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2 **Spending time in the garden is positively associated with health and wellbeing: Results**
3 **from a national survey in England**

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16 **Abstract**

17 Research has found that natural environments within urban areas are associated with benefits
18 for human health and wellbeing. However, most studies have primarily focused on publically
19 accessible green space. Less is known about domestic gardens, which in the UK comprise a
20 high proportion of land cover in urban areas and could form a resource for health promotion.

21 This study analysed secondary data from the Monitor of Engagement with the Natural
22 Environment (MENE) survey, a representative survey of the English population (n = 7,814).

23 We investigated the relationships between garden access and use and: general health;
24 evaluative and eudaimonic wellbeing; meeting physical activity guidelines; and visiting
25 nature in the last week. Statistical models included a range of individual and area-level socio-
26 demographic variables. Compared to no garden access, access to a private garden was

27 associated with better evaluative wellbeing, and people with access to a private space such as
28 a balcony, yard or patio were more likely to meet physical activity guidelines. Respondents
29 who reported both gardening and using a garden to relax also reported better health and
30 wellbeing, more physical activity, and more nature visits than those who did not. These
31 findings indicate that domestic gardens are a potential health resource and are not necessarily
32 substituted for by other natural environments, highlighting the importance of their provision
33 alongside green space in urban policy and planning.

34 **Highlights**

- 35 • Green space-health research has concentrated on public, not private, green space.
- 36 • Having access to a private garden is associated with higher wellbeing.
- 37 • Garden use is associated with wellbeing, physical activity, and visiting nature.
- 38 • Gardens need inclusion alongside public green space in urban planning.

39 **1. Introduction**

40 There is growing evidence indicating a positive relationship between urban natural
41 environments and health (Twohig-Bennett & Jones, 2018). Urban natural environments refer
42 to a variety of different types of landcover, including urban ‘green space’ or land that is
43 within a town or city, is not developed, contains natural vegetation, and is accessible to the
44 public (Taylor & Hochuli, 2014). It can also include private and domestic gardens (Dennis &
45 James, 2017) and quasi-publicly accessible spaces including allotments (Genter et al. 2015),
46 cemeteries (Nordh et al. 2017), and other features such as street trees, playing fields, and
47 areas of water (Taylor & Hochuli, 2017). Associations have been found between the amount
48 of, and proximity to, urban natural environments and better mental health, reduced risk of
49 mental health disorders, mortality, and diseases such as Type 2 diabetes, stroke and heart
50 disease (Gascon et al. 2015; Mitchell & Popham, 2008; Nutsford, Pearson, & Kingham,

51 2013; Twohig-Bennett & Jones, 2018). Health is a multidimensional construct, encompassing
52 physical, mental and social domains (Lovell, 2018); this breadth is reflected in the range of
53 health and wellbeing outcomes which have been investigated in relation to natural
54 environments. These spaces, it has been argued, can, depending on their features and
55 accessibility, be used for relaxation, physical activity, building and maintaining social
56 contacts, and spending time with friends and family. These uses are all activities that support
57 different domains of health and may, therefore, contribute to positive health and wellbeing
58 (Twohig-Bennett & Jones, 2018).

59 In objective terms, however, the most commonly researched form of urban natural
60 environment, publically accessible green spaces such as parks and public gardens (Office for
61 National Statistics (ONS), 2019), are often relatively limited in urban areas. Competing
62 demands on land use, including housing or commercial activity, mean that it is difficult for
63 planners to increase their total area (Zhao & Li, 2017). As a result, there is growing interest in
64 gaining a better understanding of the role other types of urban natural environments could
65 play in health and wellbeing promotion and how the provision and use of such areas could
66 deliver these benefits. Domestic gardens, defined as ‘the area adjacent to a domestic
67 dwelling, which itself is either privately owned or rented’ so excluding public and communal
68 gardens (Cameron et al. 2012, p. 129), are a particularly interesting case in point. In Great
69 Britain, whilst ~5% of land cover in urban areas is publically accessible green space, ~30% is
70 private gardens - approximately 530,000 hectares (ONS, 2018) - and 87% of the population
71 have access to a private garden (Davies et al. 2009). The aim of the current research was
72 therefore to explore the potential benefit of gardens using a representative sample of the adult
73 population of England.

74 Domestic gardens are a relatively neglected element in natural environment-health research
75 (Dennis & James, 2017). Many analyses investigating the benefits of neighbourhood urban

76 natural environments exclude gardens altogether (e.g. Mitchell & Popham, 2008; Nutsford,
77 Pearson, & Kingham, 2013). Others have found the association between neighbourhood
78 urban natural environments and health is not affected by the exclusion of gardens from their
79 models (e.g. Alcock et al., 2015; White et al. 2013). However, gardens represent a significant
80 proportion of the natural environments that people are likely to experience in their day to day
81 lives, offering a number of potential benefits and dis-benefits. They provide an opportunity
82 for direct exposure and contact with nature, supporting similar activities to publically
83 accessible green space in terms of use as well as further benefits such as representing a space
84 for growing food. They are also a potential source of allergens and pests (Campbell-Arvai,
85 2018; Gaston et al. 2005; Freeman et al. 2012). Studies in the field of ecosystem services
86 have found that garden owners consider cultural services, including promotion of wellbeing,
87 to be the some of the most important benefits provided by gardens (Calvet-Mir et al. 2012).
88 The benefits of gardens have previously been economically valued using hedonic analysis.
89 Property prices indicate that houses with large gardens sell for a higher price than those with
90 small gardens (Lake et al. 2000), whilst a 1% increase in the area of domestic gardens in a
91 particular district has been shown to lead to a 1% increase in house price (Gibbons, Mourato
92 & Resende, 2014).

