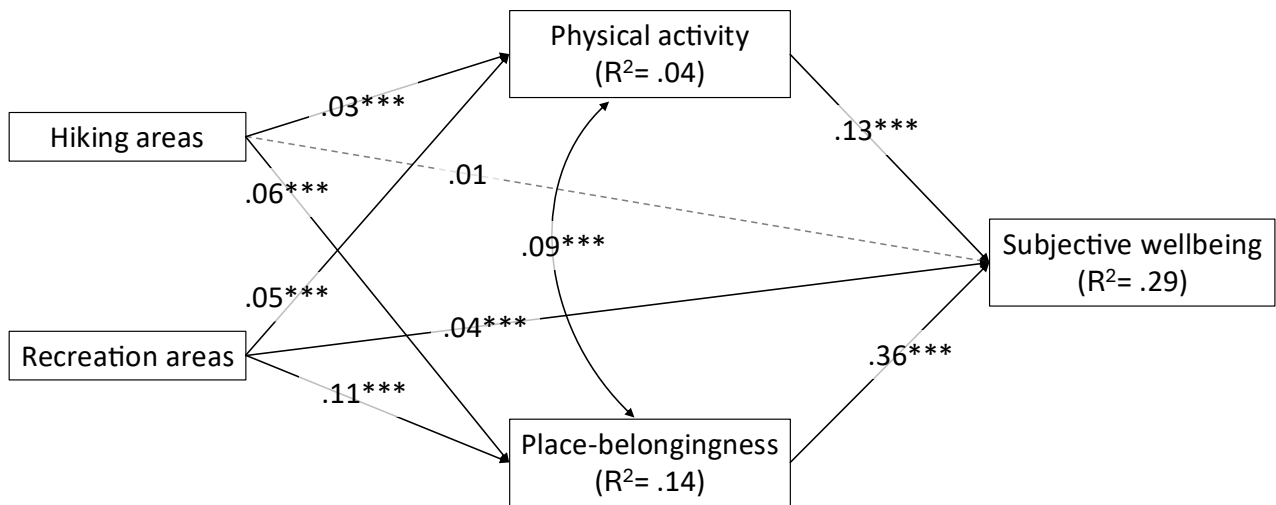
3. Results

Table 1 displays sample characteristics. Figure 3 shows a visual representation of the main study models. The structural models revealed significant relationships between residential hiking and recreation areas, physical activity, place-belongingness, and subjective wellbeing. Residential hiking and recreation areas were positively associated with physical activity and place-belongingness; in turn, these were positively related to subjective wellbeing, with a much stronger association for place-belongingness. For hiking areas, the mediation was complete (Warner, 2013, pp. 648–649), because in these controlled models, when accounting for all the other specified relationships, there was no significant direct path from hiking areas to subjective wellbeing. The paths in M1 differed slightly when tested on the alternative dataset obtained from rural Norway pre-pandemic (Statistics Norway, 2022): for recreation areas, the mediation was also complete, and the correlation between physical activity and place-belongingness was not significant.

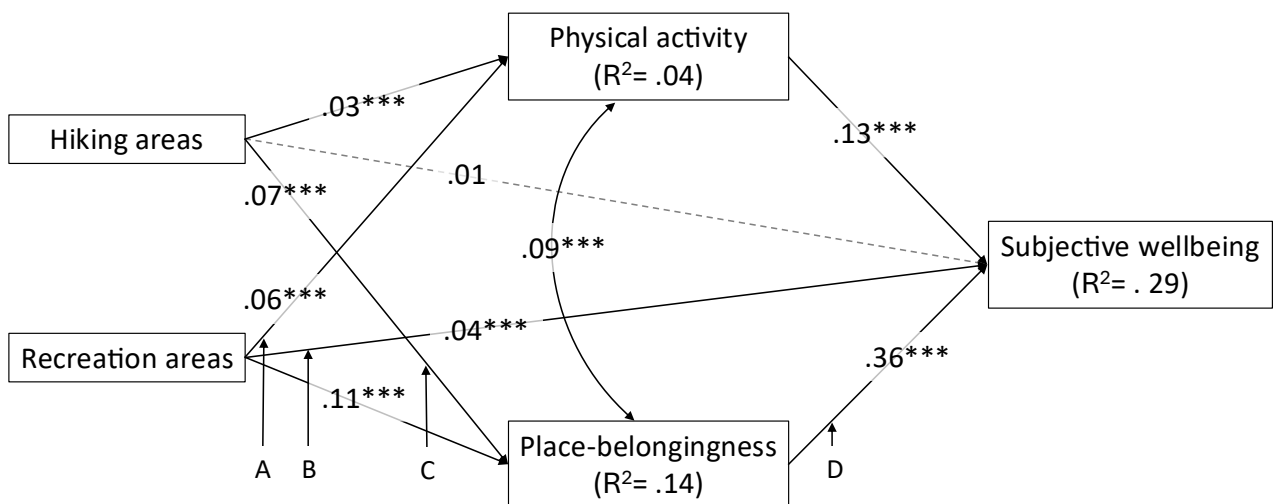
Table 1. *Characteristics of the study samples (quality-of-life 2020–21)*

Variable	Median [IQR] or <i>n</i> (Valid %)
Survey respondents in 2020	17530 (49.97)
Immigration background	
Norwegian background	30618 (87.28)
Second-generation immigrants	321 (.92)
First-generation immigrants	4140 (11.80)
Females	18116 (51.64)
Non-heterosexual	1978 (5.67)
Age	49 [34, 62]
Education level	
Below high school	5356 (15.66)
High school	12344 (36.08)
More than high school	16510 (48.26)
Employed	24901 (71)
Homeowner	28735 (82.05)
Household income	
Lowest income quartile	6522 (18.59)
Second income quartile	7532 (21.47)
Third income quartile	9608 (27.39)
Highest income quartile	11417 (32.55)
Living with a spouse or partner	24181 (69)
Urbanicity ^a	
Level 1 (municipalities with the highest centrality)	7202 (20.53)
Level 2	9236 (26.33)
Level 3	8818 (25.14)
Level 4	5431 (15.48)
Level 5	2989 (8.52)
Level 6 (municipalities with the lowest centrality)	1403 (4)
Outdoor spaces	
Having recreation areas within 200 m	31288 (89.37)
Having hiking areas within 500 m	31011 (88.53)
Physical activity (1 to 6)	
1. Never	1465 (4.19)
2. More rarely	2578 (7.37)
3. A few times a year	2881 (8.24)
4. Monthly	5365 (15.34)
5. Weekly	18333 (52.42)
6. Daily	4351 (12.44)
Place-belongingness (0 to 10)	8 [6, 10]
Affect balance (–10 to +10)	4 [1, 6]
Satisfaction with life (1 to 7)	5.40 [4.40, 6]
Meaning in life (0 to 10)	7.50 [6, 8.50]

^a The urbanicity variable can be interpreted with: <https://www.ssb.no/klass/klassifikasjoner/128>.

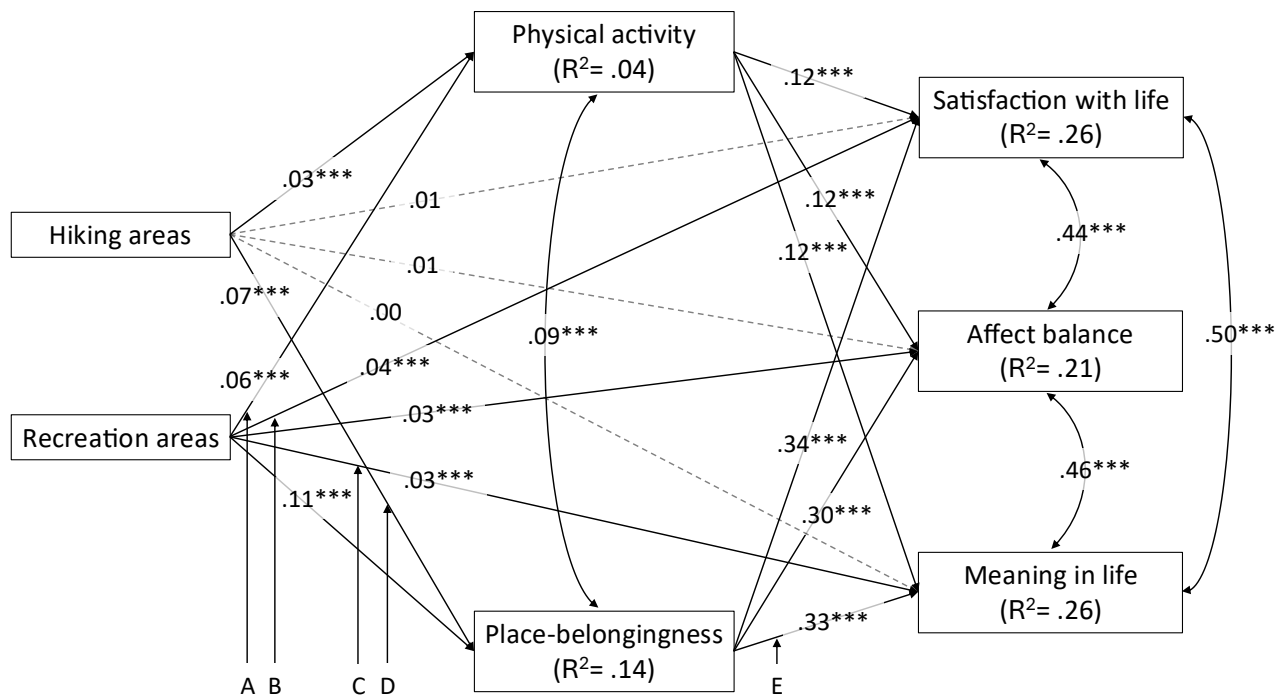
Figure 3. Pictorial representation of study models


Model 1 Fit: $\chi^2[5]=13.05$, $p=.02$, CFI=1, TLI=1, RMSEA[90% CI]=.01[.00, .01], SRMR=.00, BIC=267454.43



Interactions: ↑ Age: A=.02***; Females: B=-.01**; ↓ Urbanicity: C=.03*** & D=.01*

Model 2 Fit: $\chi^2[13]=16.25$, $p=.24$, CFI=1, TLI=1, RMSEA[90% CI]=.00[.00, .01], SRMR=.00, BIC=267439.56



Interactions: ↑ Age: A = .02***; Females: B = -.01** & C = -.02**; ↓ Urbanicity: D = .03*** & E = .02**

Model3 Fit: $\chi^2[19]=142.59$, $p=.00$, CFI=1, TIL=.99, RMSEA[90%CI]=.01[.01, .02], SRMR=.00, BIC=403683.08

Note. Path coefficients were estimated using cross-sectional data. Arrows represent relationships, not causality. Standardised coefficients are reported. * $p \leq 0.05$. ** $p \leq 0.01$. *** $p \leq 0.001$.

Several models including interaction terms in isolation gave a better fit than M1, and when combined in our M2, a good fit for all fit indices was achieved (M1: $\chi^2 p = .02$, CFI = 1, TLI = 1, RMSEA [90% CI] = .01 [.00, .01], SRMR = .00, BIC = 267454.43; M2: $\chi^2 p = .32$, CFI = 1, TLI = 1, RMSEA [90% CI] = .00 [.00, .01], SRMR = .00, BIC = 267439.56). Findings indicated that recreation areas have a stronger relation with physical activity among older residents. Additionally, the direct relationship between recreation areas and subjective wellbeing was weaker for females. Results also indicated that, in more rural communities, hiking areas had a stronger relationship with place-belongingness, and the association between place-belongingness and subjective wellbeing was also stronger. Given that the relationships between subjective wellbeing and recreation areas and place-belongingness differed across gender and urbanicity, these differences were tested according to specific subjective wellbeing measures in our M3. These follow-up analyses revealed that the interaction of gender with recreation areas concerned only satisfaction with life and meaning in life, whereas the interaction of urbanicity with place-belongingness only concerned meaning in life. However, M3 did not fit the data better than M2 (M3: $\chi^2 p < .00$, CFI = 1, TLI = .99, RMSEA [90% CI] = .01 [.01, .02], SRMR = .00, BIC = 403683.08). Figure 4 presents line plots to graphically represent these tri-variate relationships. Table 2 shows the direct, indirect, and total effects of these outdoor space types. Table 3 presents the correlation matrix.