93 Untangling a) the connections between garden availability and use on the provision of
94 benefits, and b) interactions between domestic gardens and the availability and use of other
95 forms of urban natural environments such as publically accessible green space, is needed to
96 inform urban planning and public health strategies.

97 *1.1 The direct and indirect benefits of garden access and use*

98 Whilst the few previous studies on gardening have tended to be small-scale and often in non-
99 representative populations (Soga, Gaston, & Yamaura, 2017; Genter et al. 2015), recent

100 analyses have considered associations between gardens and health at a population level in
101 England. Dennis & James (2017) found an association between domestic garden coverage
102 and reduced health deprivation. Brindley, Jorgensen, & Maheswaran (2018) showed that
103 smaller gardens are associated with a higher prevalence of self-reported poor health and
104 found greater income-related inequalities in health in areas with smaller gardens relative to
105 those with larger gardens.

106 Health benefits have been linked to directly experienced aspects of gardens. After beaches
107 and forests, private gardens are considered to be the natural spaces which contribute most to
108 enhancing wellbeing by people in England (Church et al. 2014). Different types of gardening
109 activity are associated with physical and mental health benefits in domestic (Soga, Gaston, &
110 Yamaura, 2017), therapeutic or institutional settings (Joyce & Warren, 2016; Ohly et al.
111 2016; Soga, Gaston, & Yamaura, 2017; Whear et al. 2014). Communal gardening, whether
112 directly through a community garden (Kingsley, Townsend, & Henderson-Wilson, 2009), or
113 indirectly through the shared space of an allotment (Genter et al. 2015), has been linked to
114 positive health outcomes such as lower body mass index (BMI) (Audate et al. 2019; Kunpeuk
115 et al. 2019). The promotion of social networks and cohesion are thought to be particularly
116 important in the provision of benefits from communal gardening (Soga, Gaston, & Yamaura,
117 2017; Nordh et al. 2016; Wood et al. 2016; Kingsley, Townsend, & Henderson-Wilson,
118 2009). Exposure to nature and the wildlife gardens support has also been linked to health,
119 wellbeing and quality of life outcomes (White et al. 2018; Cox & Gaston, 2015; Cox &
120 Gaston, 2016; Fuller et al. 2012; Gaston et al. 2007). Domestic gardens are an important
121 element of green infrastructure so impact indirectly on health by contributing to the provision
122 of ecosystem services in both urban and rural areas (Cox et al. 2019; Cameron et al. 2012;
123 Cabral et al. 2017; Tratalos et al. 2007). These benefits may therefore extend beyond garden
124 owners, for example trees in private gardens have been found to be more important than those

125 in publically accessible green spaces in providing indirect nature experiences within
126 neighbourhoods (Cox et al. 2019).

127 Garden provision could potentially reduce people's visits to other urban natural environments
128 through a substitution or compensation effect (Maat & Vries, 2006). However, there is some
129 evidence that those with gardens may be more likely to visit natural environments such as
130 green spaces, whether due to their sense of connection with nature, or likelihood of having
131 access to green space in the neighbourhood (Lin et al. 2014). Conversely, Syme, Fenton, &
132 Coakes (2001) found that whilst people with small gardens were more likely to visit wetlands
133 than those with larger gardens, there was no effect on park visitation. Similarly, further
134 quantitative (Lin et al. 2014) and qualitative research (Farahani et al. 2018) from Australia
135 found no evidence of a substitution effect.

136 The extent and connectivity of natural spaces in urban areas are under increasing pressure as
137 a result of population growth, housing demand and increasing land values (Lin et al. 2017). It
138 is, therefore, important to understand the benefits and dis-benefits of gardens for human
139 health and wellbeing, particularly the implications of garden access for reducing health
140 inequalities and how they might affect the use of other urban natural environments.

141

142

143 *1.3 Study aims*

144 This study addresses gaps in the literature identified in the previous section regarding the
145 direct health benefits of gardens. Specifically, we investigated whether: (i) garden access is
146 associated with health and wellbeing; (ii) garden use is associated with health and wellbeing;
147 and (iii) there is evidence of garden access and use resulting in a substitution effect with the
148 use of other urban natural environments.

149 2. Methods

150 2.1 Sample

151 Data from the English Monitor of Engagement with the Natural Environment (MENE) survey
152 were obtained for secondary analysis. The MENE is part of a weekly, repeat cross-sectional
153 omnibus survey conducted in England throughout the year. It is commissioned by Natural
154 England, a non-governmental body sponsored by the UK's Department for the Environment,
155 Food and Rural Affairs (DEFRA), and is part of the UK government's national statistics.
156 Sampling is therefore undertaken to ensure that respondents are representative of the adult
157 population of England. The survey is delivered face-to-face in the home by trained
158 interviewers who follow a computer assisted script and recording protocol (Natural England,
159 2018). The survey is structured such that some questions are asked in every weekly wave (i.e.
160 of all study participants), some in one wave per month (so only asked of around a quarter of
161 the sample) and some in one wave per quarter (around 8% of the sample). For this study,
162 anonymised data at the individual level were drawn from the first seven waves of the survey
163 (2009/10 – 2015/16).

164 2.2 Garden access and use

165 Information on garden access was obtained from the following question in the MENE: *Which*
166 *of the following best applies to you ...?*, with possible answers being *'I have access to a*
167 *private garden'*, *'I have access to a private communal garden'*, *'I have access to a private*
168 *outdoor space but not a garden (balcony, yard, patio area)'*, or *'I don't have access to a*
169 *garden'*. As the question referred to all garden types as private, we interpreted all to be
170 domestic gardens as defined in the introduction: an area next to a private dwelling (Cameron
171 et al. 2012). We interpreted 'private garden' as being a space containing vegetation and a
172 'private outdoor space' to have hard surfacing as in the examples given in the question. We

173 did not make any assumptions regarding vegetation or paving in ‘private communal gardens’
174 but interpreted them as accessible to residents of more than one dwelling e.g. a garden
175 associated with flats. This question is asked quarterly.

176 ‘Garden use’ was derived from two possible responses to a question on respondent’s
177 activities in the natural environment. Respondents were asked ‘*Which of the following*
178 *activities involving the natural environment do you take part in? Please choose everything*
179 *you do, both regularly and occasionally*’ and a number of activities, such as watching or
180 listening to nature programmes, looking at books, photos or websites about the natural world,
181 and watching wildlife, were listed. This question is asked quarterly.

182 We focused on the two possible answers which definitely took place in gardens; these were
183 ‘*Gardening*’ or ‘*Sitting or relaxing in a garden*’. For current purposes, we take ‘gardening’ to
184 refer to the physically active activity, categorised as a moderate to vigorous intensity physical
185 activity (MVPA) of 4 metabolic equivalents of task (METs) (White et al. 2016; Ainsworth et
186 al. 2011), whilst sitting and relaxing is taken to be a sedentary activity. Respondents could
187 report taking part in either or both of these activities, so we categorised them into four
188 groups: 1) those who neither gardened nor relaxed in the garden; 2) those who relaxed in the
189 garden; 3) those who gardened; or 4) those who both gardened and relaxed in the garden.

190

191 2.3 Outcomes

192 Four health outcome variables (general health; evaluative wellbeing; eudaimonic wellbeing;
193 and physical activity) were derived from responses to questions in the MENE. Questions on
194 general health and both evaluative and eudaimonic wellbeing are asked monthly whilst
195 details on physical activity are asked weekly.

196 For general health, respondents were asked '*How is your health in general?*' on a five-point
197 scale from '*Very good*' to '*Very bad*', as used in many health surveys and the UK Census.
198 Evaluative wellbeing and eudaimonic wellbeing are measured using two questions on
199 subjective wellbeing developed by the ONS (Waldron, Tinkler, & Hicks, 2010): '*Overall,*
200 *how satisfied are you with your life nowadays?*' and '*Overall to what extent do you feel that*
201 *the things you do in your life are worthwhile?*'. Respondents answered on a scale from 0 to
202 10, where zero was '*not at all satisfied*' and ten was '*completely satisfied*'. The distribution
203 of all three measures had large skews towards the positive end of the scale so were
204 dichotomised around the median into binary variables, with scores of 1-3 or 0-7 being 'low'
205 and 4-5 or 8-10 being 'high' for the respective questions (as in White et al. (2017)).

206 Regarding physical activity, the MENE survey includes the question "*In the past week, on*
207 *how many days have you done a total of 30 min or more physical activity which was enough*
208 *to raise your breathing rate? This may include sport, exercise, and brisk walking or cycling*
209 *for recreation or to get to and from places, but should not include housework or physical*
210 *activity that may be part of your job*". Government guidelines for physical activity
211 recommend 150 minutes or more per week (Bull & The Expert Working Groups, 2010). One
212 way of achieving this is through 30 minutes of exercise on at least 5 days per week, so we
213 categorised respondents as meeting or not meeting the physical activity guidelines based on
214 their response to this question.

215 Our final outcome final outcome variable indicated the frequency respondents had visited
216 nature in the past year. This variable was derived from the question '*Thinking about the last*
217 *12 months, how often, on average, have you spent your leisure time out of doors, away from*
218 *your home.* By out of doors we mean open spaces in and around towns and cities, the coast*
219 *and the countryside. This could be anything from a few minutes to all day. It may include*
220 *time spent close to your home, further afield or while on holiday in England. However, this*

221 *does not include routine shopping trips or time spent in your own garden*'. This question is
222 asked weekly. Possible responses were: (i) *more than once per day*; (ii) *every day*; (iii)
223 *several times a week*; (iv) *once a week*; (v) *once or twice a month*; (vi) *once every 2–3*
224 *months*; (vii) *once or twice*; and (viii) *never*. We collapsed the first four options into 'More
225 than once a week' and latter four options into 'Less than once a week'.

226 *2.4 Control variables*

227 We controlled for a number of individual and area-level variables which are associated with
228 health and wellbeing and likely to be related to garden access and use. Data used was
229 collected as part of the MENE survey.