Figure 3. Plots for the significant interactions in Model 3

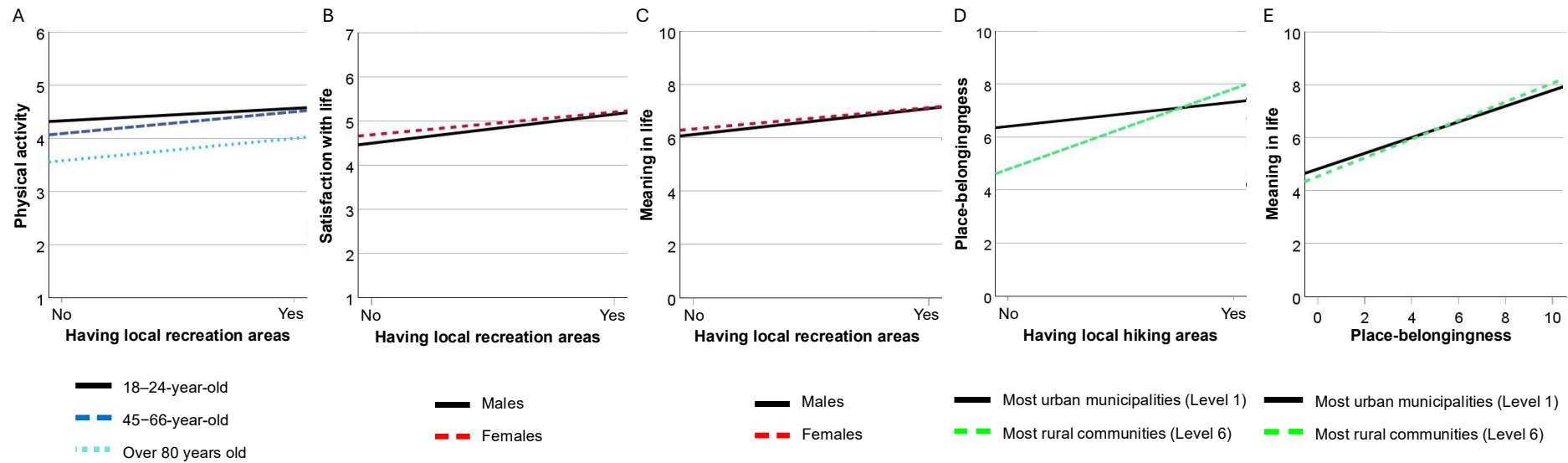


Table 2. Direct, indirect, and total effects of outdoor spaces on subjective wellbeing

	Hiking areas			Recreation areas			Outdoor spaces		
	Estimate	p- value	95% CI	Estimate	p- value	95% CI	Estimate	p- value	95% CI
Indirect via physical activity	.00	≤0.001	(.00, .01)	.01	≤0.001	(.01, .01)	.01	≤0.001	(.01, .01)
Indirect via place-belongingness	.03	≤0.001	(.02, .03)	.04	≤0.001	(.04, .04)	.07	≤0.001	(.06, .07)
Total indirect	.03	≤0.001	(.02, .04)	.05	≤0.001	(.04, .05)	.08	≤0.001	(.07, .08)
Direct	.01	.24	(-.00, .02)	.04	≤0.001	(.03, .05)	.04	≤0.001	(.03, .06)
Total effect	.04	≤0.001	(.02, .05)	.09	≤0.001	(.07, .10)	.12	≤0.001	(.11, .14)

Note. The coefficients are obtained from Model 2.

Table 3. Correlation matrix of study variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1 Satisfaction with life (<i>p</i> -value)																				
2 Affect balance (<i>p</i> -value)	.65 (<i><.001</i>)																			
3 Meaning in life (<i>p</i> -value)	.75 (<i><.001</i>)	.68 (<i><.001</i>)																		
4 Subjective wellbeing (<i>p</i> -value)	.90 (<i><.001</i>)	.87 (<i><.001</i>)	.91 (<i><.001</i>)																	
5 Hiking areas (<i>p</i> -value)	.08 (<i><.001</i>)	.09 (<i><.001</i>)	.09 (<i><.001</i>)	.10 (<i><.001</i>)																
6 Recreation areas (<i>p</i> -value)	.14 (<i><.001</i>)	.12 (<i><.001</i>)	.13 (<i><.001</i>)	.15 (<i><.001</i>)	.19 (<i><.001</i>)															
7 Physical activity (<i>p</i> -value)	.19 (<i><.001</i>)	.17 (<i><.001</i>)	.18 (<i><.001</i>)	.20 (<i><.001</i>)	.04 (<i><.001</i>)	.08 (<i><.001</i>)														
8 Place-belongingness (<i>p</i> -value)	.39 (<i><.001</i>)	.37 (<i><.001</i>)	.40 (<i><.001</i>)	.43 (<i><.001</i>)	.15 (<i><.001</i>)	.16 (<i><.001</i>)	.11 (<i><.001</i>)													
9 Age (<i>p</i> -value)	.12 (<i><.001</i>)	.23 (<i><.001</i>)	.18 (<i><.001</i>)	.20 (<i><.001</i>)	.14 (<i><.001</i>)	.08 (<i><.001</i>)	-.00 (.46)	.25 (<i><.001</i>)												
10 Gender (<i>p</i> -value)	.03 (<i><.001</i>)	-.08 (<i><.001</i>)	.02 (<i><.001</i>)	-.01 (.01)	.02 (<i><.001</i>)	.03 (<i><.001</i>)	-.00 (.60)	.04 (<i><.001</i>)	-.07 (<i><.001</i>)											
11 Income (<i>p</i> -value)	.23 (<i><.001</i>)	.18 (<i><.001</i>)	.20 (<i><.001</i>)	.23 (<i><.001</i>)	.07 (<i><.001</i>)	.10 (<i><.001</i>)	.13 (<i><.001</i>)	.15 (<i><.001</i>)	.18 (<i><.001</i>)	-.06 (<i><.001</i>)										
12 Education level (<i>p</i> -value)	.17 (<i><.001</i>)	.09 (<i><.001</i>)	.15 (<i><.001</i>)	.15 (<i><.001</i>)	-.02 (<i><.001</i>)	.11 (<i><.001</i>)	.13 (<i><.001</i>)	-.01 (.02)	.05 (<i><.001</i>)	.06 (<i><.001</i>)	.21 (<i><.001</i>)									
13 Immigration background (<i>p</i> -value)	-.05 (<i><.001</i>)	-.07 (<i><.001</i>)	-.00 (.47)	-.05 (<i><.001</i>)	-.08 (<i><.001</i>)	-.07 (<i><.001</i>)	-.09 (<i><.001</i>)	-.12 (<i><.001</i>)	-.09 (<i><.001</i>)	.01 (.21)	-.13 (<i><.001</i>)	.02 (<i><.001</i>)								
14 Sexual orientation (<i>p</i> -value)	-.09 (<i><.001</i>)	-.11 (<i><.001</i>)	-.09 (<i><.001</i>)	-.11 (<i><.001</i>)	-.06 (<i><.001</i>)	-.07 (<i><.001</i>)	-.06 (<i><.001</i>)	-.08 (<i><.001</i>)	-.12 (<i><.001</i>)	.03 (<i><.001</i>)	-.11 (<i><.001</i>)	-.09 (<i><.001</i>)	.11 (<i><.001</i>)							
15 Having a partner (<i>p</i> -value)	.27 (<i><.001</i>)	.18 (<i><.001</i>)	.24 (<i><.001</i>)	.26 (<i><.001</i>)	.08 (<i><.001</i>)	.08 (<i><.001</i>)	.04 (<i><.001</i>)	.13 (<i><.001</i>)	.22 (<i><.001</i>)	-.04 (<i><.001</i>)	.29 (<i><.001</i>)	.16 (<i><.001</i>)	.02 (<i><.001</i>)	-.08 (<i><.001</i>)						
16 Employment status (<i>p</i> -value)	.12 (<i><.001</i>)	.04 (<i><.001</i>)	.13 (<i><.001</i>)	.11 (<i><.001</i>)	.00 (.52)	.05 (<i><.001</i>)	.05 (<i><.001</i>)	-.03 (<i><.001</i>)	-.36 (<i><.001</i>)	-.04 (<i><.001</i>)	.21 (<i><.001</i>)	.19 (<i><.001</i>)	.03 (<i><.001</i>)	-.04 (<i><.001</i>)	.09 (<i><.001</i>)					
17 Owning residence (<i>p</i> -value)	.22 (<i><.001</i>)	.18 (<i><.001</i>)	.19 (<i><.001</i>)	.22 (<i><.001</i>)	.15 (<i><.001</i>)	.15 (<i><.001</i>)	.07 (<i><.001</i>)	.26 (<i><.001</i>)	.31 (<i><.001</i>)	-.00 (.62)	.33 (<i><.001</i>)	.15 (<i><.001</i>)	-.13 (<i><.001</i>)	-.11 (<i><.001</i>)	.29 (<i><.001</i>)	.05 (<i><.001</i>)				
18 Urbanicity (<i>p</i> -value)	-.00 (.71)	.04 (<i><.001</i>)	.04 (<i><.001</i>)	.03 (<i><.001</i>)	.15 (<i><.001</i>)	-.05 (<i><.001</i>)	-.01 (.23)	.08 (<i><.001</i>)	.07 (<i><.001</i>)	-.02 (<i><.001</i>)	-.05 (<i><.001</i>)	-.14 (<i><.001</i>)	-.11 (<i><.001</i>)	-.03 (<i><.001</i>)	.03 (<i><.001</i>)	-.04 (<i><.001</i>)	.02 (<i><.001</i>)			
19 Survey year (<i>p</i> -value)	-.05 (<i><.001</i>)	-.03 (<i><.001</i>)	-.09 (<i><.001</i>)	-.06 (<i><.001</i>)	.02 (<i><.001</i>)	.01 (.09)	-.00 (.94)	-.01 (.08)	.02 (<i><.001</i>)	.01 (.30)	.00 (.36)	.03 (<i><.001</i>)	.01 (.04)	.01 (.33)	.00 (.41)	.02 (<i><.001</i>)	-.00 (.93)	-.01 (.01)		
Descriptive statistics																				
Mean	5.12	3.56	7.02	.00	.89	.9	4.43	7.43	48.78	.52	2.78	2.33	.2	.05	.69	.71	.83	2.78	.5	
Standard deviation	1.30	3.69	2.04	.89	.31	.3	1.25	2.54	17.04	.5	1.09	.73	.59	.23	.46	.45	.37	1.37	.5	

4. Discussion

In the current study we investigated the roles of physical activity and place-belongingness as pathways in the association between residential nature and subjective wellbeing. We also explored whether the strength of these relations differed across age, gender, income, and the urbanicity of the municipalities. Overall, results of our path analysis showed that hiking and recreation areas were related to higher physical activity and place-belongingness, which, in turn, were related to higher subjective wellbeing. Some associations varied across age, gender, and urbanicity. These findings mostly confirmed our hypotheses and support previous theoretical understandings indicating that the nearby natural environment relates to higher wellbeing in complex ways (Lachowycz & Jones, 2013; Markevych et al., 2017).