230 *2.4.1 Area-level controls*

231 The Index of Multiple Deprivation (IMD) score (Department for Communities and Local
232 Government (DCLG), 2008) and percentage of urban natural environment (excluding
233 gardens) and domestic garden coverage in the neighbourhood were derived from
234 respondents' Lower Super Output Area (LSOA) of residence. Green space and garden area
235 density measures were obtained from the Generalised Land Use Database, as used in a
236 number of earlier studies (eg. White et al. 2013; White et al. 2017). For ease of interpretation,
237 quintiles were calculated for each measure for inclusion in the models as area-level control
238 variables. The lowest and highest categories for these were: IMD (0.00 - 10.00=reference,
239 40.60 - 87.80); public green space (0.00 - 12.70=reference, 62.80 - 98.60); and garden
240 coverage (0.00-8.00=reference, 40.90 - 71.00).

241 *2.4.2 Sociodemographic controls*

242 Controls included in the models were: gender (male=reference); age (16–34 years=reference,
243 35–64 years, ≥65 years); occupational social grade of the main income earner as a measure of
244 socioeconomic status (SES) with AB being the highest status occupations e.g. higher

245 managerial positions and DE the lowest e.g. semi- or unskilled manual roles (AB, C1, C2,
246 DE=reference) (Ipsos-MORI, 2009); employment status (full-time=reference, part-time, in
247 education, not working, retired, unemployed/not working); marital status (married/living as
248 married=reference, single, separated/divorced/widowed); children in household (any,
249 none=reference); home ownership (owned outright, mortgage=reference, rented local
250 authority, rented private, other); dog ownership (yes, no=reference).

251 *2.5 Analyses*

252 Respondents to the MENE survey have been asked about activities in the garden since 2009
253 so this sample was larger (n=24631) than that on garden access, as the question on garden
254 access was introduced in May 2014 (Natural England, 2018). We included only respondents
255 who answered both questions in our analysis (n=7,814). Due to some missing data, our
256 sample size was smaller for two of the health outcomes: general health (n=6,907) and
257 eudaimonic wellbeing (n=5,173).

258 All analyses were conducted in R v3.5.1. We ran three sequential binary logistic regression
259 models for each of the four health outcomes and for the likelihood of visiting nature once a
260 week. These models investigated the association between the five outcomes and (Model 1)
261 garden access alone; (Model 2) garden access and garden use; and (Model 3) garden access
262 and garden use, adjusted for individual and area-level potential confounders. A similar
263 approach building from crude to fully adjusted models is taken by other studies e.g. Dean et
264 al. (2018), White et al. (2017), and allows exploration of the extent to which garden access
265 and activity explain the outcomes before and after adjustment for confounding. Linear
266 models were also run for general health, evaluative wellbeing, eudaimonic wellbeing and
267 physical activity as a sensitivity analysis as in White et al. (2019); these models can be found
268 in the Supplementary Material. As there was little difference in the fully adjusted models and

269 the outcome variables were highly skewed, we report the results of the binary models here in
270 the main text.

271 **3. Results**

272 The socio-demographic characteristics of the sample can be found in Tables 1 and 2. Results
273 from the models are reported in sections 3.1, 3.2 and in Table 3; all odds ratios (ORs) and
274 confidence intervals (CIs) refer to models adjusted for individual and area-level variables.

275 There were variations in garden access between groups. Fewer people in the youngest age
276 category had access to a private garden: 69.7% compared to 79.9% among those age 35 to 64
277 and 85.6% of those aged over 65. Younger people were more likely to have no garden access
278 (18.3%), whereas only 10.0% (8.3%) of those over 65 did not have a garden. Whilst the
279 majority of respondents in all SES groups had access to a private garden, only 6.3% of those
280 in AB had no access to a garden compared with 17.1% of those in the DE group. Consistent
281 with the age findings, retired people had the highest proportion of private garden access
282 (84.9%); economic activity groups that had the lowest proportion of access to private garden
283 included those who were in education or not working (70%). Only 5.3% of respondents who
284 were homeowners and 5.2% who had a mortgage did not have access to a private garden,
285 compared to 20.8% of private renters and 24.3% of people renting from local authorities.

286 Similar variation was observed for garden use. Almost half (48.5%) of people aged over 65
287 gardened and relaxed in their garden, whereas less than a quarter (23.8%) of people aged 16
288 to 34 used the garden for both of these activities. However, more 16 to 34 year olds used their
289 garden for relaxing than any other age category. People who participated in either gardening
290 or relaxing in the garden were distributed fairly evenly between SES groups but 52.1% of
291 those in the AB group used the garden for both activities, compared to 30.1% in the DE
292 group. Almost half (48.6%) of retired people gardened and relaxed in their garden, a higher

293 proportion than any other employment category. The largest percentage of people who did
294 not use the garden was found among those in education or not working. The lowest number
295 of people using their garden for both activities were those who were renting.

296 *3.1 Garden access, health, wellbeing, and visits to nature*

297 In the unadjusted models of garden access (Model 1), respondents with access to a private
298 garden had significantly greater odds of reporting high evaluative and eudaimonic wellbeing,
299 meeting physical activity guidelines, and visiting nature once a week compared to people
300 with no garden access.

301 Those with access to a communal garden reported significantly worse general health than
302 those with no garden but were more likely to visit nature once a week. Respondents with
303 access to an outdoor space such as a yard or balcony were also more likely to visit nature
304 once a week than those with no garden as well as being more likely to meet physical activity
305 guidelines. Of note the explanatory power of gardens in these models was modest, ranging
306 from 7 to 19%.