4.1 Indirect relationships between outdoor spaces and subjective wellbeing through physical activity and place-belongingness

Results indicated that residential hiking and recreation areas were associated with subjective wellbeing through physical activity and place-belongingness. Recreation areas showed stronger relationships with physical activity, place-belongingness, and subjective wellbeing than hiking areas. This may be accounted for particularly beneficial qualities of recreation (vs hiking) areas, such as shorter perceived distance from home and better perceived quality (i.e., excellence of space), factors which have been noted as key in greenspace visits (Fongar et al., 2019). Place-belongingness emerged in the current study as a stronger mediator of the relationship between outdoor spaces and wellbeing than did physical activity. This was to some degree expectable, as previous research suggested that belongingness is a stronger predictor of wellbeing than other covariates (King & Hicks, 2021). In de Vries et al. (2013), social cohesion similarly emerged as a more robust pathway to mental health compared to physical activity. Given that, among five nature-related factors, nature connectedness has emerged as a leading factor predicting wellbeing (Richardson et al., 2021), it is likely that nature connectedness underlies the place-belongingness pathway between outdoor spaces and wellbeing which emerged in our study.

Results also indicated that hiking areas were related to higher subjective wellbeing only indirectly, through physical activity and place-belongingness (i.e., full mediation). Recreation areas showed the same indirect links, but recreation areas also had a direct relationship with subjective wellbeing (i.e., partial mediation). The finding that hiking areas only had an indirect effect differs from Grau-Ruiz et al.'s (2024) results on the relationships between hiking areas, physical activity, and multiple measures of subjective wellbeing. It is possible that most of the direct relationship between hiking areas and subjective wellbeing is explained by their link to place-belongingness, as seen in Grau-Ruiz and Løvoll (2024).

The finding indicating that hiking areas' relationship with wellbeing was completely mediated through physical activity and place-belongingness is of particular importance in explaining how hiking areas promote residents' wellbeing. Conversely, the finding of an additional direct relation between recreation areas and subjective wellbeing implies that this wellbeing benefit also occurred through processes that were not specified in our analysis. For recreation areas, unmodelled pathways linking nature and subjective wellbeing, such as increased mindfulness, resilience, and lowered rumination (Dzhambov et al., 2019), could underlie the direct relation that emerged in the current study. Although not tested in the current study, it is also possible that longer chains of relationships contributed to subjective wellbeing. For example, physical activity and place-belongingness could be linked with subjective wellbeing through increased resilience, as proposed by the biopsychosocial resilience theory (White et al., 2023).

On a final note, our analysis revealed that specifying a correlation between physical activity and place-belongingness improved the model fit. Although small, this correlation aligns with previous evidence showing associations between an individual's sense of belonging to their community and physical activity (Yip et al., 2016). This suggests that these pathways are intertwined and may contribute to wellbeing through interconnected processes in serial mediation (Dzhambov et al., 2020). However, the direction of causality remains unclear, and the possibility of feedback loops should be considered.

4.2 Pathway differences across age, gender, income, and urbanicity

The strength of some relationships varied across age, gender, and urbanicity. Older males in more rural areas appeared to experience stronger subjective wellbeing benefits from the pathways linking outdoor spaces with subjective wellbeing through physical activity and place-belongingness. No study path varied across income levels.

The finding indicating that the positive relationship between recreation areas and physical activity was stronger for older residents aligns with Dalton et al. (2016), who found that greenspace in residential neighbourhoods can protect against a decline in physical activity as people age. The absence of a similar finding for hiking areas matches with the expectations behind some of Norway's environmental and public health goals, as the criteria of a 200-meter buffer for recreation areas is justified in that some subpopulations, like elders, have an average action radius of just 300 metres (Environment Norway, 2023a, 2023b; The Norwegian Directorate of Health, 2021).

Results did not provide evidence for interactions involving the household income in any of the studied paths. The absence of this finding contrasts with studies showing that the benefits of greenspace for health are stronger for residents of lower socioeconomic status and deprived neighbourhoods (WHO, 2016). It could be that no statistically significant interaction emerged in the current study because measuring residential nature visits, and not mere exposure, is needed to find equigenic effects, as Fian et al. (2024) suggests.

The direct relationship between recreation areas and subjective wellbeing was stronger for men than women. Although evidence of this effect is mixed (Markevych et al., 2017), and males in Norway participate slightly more in outdoor recreation than females (97.7% vs. 96.4%), this finding was surprising because females are more active in walking in parks and nearby natural areas (93.6% vs. 91.4%) (Statistics Norway, 2021). One possible explanation is that sports facilities in recreation areas may be designed to appeal more to males. For example, in 2021, males were almost three times more likely than females to play football, ice hockey, or golf, almost twice as likely to play basketball, and one and a half times more likely to play tennis (Statistics Norway, 2021). Nonetheless, no legal gender differences emerged in the physical activity pathway. Interestingly, the legal gender differences concerned only satisfaction with life and meaning in life but not affect balance (M3). Affect balance is a more immediately sensitive measure to the short-term emotional state. In contrast, satisfaction with life and meaning in life are measures bounded to life evaluations and reflections. Perhaps the processes leading to shorter-term affective benefits (e.g., stress reductions) are gender-equal because the spontaneous and unfiltered affective response to nature is evolutionarily universal – as proposed by the Stress Reduction Theory (Ulrich, 2023) –. In contrast, those forms of wellbeing that involve reflections are more tied to one's culture and society, thus facilitating gender differences.

Urbanicity showed the strongest interaction in this study with a stronger relationship between hiking areas and place-belonging for residents in more rural areas. Evidence that urbanicity is an effect modifier in greenspace–health contexts is limited and inconsistent

(Markevysh et al., 2017). Our findings contradict previous findings, such as Liu et al. (2019) who found stronger greenness–social cohesion links in urban China. Differences in social cohesion versus place-belongingness, undefined greenness measures versus specific outdoor spaces, and how urbanicity is defined might explain these differences. Nonetheless, our findings are reasonable: in rural areas, hiking spaces may offer superior qualities (e.g., greater size, biodiversity, and proximity to residences). Moreover, in less central communities, there is also 8% higher participation in hiking (Statistics Norway, 2021); thus, hiking could be more integral to rural identity. Our finding is noteworthy, as one might assume that rural residents, who are generally more exposed to nature, would not show a stronger connection to hiking areas. This highlights the value of also exploring what hiking areas mean for rural vs. urban residents qualitatively.

Lastly, place-belongingness showed a stronger relationship with subjective wellbeing for rural than urban residents. This interaction concerned only meaning in life, and not satisfaction with life nor affect balance (M3). The reason for this is unclear. Previous research suggests that concepts related to place-belongingness might encompass different aspects depending on urbanicity. For instance, Belanche et al. (2021) analysed place identity as cognitive, affective, and evaluative components (self-categorisation, emotional attachment, and feelings of worth) and found that the latter two were stronger in rural areas. Riethmuller et al. (2021) noted that place attachment in rural areas relates more to home, belonging, and community, whereas in urban areas, it is linked to practical factors such as jobs and relationships. Additionally, social cohesion studies distinguish between individual and collective levels (Yip et al., 2016). Perhaps feeling individual belonging in a place with strong collective belonging has a different, potentially greater, impact on wellbeing. Concerning the specific characteristics of meaning in life, it might be that rural places do better at stimulating a sense of place-belongingness that connects strongly to existential aspects of the good life. This might happen, for example through the cultivation of traditions, stories, and a collective identity that is more readily tethered to the place and oftentimes its nature. For example, surnames in Norway often⁴ link residents with a place, typically a farmstead and its nature (e.g., strand, coast, island, forest, mountain, etc.). At marriage or when moving, Norwegians can change their surname, with those signalling old traditions and nature being preferred. Natural or farm names are thought to highlight unique aspects of identity and stimulate conversation (Amundsen, 2018). Hence, through such practices, belonging to rural places could provide anchors in life to something larger and longer lasting than the individual, thus acting as richer resources for meaning in life.

4.3 Strengths and limitations

The major strengths of this study are its large sample size (N =35,079) and thus statistical power, combined with the sample being highly representative for the Norwegian national territory, and that the analysed data was a combination of survey data with register data. Another strength is that analyses distinguished among several subjective wellbeing measures, while controlling for additional demographic and socioeconomic status variables and moderators, thereby increasing coefficient precision.

As with all studies, the current study also had limitations. The study was cross-sectional, which does not allow for causality. Several key measures, such as proxies for outdoor space exposure and physical activity, were assessed by subjective measures, which can differ substantially from objective measures (e.g., NDVI, accelerometry). Ideally, subjective and

⁴ About 2/3 of Norwegians, possibly a record in Europe (Amundsen, 2018).

objective measures should have been complemented. Nonetheless, surveys remain the most viable option for large cohorts (Markevych et al., 2017; Silva et al., 2018). Moreover, the perceived qualities of greenspaces are particularly useful for assessing instorative benefits (Wang et al., 2021). For example in Zhang et al. (2025), the physical activity pathway was only statistically significant for their subjective measure of exposure to residential nature (perceived residential greenspace quantity), and not for the objective measure (NDVI). In the current study, the buffer radii in the two items assessing outdoor space proximity were different, limiting their comparison, although most residents are likely to live closer to recreation than hiking areas. The outdoor space types analysed in the current study could not discern between additional natural elements of potential relevance for wellbeing promotion, such as bodies of water in liquid or solid state and rock/mineral dominated environments (Li et al., 2023). Importantly, outdoor space visits were not measured in these surveys. A likely consequence of this limitation was the lack of statistically significant findings for the moderation effect of residents' income (Fian et al., 2024). Measuring and analysing resident's connectedness to nature would have also been informative due to its close relationships with nature, belongingness, and wellbeing. Some measures in the current study were reductionist. Place-belongingness has multiple conceptualizations (Allen et al., 2021). For example some scholars consider loneliness to be at the opposite pole but on the same axis as belongingness, while other scholars recognise a dual continuum (Lim et al., 2021). Barstad et al. (2023) considered belongingness an expression of wellbeing, while others, such as Kitchen et al. (2015), considered it a precursor of wellbeing. Moreover, many other concepts such as place bonding, sense of rootedness, place attachment, sense of place, and place identity are tightly linked (Antonsich, 2010; de Vries et al., 2013; Hammitt et al., 2006; Raman, 2014). Hence, measuring place-belongingness in the current study with a single item was reductionist, though this is common, and no gold standard exists for assessing this multifaceted concept (Allen et al., 2021). Analysing legal gender was also reductionist. However, for our 2020 data, a comparison between legal gender and gender identity found a match for about 99% of the participants (Dalen et al., 2021). Moreover, some factors known to associate to differences in the current study pathways, such as the COVID pandemic (Grau-Ruiz et al., 2024) and immigration background (Grau-Ruiz & Løvoll, 2024), were not modelled. This was a conscious decision aimed at balancing analytical complexity with exploring new key moderators. Last, the study models revealed close to perfect fit for indices like CFI and TLI. Although good model fit is generally desirable, an overly good fit to the data can imply that the models would generalise poorly to other samples. While an effort was made to replicate Model 1 with a different sample (Model 1'), it would be advised to test the model in other contexts.

4.4 Implications, and future research

Findings from the current study have several implications. Within the environment–wellbeing context, the place-belongingness pathway has seemingly received little research attention. Residential nature appeared to benefit wellbeing mainly through place-belongingness, with this pathway being about seven times stronger than physical activity in our final model. Compared to similar research conducted in Dutch cities (de Vries et al., 2013), the relative contributions of these pathways followed the same trend (30% for social cohesion vs. 58% for place-belongingness and less than 10% for green exercise vs. 8% for physical activity), suggesting some degree of international correspondence. At the same time, these results do not diminish the role of physical activity in addressing specific public health concerns, such as reducing physical inactivity. In these contexts, physical activity may be more effective or relevant. However, loneliness, which is often linked to a lack of belongingness (Allen et al., 2021), is increasing and has been recognised

as an epidemic with severe consequences for individual health. Its impact on mortality surpasses that of obesity, physical inactivity, and smoking, affecting both mental and societal health (Office of the Surgeon General [OSG], 2023). Therefore, similar investments in science, the media, and public health policy as those made to address physical inactivity are needed to tackle the loneliness crisis. As place-belongingness was a much stronger pathway to wellbeing than being physically active, nature-based therapists aiming at promoting wellbeing can consider decreasing intervention focus on doing physical outdoor activities (e.g., hiking, paddling, etc.) and instead increase intervention focus on other facets of being in the outdoor experience that facilitate building place-belongingness. Outdoor therapists can work with multiple factors and ways identified by research to more effectively promote place-belongingness among participants, including emphasising the value of local connections with social groups (e.g., family, ancestors) and nature (e.g., trees, animals, objects, and phenomena), as well as facilitating participants' engagement with transgenerational local memories and traditions while creating their personal memories (Mohseni et al., 2024). Given that the physical activity and place-belongingness pathways may be intertwined, targeting both goals in a unified strategy could offer valuable benefits. This is noteworthy, as some scholars suggest that social cohesion interventions aimed at increasing physical activity may be more cost-effective from a policy perspective (Yip et al., 2016).

Recognising the salient role that nature near residential areas plays in fostering mental health through place-belongingness can benefit societal welfare beyond promoting individual wellbeing. The Norwegian Institute of Bioeconomy Research (NIBIO) refers to social-ecological innovations as new ways to balance social and ecological needs (NIBIO, 2025). The current study findings directly endorse social-ecological innovations aimed at benefiting both social needs (e.g., social inclusion, public health) and ecological needs (e.g., habitat creation or maintenance), as both could be targeted through ensuring residential greenspaces. The current study findings highlighted recreation areas like parks as residential nature designs with greater potential for promoting place-belongingness and subjective wellbeing. The marked emergence of the place-belongingness pathway between outdoor spaces and subjective wellbeing is also noteworthy with respect to the mental separation of humans from nature. This mental separation is seen as a philosophical root of the current ecological crisis (Richardson, 2023). The place-belongingness pathway invites us to challenge a dualist mindset and recognise that thriving humans belong with nature. As place-belongingness is intimately bound to the universal human need for belongingness, there should be an emphasis on securing close access to outdoor spaces for everyone. Moreover, natural areas are rapidly disappearing both in Norway and globally. The tendencies and projections towards 2030 indicate that forests are the type of area at greatest risk of being built over, with more rural areas in Norway being at greater risk than more urban ones (Rørholt & Steinnes, 2020). Given that in rural Norway, hiking areas/forests and place-belongingness are especially strong promoters of wellbeing, it is of paramount importance to be aware of the particularly negative consequences for wellbeing that may follow from losing these natural spaces.

Future research should address unanswered questions, including how specific design aspects of residential nature, physical activity intensities and types (e.g., green exercise) contribute to population wellbeing. Place-belongingness is a complex concept; hence, it is necessary to discern the main similarities and differences with other measures, such as social cohesion, nature connectedness, and place attachment, and to investigate further place-belongingness' possible collective dimension. Moreover, further potential indirect relationships, such as through mindfulness (Dzhambov et al., 2019) or transcendent experiences (Marselle et al., 2021), also need

examination in the Norwegian context, ideally with longitudinal data and testing more complex modes of mediation, such as serial mediation. Furthermore, some of our analyses produced findings worthy of qualitative follow-up, such as the noted differences based on legal gender and the place-belongingness dynamics across the rural–urban gradient. It is also possible that some factors, such as age, may influence the modelled relations in non-linear ways, or combined with other factors, such as gender (Markevych et al., 2017). Likewise, it is likely that many more factors are yet to be discovered concerning both socio-demographic aspects and geo-cultural contexts.

5. Conclusion

This study investigated how residential nature related with subjective wellbeing through physical activity and place-belongingness, and how the strength of these relationships varied across age, gender, income, and urbanicity in a Norwegian sample. Residential hiking and recreation areas were associated with subjective wellbeing through both physical activity and place-belongingness. Recreation areas emerged as a stronger explanatory pathway than hiking areas, and place-belongingness emerged as a stronger explanatory pathway than physical activity. Stronger subjective wellbeing benefits emerged from the studied pathways for older males in more rural areas. Future research should confirm causality in these relationships. The current findings provide valuable insights to the research field of subjective wellbeing and for sustainable development, particularly regarding place-belongingness. Urban planners, public health professionals, and outdoor educators can leverage these findings to promote mental health more effectively. Understanding our deep and complex interconnection with nature and ensuring equitable access to residential nature are important to promote wellbeing.

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Funding

This work was financed by the corresponding author's PhD scholarship obtained from Volda University College. Volda University College had no additional involvement.

Conflict of interest statement

The authors declare that they have no conflicts of interests.

AI statement

During the preparation of this work, Author 1 used ChatGPT (OpenAI) to gain familiarisation with the basic computing language and functions used in the R Studio program. After using ChatGPT for educational purposes, the authors produced the content (e.g., analysis scripts) independently as needed, and the scripts were fully supervised by Author 2, who is a seasoned user of R Studio. ChatGPT was also employed to refine the language and improve the clarity of the manuscript text, ensuring it adhered to academic standards. The authors take full responsibility for the content of the publication.

Data availability statement

The survey data used in this research – Pilot Survey on Quality of Life in Hallingdal, 2019 (<https://doi.org/10.18712/NSD-NSD2741-V3>), Quality of Life Survey 2020 (<https://doi.org/10.18712/NSD-NSD2935-V3>), and Quality of Life Survey 2021 (<https://doi.org/10.18712/NSD-NSD2995-V2>) – was obtained from the Norwegian agency for shared services in education and research (SIKT).

Acknowledgements

The authors would like to thank the participants of the Quality of Life Surveys for their valuable contributions to this study and extend their gratitude to the Norwegian agency for shared services in education and research (SIKT) for providing the necessary data that made this research possible.

Publishing Timeline

Received 25 February 2025

Revised version received 25 November 2025

Accepted 28 December 2025

Published 12 January 2026

References

- Allen, K.-A., Kern, M. L., Rozek, C. S., McInerney, D. M., & Slavich, G. M. (2021). Belonging: A review of conceptual issues, an integrative framework, and directions for future research. *Australian Journal of Psychology*, 73(1), 87–102. <https://doi.org/10.1080/00049530.2021.1883409>
- Amundsen, B. (2018). Nå er to av tre norske etternavn et gårdsnavn [Now two out of three Norwegian surnames are farm names]. <https://www.forskning.no/sprak-ny-etnisitet/na-er-to-av-tre-norske-etternavn-et-gardsnavn/276679>
- Antonsich, M. (2010). Searching for belonging – An analytical framework. *Geography Compass*, 4(6), 644–659. <https://doi.org/https://doi.org/10.1111/j.1749-8198.2009.00317.x>
- Baceviciene, M., & Jankauskiene, R. (2022). The mediating effect of nature restorativeness, stress level, and nature connectedness in the association between nature exposure and quality of life. *International Journal of Environmental Research and Public Health*, 19(4), 2098. <https://doi.org/10.3390/ijerph19042098>
- Barboza, E. P., Cirach, M., Khomenko, S., Iungman, T., Mueller, N., Barrera-Gómez, J., Rojas-Rueda, D., Kondo, M., & Nieuwenhuijsen, M. (2021). Green space and mortality in European cities: A health impact assessment study. *The Lancet Planetary Health*, 5(10), e718–e730. [https://doi.org/https://doi.org/10.1016/S2542-5196\(21\)00229-1](https://doi.org/https://doi.org/10.1016/S2542-5196(21)00229-1)
- Barstad, A., Bjørnskau, T., & Rønning, E. (2023). *Forslag til et rammeverk for måling av livskvalitet i Norge [Proposal for a framework for measuring quality of life in Norway]* (978-82-587-1885-4).

- <https://www.ssb.no/sosiale-forhold-og-kriminalitet/levekar/artikler/forslag-til-et-rammeverk-formaling-av-livskvalitet-i-norge>
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117(3), 497–529. <https://doi.org/10.1037/0033-2909.117.3.497>
- Belanche, D., Casalo, L. V., & Rubio, M. A. (2021). Local place identity: A comparison between residents of rural and urban communities. *Journal of Rural Studies*, 82, 242–252. <https://doi.org/https://doi.org/10.1016/j.jrurstud.2021.01.003>
- Beute, F., Marselle, M. R., Olszewska-Guizzo, A., Andreucci, M. B., Lammel, A., Davies, Z. G., Glanville, J., Keune, H., O'Brien, L., Remmen, R., Russo, A., & de Vries, S. (2023). How do different types and characteristics of green space impact mental health? A scoping review. *People and Nature*, 5(6), 1839–1876. <https://doi.org/https://doi.org/10.1002/pan3.10529>
- Bonaiuto, M., & Alves, S. (2024). Nature-based solutions and quality of life: protecting, restoring and building human capacities. In *Handbook of Quality of Life Research: Place and Space Perspectives*, (308–321). Edward Elgar Publishing. <http://dx.doi.org/10.4337/9781789908794>
- Bonaiuto, M., & Chiozza, V. (2024). Understanding environmental impacts on people's quality of life via environmental psychology: Three basic principles. In *Handbook of Quality of Life Research: Place and Space Perspectives* (45–59). Edward Elgar Publishing. <http://dx.doi.org/10.4337/9781789908794>
- Braubach, M., Kendrovski, V., Jarosinska, D., Mudu, P., Andreucci, M. B., Beute, F., Davies, Z., de Vries, S., Glanville, J., Keune, H., Lammel, A., Marselle, M., O'Brien, L., Olszewska-Guizzo, A., Remmen, R., & Russo, A. (2021). *Green and blue spaces and mental health: New evidence and perspectives for action*. World Health Organization. <https://apps.who.int/iris/bitstream/handle/10665/342931/9789289055666-eng.pdf>
- Capaldi, C. A., Passmore, H.-A., Nisbet, E. K., Zelenski, J. M., & Dopko, R. L. (2015). Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention. *International Journal of Wellbeing*, 5(4), 1–16. <https://doi.org/10.5502/ijw.v5i4.449>
- Dalen, H. B., Berglund, F., & Lillegård, M. (2021). *Kjønn, identitet og seksualitet i kvantitative spørreundersøkelser. Veileder for spørsmål om seksuell orientering, kjønnsidentitet, kjønnsuttrykk og kjønnskarakteristika [Gender, identity and sexuality in quantitative surveys. Guidance for questions about sexual orientation, gender identity, gender expression and gender characteristics]* https://www.ssb.no/sosiale-forhold-og-kriminalitet/levekar/artikler/kjonn-identitet-og-seksualitet-i-kvantitative-sporreundersokelser/_/attachment/inline/86aeca7c-c6f5-4eee-a00a-8274c5261bb5:e89fc5d40b795930969cb01371b2e7fee41d5b55/NOT2021-28_web.pdf
- Dalton, A. M., Wareham, N., Griffin, S., & Jones, A. P. (2016). Neighbourhood greenspace is associated with a slower decline in physical activity in older adults: A prospective cohort study. *SSM - Population Health*, 2, 683–691. <https://doi.org/https://doi.org/10.1016/j.ssmph.2016.09.006>
- de Vries, S., van Dillen, S. M. E., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine*, 94, 26–33. <https://doi.org/https://doi.org/10.1016/j.socscimed.2013.06.030>
- Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268. https://doi.org/https://doi.org/10.1207/S15327965PLI1104_01
- Diener, E., Emmons, R., Larsen, R., & Griffin, S. (1985). The Satisfaction With Life Scale. *Journal of Personality Assessment*, 49(1), 71–75. https://doi.org/https://doi.org/10.1207/s15327752jpa4901_13
- Donald, I. (2022). *Environmental and Architectural Psychology: The Basics*. Routledge. <https://doi.org/10.4324/9780429274541>
- Dzhambov, A. M., Browning, M. H. E. M., Markevych, I., Hartig, T., & Lercher, P. (2020). Analytical approaches to testing pathways linking greenspace to health: A scoping review of the empirical literature. *Environmental Research*, 186, 109613. <https://doi.org/https://doi.org/10.1016/j.envres.2020.109613>
- Dzhambov, A. M., Hartig, T., Tilov, B., Atanasova, V., Makakova, D. R., & Dimitrova, D. D. (2019). Residential greenspace is associated with mental health via intertwined capacity-building and