307 *3.2 Garden access and use, health, wellbeing, and visits to nature*

308 In Model 2, the inclusion of respondents' participation in activities in the garden in the
309 models resulted in private garden or outdoor space access no longer being associated with
310 eudaimonic wellbeing or visiting nature. Private garden access continued to be associated
311 with evaluative wellbeing, whilst meeting physical activity guidelines was associated with
312 having access to a private outdoor space. Respondents with a communal garden were more
313 likely to report poor general health compared to those with no garden, as in the model which
314 did not include participation in garden activities.

315 Garden activities were associated with the outcome variables after adjusting for garden access
316 (again Model 2). Those who used the garden for any activity (relaxing in the garden,

317 gardening, or both of these activities) were more likely than those who did not use it to report
318 higher eudaimonic wellbeing and visiting nature once a week. Those who both gardened and
319 relaxed in the garden were also more likely to report good general health, high evaluative
320 wellbeing, and meeting physical activity guidelines than those who did neither. Compared
321 with those who took part in no garden activities, respondents who only gardened had better
322 general health whilst those who only relaxed reported higher evaluative wellbeing.

323 After adjustment for individual and area-level covariates in Model 3, garden access became
324 associated with some outcomes. Owning a private garden was associated with higher
325 evaluative wellbeing than having no garden (OR 1.22, CI 1.02-1.47). Those who had access
326 to a private outdoor space were more likely to meet physical activity guidelines (OR 1.54,
327 1.15-2.05).

328 Using the garden for both relaxing and gardening was associated with reporting better
329 outcomes in all five models: general health (OR 1.48, CI 1.26-1.74), evaluative wellbeing
330 (OR 1.48, CI 1.27-1.74), eudaimonic wellbeing (OR 1.88, CI 1.56-2.26), physical activity
331 (OR 1.44, CI 1.24-1.67), and visiting nature (OR 1.90, CI 1.66-2.16), compared with doing
332 neither activity. As before adjustment, using the garden for relaxing or gardening were also
333 associated with reporting high eudaimonic wellbeing (relaxing OR 1.29, CI 1.07-1.55;
334 gardening OR 1.53, CI 1.19-1.98) and visiting nature once a week (relaxing OR 1.26, CI
335 1.10-1.44; gardening OR 1.36, CI 1.14-1.62). Gardening remained associated with reporting
336 better general health (OR 1.56, 1.26-1.95) and became associated with meeting physical
337 activity guidelines (OR 1.24, CI 1.02-1.51). However, after adjustment, relaxing in the
338 garden was no longer associated with reporting higher evaluative wellbeing.

339 Fig. 1 presents a comparison of associations between garden use and being in the highest SES
340 group and health and wellbeing, meeting physical activity guidelines, and visiting nature once

341 a week, using fully adjusted ORs from Model 3. Both garden use and high SES were
342 associated with higher odds of reporting good health and wellbeing and being more likely to
343 meet physical activity guidelines and visit nature once a week. The ORs were similar, and in
344 most cases larger, for garden use.

345 **4. Discussion**

346 In our final models (Model 3), which were fully adjusted for both individual and area-level
347 covariates, access to a private outdoor space was associated with positive health and
348 wellbeing outcomes. Private garden owners reported higher evaluative wellbeing than
349 respondents with no garden, whilst people with access to a private space such as a yard were
350 more likely to meet physical activity guidelines. Reported use of the garden was important in
351 deriving benefits: compared to people who did not use the garden, respondents who both
352 relaxed in the garden and gardened had better general health, mental wellbeing, higher levels
353 of physical activity and visited nature more frequently. People who reported using the garden
354 for one of these activities had higher eudaimonic wellbeing than those who did not use the
355 garden, and gardeners were also more likely to meet physical activity guidelines.

356

357

358 *4.1 Health and wellbeing benefits of garden access and use*

359 We found that access to a private space, whether a garden or other outdoor area, has benefits
360 for health and wellbeing. There is limited research into the links between gardens and health
361 at a neighbourhood level but our results are supported by previous studies which have found
362 associations between garden coverage, reduced health deprivation (Dennis & James, 2017),
363 and poor health (Brindley, Jorgensen, & Maheswaran, 2018). Similarly to Cervinka et al.
364 (2016), who found that gardens were rated as more restorative than other private spaces, we

365 found that only private garden access was associated with wellbeing. More broadly, research
366 has shown that living in a greener neighbourhood, to which private gardens contribute, is
367 associated with better mental and physical health (Alcock et al. 2015; Nutsford, Pearson, &
368 Kingham, 2013; White et al. 2013; Twohig-Bennett & Jones, 2018). Our findings suggest
369 that private green spaces are important in providing these benefits as well as other urban
370 natural environments.

371 The results also indicate that using gardens may play a major role in deriving benefits from
372 them. Both of the activities we focused on, gardening and sitting and relaxing in the garden,
373 were associated with health and wellbeing. In models of eudaimonic wellbeing and visiting
374 nature once a week, the addition of garden activities led to the type of garden access no
375 longer being significant, indicating that the benefits of having garden access are explained by
376 actual garden use. Domestic or everyday gardening has been linked with positive physical
377 and mental health outcomes in previous small-scale studies (Soga, Gaston, & Yamaura,
378 2017); our study provides evidence for this association at a larger scale and in a
379 representative sample. Respondents who relaxed and gardened or who only gardened were
380 more likely to meet physical activity guidelines, whereas those who only relaxed were not.
381 These activities were only significant in models which had been fully adjusted for
382 sociodemographic variables which could confound the association, suggesting that gardening
383 is contributing to meeting the guidelines. Government policy increasingly recognises and
384 promotes everyday, as well as intentional or sport-related, activities such as gardening as a
385 key means of increasing population-level physical activity (NHS, 2018). Our findings
386 highlight the importance of activities which people might not typically consider 'exercise' in
387 contributing to health. In terms of wellbeing, garden use may have an additive effect in
388 providing benefits; garden owners reported higher life satisfaction, whilst using the garden
389 was associated with eudaimonic wellbeing, feeling life is worthwhile.

390 *4.2 Types of gardens*

391 Private gardens and private outdoor spaces were the two types of garden most associated with
392 positive health outcomes. This may reflect some of the socio-demographic variations seen in
393 garden access and use. It also suggests that privacy, and the security it affords, may be an
394 important aspect in the provision of benefits by domestic gardens (Cameron et al. 2012).
395 Further, the ownership of a private garden or outdoor space avoids the inherent potential for
396 conflict in the design, management and use of shared spaces. People with access to a
397 communal garden may have no actual agency over what it contains or how it is used (Buck,
398 2016), and we did see a negative association between general health and reporting access to a
399 communal garden in the unadjusted model. A private garden can afford the opportunity to
400 craft and nurture one's own space, and to express and act on identity and values (Freeman et
401 al. 2012).

402 Although it has been suggested that access to a private garden may reduce people's visits to
403 publically accessible green space through a substitution or compensation effect (Maat &
404 Vries, 2006), we found the opposite, with people who used their gardens being more likely to
405 visit other urban natural environments. Lin et al. (2014) also found that people who visited
406 green space were more likely to spend time in their garden which they attributed to
407 'orientation' as these people were more connected with nature. Connection with nature has
408 been associated with positive health outcomes (Capaldi, Dopko, & Zelenski, 2014; Dean et
409 al. 2018) as well as with visiting nature more frequently (Lin et al. 2014; Soga & Gaston,
410 2016). It may therefore be a pathway through which garden access and use benefits health.

411 *4.3 Implications for green infrastructure and planning*

412 Gardens can provide multiple benefits as part of the urban green infrastructure, from food
413 production to noise mitigation (ONS, 2018). However, their role as a health resource needs

414 further recognition. Urbanisation and a growing population are placing pressure on local
415 authorities and developers to provide houses, and at a greater density, whether in existing
416 urban areas or in new developments (Wilson & Barton, 2018). Gardens are currently an
417 extensive resource (ONS, 2018) but with increasing pressure on budgets, urban natural
418 environments of all types are in danger of being cut to make savings or maximise profits. Our
419 findings demonstrate the importance of gardens and private outdoor spaces for both the
420 physical and mental health of the community and indicate that other urban natural
421 environments are not substitutable. There is some indication from previous studies that
422 garden size is important, with smaller gardens providing fewer health benefits (Brindley,
423 Jorgensen, & Maheswaran, 2018), whilst larger gardens are more likely to be used and have
424 different characteristics e.g. more tree cover (Lin et al. 2017). Our results also indicate the
425 type of space is important, with the provision of health benefits differing between gardens
426 and other outdoor spaces e.g. balconies, yards or patios. As with publically accessible green
427 space, whilst there are recommendations for minimum garden size, there may be a need for
428 standards or guidelines regarding garden characteristics and to prevent their loss to other land
429 uses (Chalmuin-Pui et al. 2019). Private gardens appear to be most important in the provision
430 of benefits, so aspects such as whether spaces are overlooked need greater consideration in
431 green infrastructure planning and the implementation of nature-based solutions.

432 *4.4 Implications for the promotion of gardening for health*

433 Our findings regarding the health benefits of the use of gardens have implications for the
434 development of public health messages relating to gardening. We showed that those who
435 reported gardening reported better general health and were more likely to meet physical
436 activity guidelines. Our findings support the recognition of gardening as a route to the
437 achievement of the recommended physical activity guidelines. Prior research has found that
438 gardening becomes more important as people age and is one of the most active pastimes of

439 older people (Buck, 2016). Gardening may, therefore, represent an alternative activity which
440 appeals to those who are less interested in other forms of exercise, such as competitive sports,
441 with the potential to promote higher rates of activity in traditional harder to reach groups e.g.
442 people from ethnic minorities or low-income groups (Bonevski et al. 2014). Our findings
443 support the value of efforts to promote garden use in the general population. These include
444 programmes such as the Royal Horticultural Society (RHS) Support for School Gardening
445 which aims to help children to learn about gardening (RHS, n. d.); gardening is also
446 recommended as an activity by the NHS Get Active Your Way campaign (NHS, 2018).
447 However, we recommend that further promotion activities are needed, specifically those
448 which target groups who could benefit most; these would, however, need to be sensitive to
449 the socio-economic inequalities in access to private gardens noted in this analysis.