- capacity-restoring pathways. *Environmental Research*, 178, 108708.
<https://doi.org/10.1016/j.envres.2019.108708>
- Environment Norway. (2023a, 02.04.2023). *Andel av befolkningen som har trygg tilgang til leke- og rekreasjonsarealer innen en avstand på 200 meter [Proportion of the population that has safe access to play and recreation areas within a distance of 200 metres]*.
<https://miljostatus.miljodirektoratet.no/miljomal/friluftsliv/miljomal-3.1/miljoindikator-3.1.3>
- Environment Norway. (2023b, 13.04.2023). *Andel av befolkningen som har trygg tilgang til nærturterreng innen en avstand på 500 meter [Proportion of the population that has safe access to short-distance hiking terrain within a distance of 500 metres]*.
<https://miljostatus.miljodirektoratet.no/miljomal/friluftsliv/miljomal-3.1/miljoindikator-3.1.2>
- Fian, L., White, M. P., Arnberger, A., Thaler, T., Heske, A., & Pahl, S. (2024). Nature visits, but not residential greenness, are associated with reduced income-related inequalities in subjective well-being. *Health & Place*, 85, 103175. <https://doi.org/https://doi.org/10.1016/j.healthplace.2024.103175>
- Fongar, C., Aamodt, G., Randrup, T. B., & Solfeld, I. (2019). Does perceived green space quality matter? Linking Norwegian adult perspectives on perceived quality to motivation and frequency of visits. *International Journal of Environmental Research and Public Health*, 16(13).
<https://doi.org/10.3390/ijerph16132327>
- Friesinger, J. G., Haugland, S. H., & Vederhus, J.-K. (2022). The significance of the social and material environment to place attachment and quality of life: Findings from a large population-based health survey. *Health and Quality of Life Outcomes*, 20(1), 135. <https://doi.org/10.1186/s12955-022-02045-2>
- Geary, R. S., Thompson, D. A., Garrett, J. K., Mizen, A., Rowney, F. M., Song, J., White, M. P., Lovell, R., Watkins, A., Lyons, R. A., Williams, S., Stratton, G., Akbari, A., Parker, S. C., Nieuwenhuijsen, M. J., White, J., Wheeler, B. W., Fry, R., Tsimpida, D., & Rodgers, S. E. (2023). Green blue space exposure changes and impact on individual-level well-being and mental health: A population-wide dynamic longitudinal panel study with linked survey data. *Public Health Research*, 11, 10.
<https://doi.org/10.3310/LQPT9410>
- Gelman, A. (2018). You need 16 times the sample size to estimate an interaction than to estimate a main effect. *Statistical Modeling, Causal Inference, and Social Science*. Available from:
<https://statmodeling.stat.columbia.edu/2018/03/15/need-16-times-sample-size-estimate-interaction-estimate-main-effect/>
- Grau-Ruiz, R., & Løvoll, H. S. (2024). Nearby nature and wellbeing: An examination of place-belongingness and meaning in life among native and migrant residents in Norway. *Journal of Adventure Education and Outdoor Learning*, 25(1), 261–281.
<https://doi.org/10.1080/14729679.2024.2412081>
- Grau-Ruiz, R., Løvoll, H. S., & Dyrddal, G. M. (2024). Norwegian outdoor happiness: Residential outdoor spaces and active leisure time contributions to subjective well-being at the national population level at the start of and during the COVID-19 pandemic. *Journal of Happiness Studies*, 25(1), 9.
<https://doi.org/10.1007/s10902-024-00732-z>
- Gunnarsson, B., & Hedblom, M. (2023). Biophilia revisited: nature versus nurture. *Trends in Ecology & Evolution*, 38(9), 792–794. <https://doi.org/https://doi.org/10.1016/j.tree.2023.06.002>
- Hammitt, W. E., Backlund, E. A., & Bixler, R. D. (2006). Place bonding for recreation places: Conceptual and empirical development. *Leisure Studies*, 25(1), 17–41. <https://doi.org/10.1080/02614360500098100>
- Hartig, T. (2021). Restoration in Nature: Beyond the Conventional Narrative. In A. R. Schutte, J. C. Torquati, & J. R. Stevens (Eds.), *Nature and Psychology: Biological, Cognitive, Developmental, and Social Pathways to Well-being* (pp. 89–151). Springer International Publishing. https://doi.org/10.1007/978-3-030-69020-5_5
- Hartig, T., Mitchell, R., De Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, 35, 207–228. <https://doi.org/10.1146/annurev-publhealth-032013-182443>
- Houlden, V., Weich, S., Porto de Albuquerque, J., Jarvis, S., & Rees, K. (2018). The relationship between greenspace and the mental wellbeing of adults: A systematic review. *PLoS One*, 13(9), e0203000.
<https://doi.org/https://doi.org/10.1371/journal.pone.0203000>

- Huta, V., & Waterman, A. S. (2014). Eudaimonia and its distinction from hedonia: Developing a classification and terminology for understanding conceptual and operational definitions. *Journal of Happiness Studies*, 15(6), 1425–1456. <https://doi.org/10.1007/s10902-013-9485-0>
- Jenkins, M., Lee, C., Hogue Mackenzie, S., Hargreaves, E. A., Hodge, K., & Calverley, J. (2022). Nature-based physical activity and hedonic and eudaimonic wellbeing: The mediating roles of motivational quality and nature relatedness. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.783840>
- Jennings, V., & Bamkole, O. (2019). The relationship between social cohesion and urban green space: An avenue for health promotion. *International Journal of Environmental Research and Public Health*, 16(3), 452. <https://doi.org/10.3390/ijerph16030452>
- Joye, Y., & Bolderdijk, J. W. (2015). An exploratory study into the effects of extraordinary nature on emotions, mood, and prosociality [Original Research]. *Frontiers in Psychology*, 5, 1577. <https://doi.org/10.3389/fpsyg.2014.01577>
- Juul, V., & Nordbø, E. C. A. (2023). Examining activity-friendly neighborhoods in the Norwegian context: Green space and walkability in relation to physical activity and the moderating role of perceived safety. *BMC Public Health*, 23(1), 259. <https://doi.org/10.1186/s12889-023-15170-4>
- Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15(3), 169–182. [https://doi.org/https://doi.org/10.1016/0272-4944\(95\)90001-2](https://doi.org/https://doi.org/10.1016/0272-4944(95)90001-2)
- Kellert, S. R., & Wilson, E. O. (1993). *The Biophilia Hypothesis*. Island Press.
- King, L. A., & Hicks, J. A. (2021). The science of meaning in life. *Annual Review of Psychology*, 72, 561–584. <https://doi.org/10.1146/annurev-psych-072420-122921>
- Kitchen, P., Williams, A. M., & Gallina, M. (2015). Sense of belonging to local community in small-to-medium sized Canadian urban areas: A comparison of immigrant and Canadian-born residents. *BMC Psychology*, 3(1), 28. <https://doi.org/10.1186/s40359-015-0085-0>
- Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway [Mini Review]. *Frontiers in Psychology*, 6, 1093. <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. <https://doi.org/https://doi.org/10.1016/j.landurbplan.2012.10.012>
- Li, H. S., Browning, M., Rigolon, A., Larson, L. R., Taff, D., Labib, S. M., Ben, J. C., Yuan, S., McAnirlin, O., Hatami, N., & Kahn, P. H. K. (2023). Beyond "bluespace" and "greenspace": A narrative review of possible health benefits from exposure to other natural landscapes. *Science of the Total Environment*, 856, 159292. <https://doi.org/10.1016/j.scitotenv.2022.159292>
- Lim, M. H., Allen, K.-A., Furlong, M. J., Craig, H., & Smith, D. C. (2021). Introducing a dual continuum model of belonging and loneliness. *Australian Journal of Psychology*, 73(1), 81–86. <https://doi.org/10.1080/00049530.2021.1883411>
- Liu, Y., Wang, R., Xiao, Y., Huang, B., Chen, H., & Li, Z. (2019). Exploring the linkage between greenness exposure and depression among Chinese people: Mediating roles of physical activity, stress and social cohesion and moderating role of urbanicity. *Health & Place*, 58, 102168. <https://doi.org/https://doi.org/10.1016/j.healthplace.2019.102168>
- Main, K. (2013). Planting roots in foreign soil?—Immigrant place meanings in an urban park. *Journal of Environmental Psychology*, 36, 291–304. <https://doi.org/https://doi.org/10.1016/j.jenvp.2013.08.003>
- Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., 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/https://doi.org/10.1016/j.envres.2017.06.028>
- Marselle, M. R., Hartig, T., Cox, D. T. C., de Bell, S., Knapp, S., Lindley, S., Triguero-Mas, M., Böhning-Gaese, K., Braubach, M., Cook, P. A., de Vries, S., Heintz-Buschart, A., Hofmann, M., Irvine, K. N., Kabisch, N., Kolek, F., Kraemer, R., Markevych, I., Martens, D., Müller, R., Nieuwenhuijsen, M., Potts, J. M., Stadler, J., Walton, S., Warber, S. L., & Bonn, A. (2021). Pathways linking biodiversity to

- human health: A conceptual framework. *Environment International*, 150, 106420.
<https://doi.org/https://doi.org/10.1016/j.envint.2021.106420>
- Martela, F., Greve, B., Rothstein, B., & Saari, J. (2020). The Nordic exceptionalism: What explains why the Nordic countries are constantly among the happiest in the world. *World Happiness Report*, 2020, 129–146. Sustainable Development Solutions Network (2020). <https://worldhappiness.report/ed/2020/the-nordic-exceptionalism-what-explains-why-the-nordic-countries-are-constantly-among-the-happiest-in-the-world/>
- Maslow, A. H. (1954). *Motivation and Personality*. Harper and Row.
- Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why is nature beneficial? The role of connectedness to nature. *Environment and Behavior*, 41(5), 607–643.
<https://doi.org/https://doi.org/10.1177/0013916508319745>
- Mensah, C. A., Andres, L., Perera, U., & Roji, A. (2016). Enhancing quality of life through the lens of green spaces: A systematic review approach. *International Journal of Wellbeing*, 6(1), 142–163.
<https://doi.org/https://doi.org/10.5502/ijw.v6i1.445>
- Mohseni, H., Silvennoinen, J., & Kujala, T. (2024). Place-belongingness in real-life contexts: A review of practical meanings, contributing factors, and evaluation methods. *GeoJournal*, 89, 187.
<https://doi.org/10.1007/s10708-024-11173-9>
- Nes, R., Hansen, T., Barstad, A., Vittersø, J., Carlquist, E., & Røysamb, E. (2018). Anbefalinger for et bedre målesystem. [Recommendations of a better measuring system]. The Norwegian Directorate of Health.
- NIBIO. (2025). *Social-Ecological Innovations*. Retrieved 11.11.2025 from
<https://www.nibio.no/en/subjects/environment/social-ecological-innovations>
- Nieuwenhuijsen, M. J., Khreis, H., Triguero-Mas, M., Gascon, M., & Dadvand, P. (2017). Fifty shades of green: Pathway to healthy urban living. *Epidemiology*, 28(1), 63–71.
<https://doi.org/10.1097/EDE.0000000000000549>
- Norwegian Environment Agency. (2014). *Kartlegging og verdsetting av friluftslivsområder [Mapping and valuation of outdoor recreation areas]*. Miljødirektoratet.
<https://www.miljodirektoratet.no/publikasjoner/2014/mai-2014/kartlegging-og-verdsetting-av-friluftslivsomrader/>
- OECD. (2013). *OECD Guidelines on Measuring Subjective Well-being*. OECD Publishing. <https://www.oecd-ilibrary.org/content/publication/9789264191655-en>
- Office of the Surgeon General (OSG). (2023). *Our Epidemic of Loneliness and Isolation: The U.S. Surgeon General's Advisory on the Healing Effects of Social Connection and Community*. [Internet]. Washington (DC): US Department of Health and Human Services; 2023–. PMID: 37792968.
<https://www.ncbi.nlm.nih.gov/books/NBK595227/>
- Peters, K., Stodolska, M., & Horolets, A. (2016). The role of natural environments in developing a sense of belonging: A comparative study of immigrants in the US, Poland, the Netherlands and Germany. *Urban Forestry & Urban Greening*, 17, 63–70. <https://doi.org/https://doi.org/10.1016/j.ufug.2016.04.001>
- Pettersen, A.-M., & Støren, K. S. (2020). *Livskvalitetsundersøkelsen 2020. Dokumentasjonsnotat [Quality of life survey 2020. Documentation note]* (Notes, Issue. <https://www.ssb.no/sosiale-forhold-og-kriminalitet/artikler-og-publikasjoner/livskvalitetsundersokelsen-2020>
- Pettersen, A.-M., & Støren, K. S. (2021). *Livskvalitetsundersøkelsen 2021. Dokumentasjonsnotat [Quality of life survey 2021. Documentation note]* (Notes, Issue. <https://www.ssb.no/sosiale-forhold-og-kriminalitet/levekar/artikler/livskvalitetsundersokelsen-2021>
- Pierce, J. R., & Aguinis, H. (2013). The Too-Much-of-a-Good-Thing Effect in Management. *Journal of Management*, 39(2), 313–338. <https://doi.org/10.1177/0149206311410060>
- Plane, J., & Klodawsky, F. (2013). Neighbourhood amenities and health: Examining the significance of a local park. *Social Science & Medicine*, 99, 1–8.
<https://doi.org/https://doi.org/10.1016/j.socscimed.2013.10.008>
- Raman, S. (2014). Sense of belonging. In A. C. Michalos (Ed.), *Encyclopedia of Quality of Life and Well-being Research* (pp. 5828–5831). Springer Netherlands. https://doi.org/10.1007/978-94-007-0753-5_2646
- R Core Team. (2023). *R: A language and environment for statistical computing. R v4.3.2*. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>

- Reyes-Riveros, R., Altamirano, A., De La Barrera, F., Rozas-Vásquez, D., Vieli, L., & Meli, P. (2021). Linking public urban green spaces and human well-being: A systematic review. *Urban Forestry & Urban Greening*, 61, 127105. <https://doi.org/https://doi.org/10.1016/j.ufug.2021.127105>
- Richardson, M. (2023). *Reconnection: Fixing our Broken Relationship with Nature*. Pelagic Publishing Ltd. <https://doi.org/10.53061/KFSP1540>
- Richardson, M., Passmore, H.-A., Lumber, R., Thomas, R., & Hunt, A. (2021). Moments, not minutes: The nature-wellbeing relationship. *International Journal of Wellbeing*, 11(1), 8–33. <https://doi.org/10.5502/ijw.v11i1.1267>
- Riethmuller, M. L., Dzidic, P. L., & Newnham, E. A. (2021). Going rural: Qualitative perspectives on the role of place attachment in young people's intentions to return to the country. *Journal of Environmental Psychology*, 73, 101542. <https://doi.org/https://doi.org/10.1016/j.jenvp.2020.101542>
- Rørholt, A., & Steinnes, M. (2020). *Planlagt utbygd areal 2019 til 2030. En kartbasert metode for estimering av framtidige arealendringer med negativ klimaeffekt.* [Planned developed area 2019 to 2030. A map-based method for estimating future area changes with a negative climate effect]. Notater 2020/10. Statistics Norway. <https://hdl.handle.net/11250/3162132>
- Silva, R. A., Rogers, K., & Buckley, T. J. (2018). Advancing environmental epidemiology to assess the beneficial influence of the natural environment on human health and well-being. *Environmental Science & Technology*, 52(17), 9545–9555. <https://doi.org/10.1021/acs.est.8b01781>
- Statistics Norway. (2020). *Standard for Sentralitet [Classification of Centrality]*. <https://www.ssb.no/klass/klassifikasjoner/128>
- Statistics Norway. (2021). *Sports and outdoor activities, survey on living conditions*. <https://www.ssb.no/en/kultur-og-fritid/idrett-og-friluftsliv/statistikk/idrett-og-friluftsliv-levelkarsundersokelsen>
- Statistics Norway. (2022). *Pilot survey on quality of life in Hallingdal, 2019* [Data set]. Sikt – Norwegian Agency for Shared Services in Education and Research. <https://doi.org/10.18712/NSD-NSD2741-V3>
- Statistics Norway. (2023a). *Quality of life survey 2020* [Data set]. Sikt – Norwegian Agency for Shared Services in Education and Research. <https://doi.org/10.18712/NSD-NSD2935-V3>
- Statistics Norway. (2023b). *Quality of life survey 2021* [Data set]. Sikt – Norwegian Agency for Shared Services in Education and Research. <https://doi.org/10.18712/NSD-NSD2995-V2>
- Statistics Norway. (2024a). *Land use and land cover*. <https://www.ssb.no/en/natur-og-miljo/areal/statistikk/arealbruk-og-arealressurser>
- Statistics Norway. (2024b). *Population*. <https://www.ssb.no/en/befolkning/folketall/statistikk/befolkning>
- The Norwegian Directorate of Health. (2021). *Sektorrapport om folkehelse 2021 [Sector Report on Public Health 2021]*. <https://www.helsedirektoratet.no/rapporter/sektorrapport-om-folkehelse>
- Ulrich, R. S. (2023). Stress reduction theory. In D. Marchand, Weiss, K., & Pol, E. (Ed.), *100 Key Concepts in Environmental Psychology* (1st edition ed., pp. 143-146). Routledge. <https://doi.org/https://doi.org/10.4324/9781003382904>
- van den Bogerd, N., Coosje Dijkstra, S., Koole, S. L., Seidell, J. C., de Vries, R., & Maas, J. (2020). Nature in the indoor and outdoor study environment and secondary and tertiary education students' well-being, academic outcomes, and possible mediating pathways: A systematic review with recommendations for science and practice. *Health & Place*, 66, 102403. <https://doi.org/https://doi.org/10.1016/j.healthplace.2020.102403>
- Vederhus, J.-K., Timko, C., & Haugland, S. H. (2021). Adverse childhood experiences and impact on quality of life in adulthood: development and validation of a short difficult childhood questionnaire in a large population-based health survey. *Quality of Life Research*, 30(6), 1769–1778. <https://doi.org/10.1007/s11136-021-02761-0>
- Wang, R., Browning, M. H. E. M., Kee, F., & Hunter, R. F. (2023). Exploring mechanistic pathways linking urban green and blue space to mental wellbeing before and after urban regeneration of a greenway: Evidence from the Connswater Community Greenway, Belfast, UK. *Landscape and Urban Planning*, 235, 104739. <https://doi.org/https://doi.org/10.1016/j.landurbplan.2023.104739>

- Wang, R., Feng, Z., Pearce, J., Liu, Y., & Dong, G. (2021). Are greenspace quantity and quality associated with mental health through different mechanisms in Guangzhou, China: A comparison study using street view data. *Environmental Pollution*, 290, 117976. <https://doi.org/10.1016/j.envpol.2021.117976>
- Warner, R. M. (2013). *Applied Statistics: From Bivariate through Multivariate Techniques* (2nd ed.). Sage Publications, Inc.
- Werneck, A. O., Stubbs, B., Kandola, A., Oyeyemi, A. L., Schuch, F. B., Hamer, M., Vancampfort, D., & Silva, D. R. (2022). Prospective associations of leisure-time physical activity with psychological distress and well-being: A 12-year cohort study. *Psychosomatic Medicine*, 84(1), 116–122. <https://doi.org/https://doi.org/10.1097/psy.0000000000001023>
- White, M. P., Hartig, T., Martin, L., Pahl, S., van den Berg, A. E., Wells, N. M., Costongs, C., Dzhambov, A. M., Elliott, L. R., Godfrey, A., Hartl, A., Konijnendijk, C., Litt, J. S., Lovell, R., Lymeus, F., O'Driscoll, C., Pichler, C., Pouso, S., Razani, N., Secco, L., Steininger, M. O., Stigsdotter, U. K., Uyarra, M., & van den Bosch, M. (2023). Nature-based biopsychosocial resilience: An integrative theoretical framework for research on nature and health. *Environment international*, 181, 108234. <https://doi.org/https://doi.org/10.1016/j.envint.2023.108234>
- Wicks, C., Barton, J., Orbell, S., & Andrews, L. (2022). Psychological benefits of outdoor physical activity in natural versus urban environments: A systematic review and meta-analysis of experimental studies. *Applied Psychology: Health and Well-Being*, 14(3), 1037–1061. <https://doi.org/https://doi.org/10.1111/aphw.12353>
- Wiese, C. W., Kuykendall, L., & Tay, L. (2018). Get active? A meta-analysis of leisure-time physical activity and subjective well-being. *The Journal of Positive Psychology*, 13(1), 57–66. <https://doi.org/https://doi.org/10.1080/17439760.2017.1374436>
- WHO. (2016). *Urban green spaces and health*. <https://www.who.int/europe/publications/i/item/WHO-EURO-2016-3352-43111-60341>
- Yang, B.-Y., Zhao, T., Hu, L.-X., Browning, M. H. E. M., Heinrich, J., Dharmage, S. C., Jalaludin, B., Knibbs, L. D., Liu, X.-X., Luo, Y.-N., James, P., Li, S., Huang, W.-Z., Chen, G., Zeng, X.-W., Hu, L.-W., Yu, Y., & Dong, G.-H. (2021). Greenspace and human health: An umbrella review. *The Innovation*, 2(4), 100164. <https://doi.org/10.1016/j.xinn.2021.100164>
- Yang, Y., Cai, H., Yang, Z., Zhao, X., Li, M., Han, R., & Chen, S. X. (2022). Why does nature enhance psychological well-being? A Self-Determination account. *Journal of environmental psychology*, 83, 101872. <https://doi.org/10.1016/j.jenvp.2022.101872>
- Yip, C., Sarma, S., & Wilk, P. (2016). The association between social cohesion and physical activity in Canada: A multilevel analysis. *SSM - Population Health*, 2, 718–723. <https://doi.org/https://doi.org/10.1016/j.ssmph.2016.09.010>
- Zhang, J., Xia, T., Cheng, Y., Zhou, S., Cai, Z., Zhao, B., & Dadvand, P. (2025). Unraveling the heterogeneity of pathways linking residential green space quantity and quality to the well-being of older adults in different housing price communities. *Cities*, 156, 105561. <https://doi.org/https://doi.org/10.1016/j.cities.2024.105561>

Appendix

1. Preliminary analyses

Table A1. Preliminary analysis of the subjective wellbeing variables

	Model 0	Model 0.1
Treatment of subjective wellbeing outcome	Composite score	Satisfaction with life, affect balance, and meaning in life
Satisfaction with life ~ hiking areas	–	.01
Affect balance ~ hiking areas	–	.01
Meaning in life ~ hiking areas	–	.00
Composite score~ hiking areas	.01	–
Satisfaction with life ~ recreation areas	–	.04 ***
Affect balance ~ recreation areas	–	.03 ***
Meaning in life ~ recreation areas	–	.04 ***
Composite score~ recreation areas	.04 ***	–
Satisfaction with life ~ physical activity	–	.12 ***
Affect balance ~ physical activity	–	.12 ***
Meaning in life ~ physical activity	–	.12 ***
Composite score~ physical activity	.13 ***	–
Satisfaction with life ~ place-belongingness	–	.34 ***
Affect balance ~ place-belongingness	–	.31 ***
Meaning in life ~ place-belongingness	–	.33 ***
Composite score~ place-belongingness	.36 ***	–
Chi Square (DF)	309.42 (6)	421.93 (8)
Chi square p value	.00	.00
CFI	.98	.99
TLI	.88	.95
RMSEA (90% CI lower-upper)	.04 (.04-.04)	.04 (.04-.04)
SRMR	.01	.01
BIC	267740.39	403956.67