450 *4.5 Strengths and limitations, and research needs*

451 The strengths of this study lie in the use of a large-scale dataset from a national survey, with
452 the sample being representative of the English population. However, the limitations of the use
453 of data resulting from self-reported aspects of the survey should be noted. We assumed that
454 all private gardens had natural features but they may have only had a patio, meaning they
455 could have been classed as a 'private outdoor space'. As people were offered these two
456 alternatives side by side, we think the number of misclassifications is likely to be small but
457 given that the MENE is conducted as part of an in-home interview, future iterations might ask
458 interviewers to check the status of garden and make their own assessment on the presence of
459 natural features. We also do not know if the garden activities in which people participated
460 took place in the respondent's own garden. As a result of our findings and these limitations,
461 we have some suggestions for future research into the association between gardens and
462 health.

463 We found no evidence of a substitution effect between garden access and visiting other urban
464 natural environments. However, we were relying on self-reported visits to these spaces. The
465 question of substitution is important for urban planning so merits detailed study using actual
466 visit data, considering the frequency and duration of people's visits as well as comparison of
467 the use of gardens and other urban natural environments in terms of types and intensity of
468 activity. There are also further questions relating to the influence of the type and
469 characteristics of the garden on health outcomes. Although we could distinguish between
470 private gardens and outdoors spaces such as yards or patios, we had no further information on
471 the qualities of the space, such as whether they contained plants, trees or water, or whether
472 they were covered in artificial surfacing. Different features are likely to afford different
473 experiences and uses and some, such as trees, may provide benefits to people beyond the
474 garden owner (Cox et al. 2019). A connected avenue of research is needed investigating why
475 these different spaces are beneficial, for example, the importance of giving people agency
476 over garden design and whether communal gardens might offer benefits if people had more
477 involvement in their management. This would aid understanding of how the integration of
478 different characteristics may facilitate or promote health and wellbeing outcomes. We were
479 also unable to investigate variation in outcomes between different social and demographic
480 groups to a greater degree due to small sample sizes for some categories. Further research
481 into the distribution and equity of opportunity and benefits is needed and would help craft
482 public health messages and inform planning and green infrastructure standards.

483 Understanding positive relationships between garden use and health, such as the contribution
484 of gardening to meeting physical activity guidelines, is important. However, there is the
485 potential for negative interaction with the garden (Cameron et al. 2012). Maintaining the
486 garden, for example, demands time, carries the risk of injury, and depending on a person's
487 abilities may not be achievable (Cameron et al. 2012). Further research is needed into how

488 we provide and design appropriate garden or outdoor spaces for different needs and desires.
489 The development of co-beneficial ownership and management models where, for example,
490 young or transient populations with no gardens work with older households, for whom
491 gardening may have become a burden, to look after their gardens may also be of value. There
492 is also a need to develop our understanding of the implications of planning and developing
493 complex ‘private-public spaces’, as exemplified by recent controversies in the UK regarding
494 unequal access to outdoors spaces (eg. Grant, Mohdin & Michael, 2019).

495 **5. Conclusions**

496 This study of a representative sample of the English population demonstrates the link
497 between gardens and health and wellbeing outcomes, finding positive effects of private
498 garden access, gardening and other uses of gardens for both wellbeing and physical activity
499 levels. These findings have important implications for the planning and development of urban
500 areas, providing evidence there may be a need for private green and outdoor spaces *alongside*
501 publically accessible green spaces. They also establish the benefits of gardens to public
502 health, further clarifying their role in helping individuals to meet physical activity guidelines
503 and promote wellbeing. Gardens have been relatively neglected in the study of green space-
504 health. Further research is needed to better understand the characteristics and pathways
505 responsible for the provision of benefits by gardens and how to harness the health benefits
506 associated with the use of these spaces.

507 **Author Statement**

508 **Sian de Bell:** Conceptualization, Methodology, Formal Analysis, Writing - Original Draft
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512 Conceptualization, Writing- Reviewing and Editing, **Rebecca Lovell:** Conceptualization,
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Figure 1 Comparison of associations between garden use (relaxing in the garden and gardening, ref=no garden use), SES (AB, ref= DE) and reporting: good general health (GH), high evaluative wellbeing (EV), high eudaimonic wellbeing (EU), meeting physical activity guidelines (PA), and visiting nature once a week (VN) (Odds ratios and 95 CIs). Note: All coefficients adjusted for individual and area level covariates.