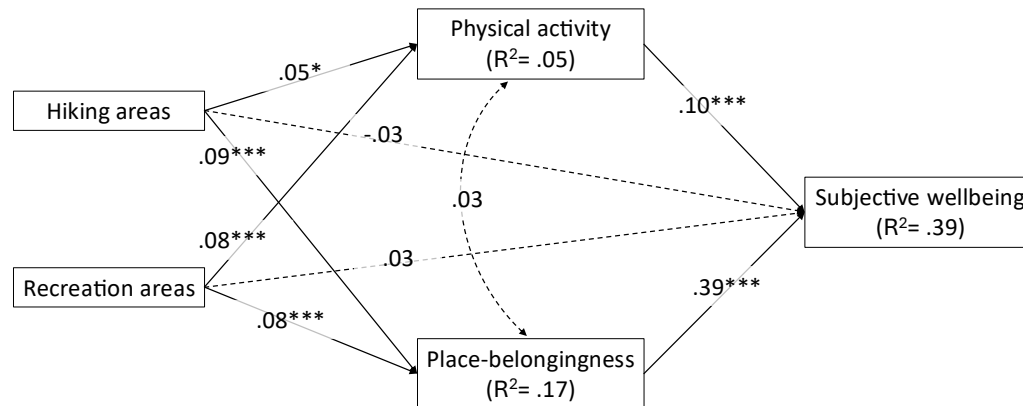
Table A2. Preliminary analysis of the physical activity variable

	Model 0	Model 0.2
Treatment Relation Physical activity	Continuous Linear .13***	Continuous Quadratic .20*** -.07**
Chi Square (DF)	309.42 (6)	110130.80 (8)
Chi square p value	.00	.00
CFI	.98	.14
TLI	.88	-3.85
RMSEA (90% CI lower-upper)	.04 (.04-.04)	.64 (.64-.64)
SRMR	.01	.08
BIC	267740.39	267742.22

Table A3. Analysis of the physical activity-place-belongingness relation

	Model 0	Model 1
Physical activity-place-belongingness relation	Unmodelled	Correlated (.09 ***)
Chi square (DF)	309.42 (6)	13.05 (5)
Chi square p value	.00	.02
CFI	.98	1
TLI	.88	1
RMSEA (90% CI lower-upper)	.04 (.04-.04)	.01 (.00-.01)
SRMR	.01	.00
BIC	267740.39	267454.43

Figure A1. Graphical representation of Model 1 with the dataset quality-of-life in Hallingdal 2019 (M1')

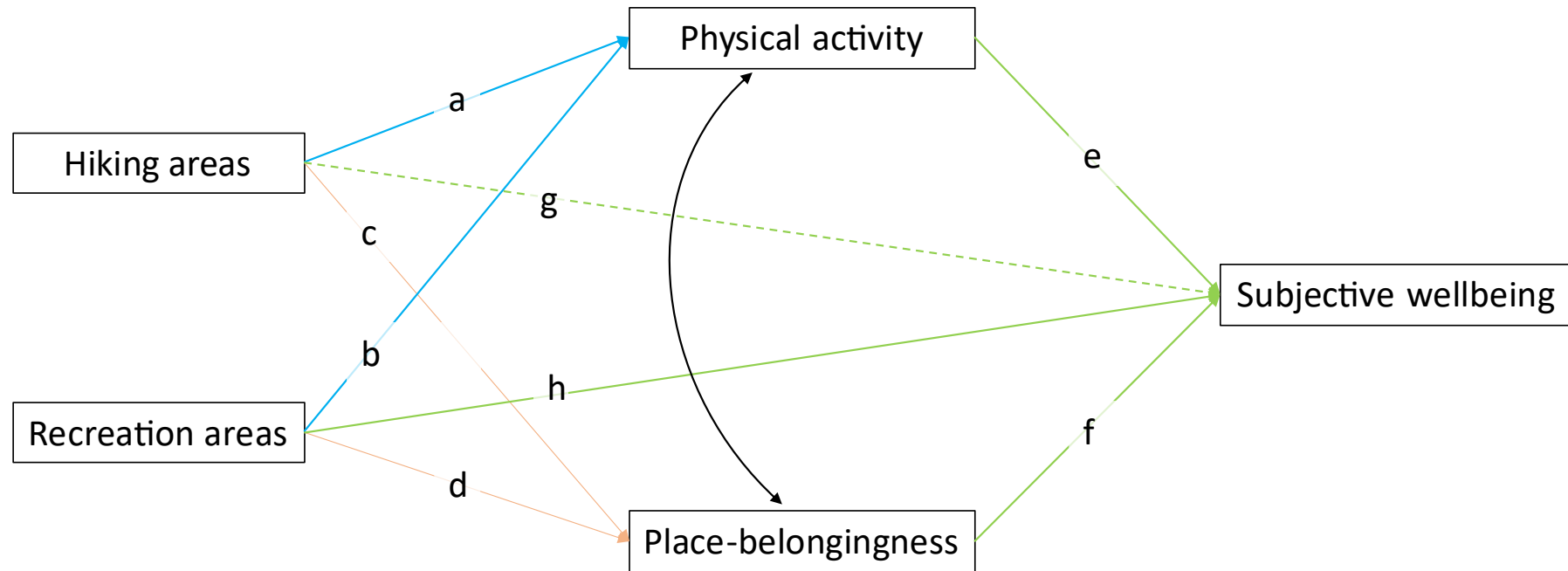


Model 1' Fit: $\chi^2 [3] = 6.09$, $p = .107$, CFI = 1, TLI = .97, RMSEA (90% CI) = .02 (.00, .05), SRMR = .01, BIC = 16004.84

Note. Some variables are different or missing. Missing Variables: Survey year, urbanicity and income quartiles (in these models this variable is replaced by economic solvency (how hard/easy it is to cover daily expenses with the income of the household (6 levels from very hard to very easy))). Differing variables: Immigration background is dichotomous, and Age is categorical with 7 levels: 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and over 75. * $p \leq 0.05$. ** $p \leq 0.01$. *** $p \leq 0.001$.

2. Moderation analyses

Figure 2. Key for paths' names for moderation analyses and effect calculations



	Direct effect	Indirect effect via physical activity	Indirect effect via place-belongingness	Total effect
Hiking areas	g	$a * e$	$c * f$	$g + (a * e) + (c * f)$
Recreation areas	h	$b * e$	$d * f$	$h + (b * e) + (d * f)$
Outdoor spaces	$g + h$	$(a * e) + (b * e)$	$(c * f) + (d * f)$	$g + (a * e) + (c * f) + h + (b * e) + (d * f)$

Table 4. Overview of models including single gender interactions with paths in Model 1

	Model	Paths to physical activity		Paths to place-belongingness		Paths to subjective wellbeing			
		GA	GB	GC	GD	GE	GF	GG	GH
Gender coefficient	–	-.01	-.01	.06***	.06***	-.01**	-.01**	-.01**	-.01**
Moderated variable	–	.03 ***	.05 ***	.06***	.11***	.13***	.36***	.01	.04***
Interaction term	–	-.00	.00	-.01	-.00	-.01	.00	-.01	-.01**
Chi square (DF)	13.05 (5)	17.35 (7)	21.47 (7)	15.25 (7)	21.70 (7)	33.72 (7)	41.97 (7)	15.48 (7)	13.81 (7)
Chi square p value	.02	.02	.00	.03	.00	.00	.00	.03	.06
CFI	1	1	1	1	1	1	1	1	1
TLI	1	1	1	1	1	.99	.99	1	1
RMSEA (90% CI lower–upper)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.02)	.01 (.00–.01)	.01 (.00–.01)
SRMR	.00	.00	.00	.00	.00	.00	.00	.00	.00
BIC	267454.43	267464.77	267464.31	267462.67	267464.55	267463.79	267464.37	267462.91	267456.65

Table 5. Overview of models including single economy interactions with paths in Model 1

	Model	Paths to physical activity		Paths to place-belongingness		Paths to subjective wellbeing			
		EA	EB	EC	ED	EE	EF	EG	EH
Economy coefficient	–	.09 ***	.09 ***	.05***	.05***	.06***	.06***	.06***	.06***
Moderated variable	–	.03 ***	.05 ***	.06***	.11***	.13***	.36***	.01	.04***
Interaction term	–	.01	.00	-.00	-.01	-.02**	-.01**	.01*	.00
Chi square (DF)	13.05 (5)	18.5 (7)	18.07 (7)	22.20 (7)	13.32 (7)	1451.02 (7)	674.37 (7)	17.22 (7)	17.9 (7)
Chi square p value	.02	.01	.01	.00	.07	.00	.00	.02	.01
CFI	1	1	1	1	1	.93	.96	1	1
TLI	1	1	1	1	1	.52	.77	1	1
RMSEA (90% CI lower–upper)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.08 (.08–.08)	.05(.05–.06)	.01 (.00–.01)	.01 (.00–.01)
SRMR	.00	.00	.00	.00	.00	.02	.01	.00	.00
BIC	267454.43	267461.15	267464.85	267464.85	267460.1	267452.29	267455.66	267459.87	267464.68

Table 6. Overview of models including single age interactions with paths in Model 1

	Model	Paths to physical activity		Paths to place-belongingness		Paths to subjective wellbeing			
		AA	AB	AC	AD	AE	AF	AG	AH
Age coefficient	–	-.05 ***	-.05 ***	.18***	.18***	.10***	.10***	.10***	.10***
Moderated variable	–	.04 ***	.06 ***	.06***	.11***	.14***	.37***	.01*	.04***
Interaction term	–	.03 ***	.02 ***	.00	-.01	-.03***	.04***	.01 **	-.00
Chi square (DF)	13.05 (5)	22.35 (7)	13.58 (7)	58.64 (7)	29.04 (7)	146.82 (7)	1193.92 (7)	49.83 (7)	29.81 (7)
Chi square p value	.02	.00	.06	.00	.00	.00	.00	.00	.00
CFI	1	1	1	1	1	.99	.94	1	1
TLI	1	1	1	.98	.99	.95	.60	.99	.99
RMSEA (90% CI lower–upper)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.02 (.01–.02)	.01 (.00–.01)	.02 (.02–.03)	.07 (.07–.08)	.01 (.01–.02)	.01 (.01–.01)
SRMR	.00	.00	.00	.00	.00	.01	.02	.00	.00
BIC	267454.43	267428.53	267448.26	267464.82	267463.72	267407.46	267397.98	267456.02	267464.48

Table 7. Overview of models including single urbanicity interactions with paths in Model 1

	Model	Paths to physical activity		Paths to place-belongingness		Paths to subjective wellbeing			
		UA	UB	UC	UD	UE	UF	UG	UH
Urbanicity coefficient	–	.01	.01	.04***	.05***	.01	.01	.01	.01
Moderated variable	–	.03 ***	.05 ***	.07***	.11***	.13***	.36***	.01	.04***
Interaction term	–	-.00	.01	.03***	.01*	-.00	.01*	.00	.00
Chi square (DF)	13.05 (5)	40.22 (7)	20.75 (7)	13.74 (7)	18.45 (7)	16.93 (7)	15.1 (7)	39.93 (7)	23.02 (7)
Chi square p value	.02	.00	.00	.06	.01	.02	.04	.00	.00
CFI	1	1	1	1	1	1	1	1	1
TLI	1	.99	1	1	1	1	1	1	.99
RMSEA (90% CI lower–upper)	.01 (.00–.01)	.01 (.01–.02)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.00–.01)	.01 (.01–.02)	.01 (.01–.01)
SRMR	.00	.00	.00	.00	.00	.00	.00	.00	.00
BIC	267454.43	267464.82	267461.63	267438.35	267459.33	267464.77	267459.55	267464.54	267463.9

Table 8. Comparison of Model 1 with Model 2 (interaction terms combined)

		Model 1	Model 2
Criterion		–	Included significant interactions leading to better fit than Model 1:
Interactions		–	Gender on H, Age on B, Urbanicity on C and F
Moderator's coefficient			
Physical activity ~			
	Age	-.05 ***	-.05 ***
Place-belongingness ~			
	Urbanicity	.05 ***	.04 ***
Subjective wellbeing ~			
	Gender	-.01**	-.01**
	Urbanicity	.01	.01
Moderated variable			
Physical activity ~			
	Recreation areas	.05 ***	.06 ***
Place-belongingness ~			

	Model 1	Model 2
Subjective wellbeing		
Hiking areas	.06 ***	.07 ***
Recreation areas	.04***	.04***
Place-belongingness	.36***	.36***
Interaction terms		
Physical activity ~		
Age*Recreation areas	–	.02 ***
Place-belongingness		
~		
Urbanicity*Hiking areas	–	.03 ***
Subjective wellbeing		
~		
Gender*Recreation areas	–	-.01**
Urbanicity*Place-belongingness	–	.01*
Chi square (DF)	13.05 (5)	16.25 (13)
Chi square p value	.02	.24
CFI	1	1
TLI	1	1
RMSEA (90% CI lower-upper)	.01 (.00–.01)	.00 (.00–.01)
SRMR	.00	.00
BIC	267454.43	267439.56

Table 9. Full models

M1	Excluded cases N° of model parameters N° of observations	16 40 33482	Estimate	St.Err	z-value	P(> z)
Physical activity ~						
	Hiking areas		.027	.006	4.504	.000
	Recreation areas		.052	.006	8.222	.000
	Age		-.049	.006	-7.906	.000
	Gender		-.007	.005	-1.379	.168
	Income		.091	.006	15.221	.000
	Education		.105	.006	17.778	.000
	Immigration background		-.072	.006	-11.362	.000
	Sexual orientation		-.029	.006	-4.595	.000
	Owning residence		.017	.007	2.569	.010
	Urbanicity		.005	.005	.848	.396
Place-belongingness ~						
	Hiking areas		.059	.006	9.942	.000
	Recreation areas		.110	.006	17.838	.000
	Age		.175	.006	28.137	.000
	Gender		.064	.005	12.366	.000
	Income		.046	.006	7.705	.000
	Education		-.074	.006	-13.266	.000
	Immigration background		-.058	.006	-10.246	.000
	Sexual orientation		-.027	.006	-4.447	.000
	Having a partner		.033	.006	5.668	.000
	Employment status		.028	.006	4.724	.000
	Owning residence		.148	.007	22.184	.000
	Urbanicity		.046	.005	8.748	.000
Subjective wellbeing ~						
	Physical activity		.133	.005	25.196	.000
	Place-belongingness		.363	.006	62.761	.000
	Hiking areas		.006	.005	1.160	.246
	Recreation areas		.040	.005	7.602	.000
	Age		.102	.006	17.771	.000
	Gender		-.013	.005	-2.768	.006

	Income	.056	.005	10.479	.000
	Education	.078	.005	15.305	.000
	Immigration background	.026	.005	5.267	.000
	Sexual orientation	-.027	.005	-5.703	.000
	Having a partner	.137	.005	25.636	.000
	Employment status	.111	.006	19.431	.000
	Urbanicity	.008	.005	1.788	.074
	Survey year	-.068	.005	-14.817	.000
Physical activity~ ~ Place-belongingness		.086	.006	15.368	.000
Variances					
	Physical activity	.960	.009	112.814	.000
	Place-belongingness	.865	.008	110.482	.000
	Subjective wellbeing	.709	.006	116.684	.000
	Chi Square (DF)			13.047 (5)	
	Chi square p value			.023	
	CFI			1	
	TLI			.996	
	RMSEA (90% CI lower-upper)			.007 (.002-.012)	
	SRMR			.002	
	BIC			267454.433	

M2	Excluded cases		16		
	Number of model parameters		44		
	N° of observations		33482		
		Estimate	St.Err	z-value	P(> z)
Physical activity ~					
	Hiking areas	.026	.006	4.462	.000
	Recreation areas	.056	.006	8.645	.000
	Age	-.049	.006	-7.787	.000
	Gender	-.007	.005	-1.380	.167
	Income	.091	.006	15.176	.000
	Education	.105	.006	17.832	.000
	Immigration background	-.072	.006	-11.329	.000
	Sexual orientation	-.029	.006	-4.644	.000
	Owning residence	.018	.007	2.704	.007
	Urbanicity	.004	.005	.766	.443
	Age*Recreation areas	.020	.006	3.459	.001
Place-belongingness ~					
	Hiking areas	.071	.007	10.618	.000
	Recreation areas	.108	.006	17.549	.000
	Age	.175	.006	28.053	.000
	Gender	.064	.005	12.412	.000
	Income	.046	.006	7.713	.000
	Education	-.074	.006	-13.338	.000
	Immigration background	-.058	.006	-10.169	.000
	Sexual orientation	-.027	.006	-4.491	.000
	Having a partner	.033	.006	5.610	.000
	Employment status	.027	.006	4.536	.000
	Owning residence	.149	.007	22.219	.000
	Urbanicity	.044	.005	8.182	.000
	Urbanicity*Hiking areas	.029	.007	4.430	.000
Subjective wellbeing ~					
	Physical activity	.133	.005	25.201	.000
	Place-belongingness	.363	.006	62.783	.000
	Hiking areas	.006	.005	1.227	.220
	Recreation areas	.038	.005	7.334	.000
	Age	.102	.006	17.765	.000
	Gender	-.013	.005	-2.713	.007
	Income	.057	.005	10.504	.000
	Education	.078	.005	15.311	.000
	Immigration background	.026	.005	5.306	.000

	Sexual orientation	-.030	.005	-5.744	.000
	Having a partner	.136	.005	25.516	.000
	Employment status	.111	.006	19.418	.000
	Urbanicity	.008	.005	1.685	.092
	Survey year	-.068	.005	-14.831	.000
	Gender*Recreation areas	-.013	.005	-2.612	.009
	Urbanicity*Place-belongingness	.011	.005	1.970	.049
Physical activity~ ~ Place-belongingness		.086	.006	15.389	.000
Variiances					
	Physical activity	.959	.009	112.725	.000
	Place-belongingness	.865	.008	110.468	.000
	Subjective wellbeing	.709	.006	116.662	.000
	Chi Square (DF)			16.249 (13)	
	Chi square p value			.236	
	CFI			1	
	TLI			.999	
	RMSEA (90% CI lower-upper)			.003 (.000-.006)	
	SRMR			.001	
	BIC			267439.564	

M3	Excluded cases	16			
	Number of model parameters	81			
	N° of observations	33482			
		Estimate	St.Err	z-value	P(> z)
Physical activity ~					
	Hiking areas	.026	.006	4.462	.000
	Recreation areas	.056	.006	8.645	.000
	Age	-.049	.006	-7.787	.000
	Gender	-.007	.005	-1.380	.167
	Income	.091	.006	15.176	.000
	Education	.105	.006	17.832	.000
	Immigration background	-.072	.006	-11.329	.000
	Sexual orientation	-.029	.006	-4.644	.000
	Owning residence	.018	.007	2.704	.007
	Urbanicity	.004	.005	.766	.443
	Age*Recreation areas	.020	.006	3.459	.001
Place-belongingness ~					
	Hiking areas	.071	.007	10.618	.000
	Recreation areas	.108	.006	17.549	.000
	Age	.175	.006	28.053	.000
	Gender	.064	.005	12.412	.000
	Income	.046	.006	7.713	.000
	Education	-.074	.006	-13.338	.000
	Immigration background	-.058	.006	-10.169	.000
	Sexual orientation	-.027	.006	-4.491	.000
	Having a partner	.033	.006	5.610	.000
	Employment status	.027	.006	4.536	.000
	Owning residence	.149	.007	22.219	.000
	Urbanicity	.044	.005	8.182	.000
	Urbanicity*Hiking areas	.029	.007	4.430	.000
Satisfaction with life ~					
	Physical activity	.117	.005	21.601	.000
	Place-belongingness	.325	.006	57.269	.000
	Hiking areas	.005	.005	.894	.371
	Recreation areas	.037	.005	6.876	.000
	Age	.008	.006	1.339	.000
	Gender	.024	.005	5.054	.181
	Income	.074	.006	13.395	.000
	Education	.091	.005	17.382	.000
	Immigration background	.009	.005	1.799	.072

	Sexual orientation	-.024	.005	-4.421	.000
	Having a partner	.177	.005	32.312	.000
	Employment status	.081	.006	13.678	.000
	Urbanicity	-.014	.005	-2.773	.006
	Survey year	-.056	.005	-11.890	.000
	Gender*Recreation areas	-.014	.005	-2.775	.006
	Urbanicity*Place-belongingness	.005	.005	.956	.339
Affect balance ~					
	Physical activity	.118	.005	21.918	.000
	Place-belongingness	.304	.006	52.398	.000
	Hiking areas	.007	.005	1.354	.176
	Recreation areas	.031	.005	5.750	.000
	Age	.141	.006	23.797	.000
	Gender	-.080	.005	-16.185	.000
	Income	.042	.006	7.469	.000
	Education	.044	.005	8.275	.000
	Immigration background	-.002	.005	-.343	.732
	Sexual orientation	-.041	.005	-7.587	.000
	Having a partner	.067	.005	12.159	.000
	Employment status	.067	.006	11.482	.000
	Urbanicity	.014	.005	2.738	.006
	Survey year	-.030	.005	-6.239	.000
	Gender*Recreation areas	-.005	.005	-.898	.369
	Urbanicity*Place-belongingness	.008	.005	1.495	.135
Meaning in life ~					
	Physical activity	.121	.006	21.917	.000
	Place-belongingness	.332	.006	55.387	.000
	Hiking areas	.005	.005	.933	.351
	Recreation areas	.034	.005	6.307	.000
	Age	.123	.006	20.662	.000
	Gender	.021	.005	4.486	.000
	Income	.035	.005	6.391	.000
	Education	.074	.005	13.998	.000
	Immigration background	.062	.005	12.180	.000
	Sexual orientation	-.016	.006	-2.908	.004
	Having a partner	.121	.005	22.201	.000
	Employment status	.149	.006	25.374	.000
	Urbanicity	.021	.005	4.350	.000
	Survey year	-.096	.005	-20.429	.000

	Gender*Recreation areas	-.016	.005	-3.070	.002
	Urbanicity*Place-belongingness	.015	.006	2.685	.007
	Physical activity ~ ~ Place-belongingness	.086	.006	15.389	.000
	Satisfaction with life ~ ~ Affect balance	.441	.005	84.054	.000
	Satisfaction with life ~ ~ Meaning in life	.497	.006	89.294	.000
	Affect balance ~ ~ Meaning in life	.459	.005	85.867	.000
Variiances					
	Physical activity	.959	.009	112.725	.000
	Place-belongingness	.865	.008	110.468	.000
	Satisfaction with life	.744	.007	114.297	.000
	Affect balance	.790	.006	129.967	.000
	Meaning in life	.741	.007	113.631	.000
	Chi Square (DF)			142.592 (19)	
	Chi square p value			.000	
	CFI			.998	
	TLI			.991	
	RMSEA (90% CI lower-upper)			.014 (.012-.016)	
	SRMR			.002	
	BIC			403683.078	

Note. In 2020, exclusions concerned cases n° 2339, 2410, 11601, 9842; and in 2021, n° 1661, 4692, 12191, 475, 4880, 4930, 7662, 9248, 10547, 10781, 16949, 4594.