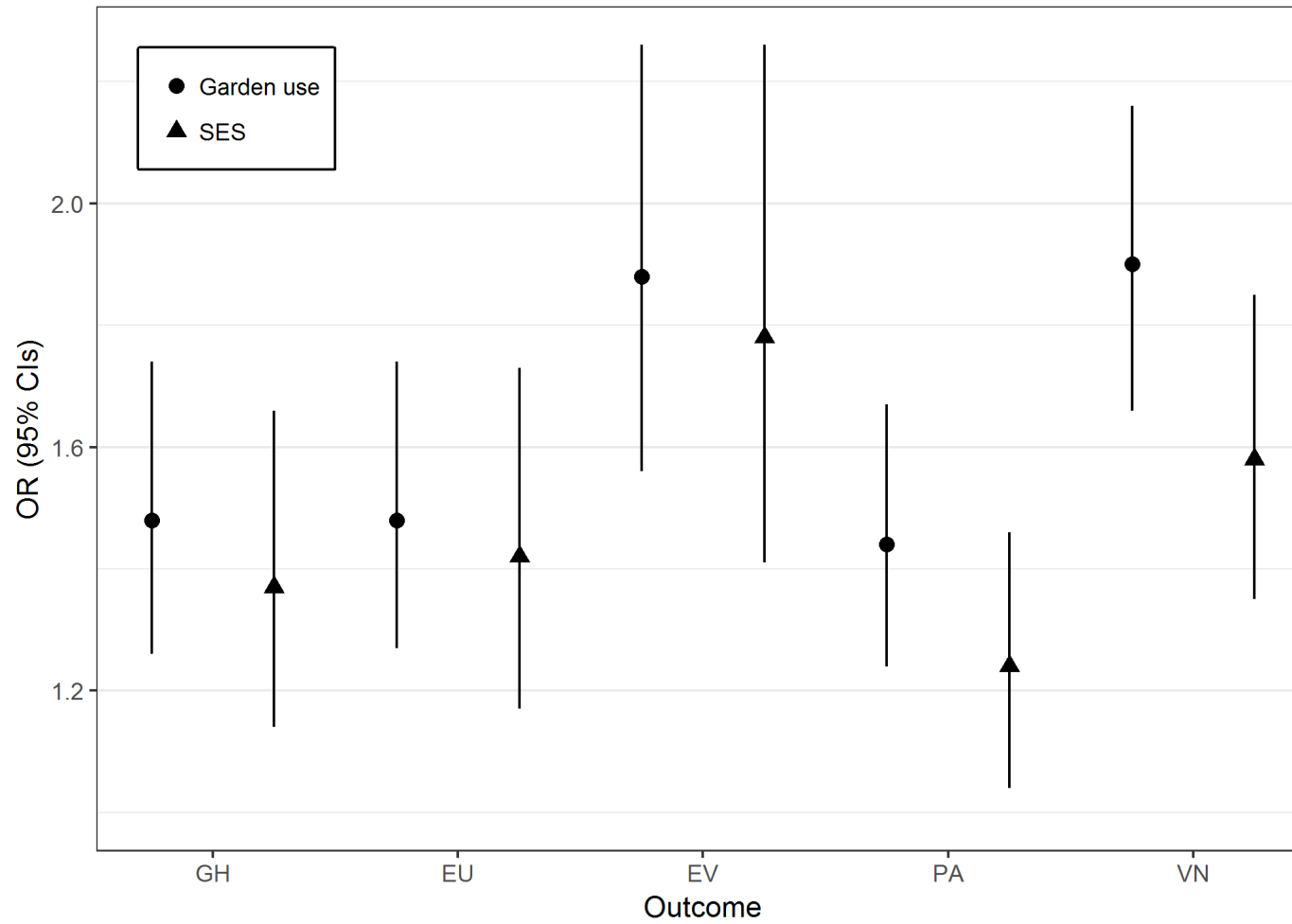


Figure 1 Comparison of associations between garden use (relaxing in the garden and gardening, ref=no garden use), SES (AB, ref= DE) and reporting: good general health (GH), high evaluative wellbeing (EV), high eudaimonic wellbeing (EU), meeting physical activity guidelines (PA), and visiting nature once a week (VN) (Odds ratios and 95 CIs). Note: All coefficients adjusted for individual and area level covariates.

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Table 1 Garden access by sociodemographic and area level factors (n=7814)

	Private garden		Communal garden		Private yard/patio/ balcony		No garden		Total
	n	%	n	%	n	%	n	%	
<i>Individual demographics</i>									
Gender									
Male	2814	76.4	185	5.0	143	3.9	542	14.7	3684
Female	3286	79.6	192	4.6	178	4.3	474	11.5	4130
Age									
16-34	1760	69.7	147	5.8	155	6.1	462	18.3	2524
35-64	2645	79.9	157	4.7	118	3.6	391	11.8	3311
65+	1695	85.6	73	3.7	48	2.4	163	8.2	1979
SES									
AB	1249	88.8	33	2.3	35	2.5	89	6.3	1406
C1	1576	79.4	87	4.4	92	4.6	229	11.5	1984
C2	1261	78.9	64	4.0	60	3.8	214	13.4	1599
DE	2014	71.3	193	6.8	134	4.7	484	17.1	2825
Work status									
Employed fulltime	2068	78.1	122	4.6	96	3.6	362	13.7	2648
Employed part-time	797	78.8	40	4.0	50	4.9	124	12.3	1011
Retired	1858	84.9	86	3.9	54	2.5	191	8.7	2189
In education/training	395	70.2	26	4.6	50	8.9	92	16.3	563
Not working	982	70.0	103	7.3	71	5.1	247	17.6	1403
Marital status									
Married/living as married	3559	83.4	137	3.2	131	3.1	442	10.4	4269
Single	1490	67.5	147	6.7	138	6.3	433	19.6	2208
Separated/divorced/ widowed	1051	78.6	93	7.0	52	3.9	141	10.5	1337
Children in household									
Any	1735	78.4	88	4.0	81	3.7	308	13.9	2212
None	4365	77.9	289	5.2	240	4.3	708	12.6	5602
Ethnicity									
White British	4915	82.9	231	3.9	223	3.8	562	9.5	5931
Other	1185	62.9	146	7.8	98	5.2	454	24.1	1883
Home ownership									
Owned outright	1498	89.8	34	2.0	49	2.9	88	5.3	1669
Mortgage	2219	90.6	51	2.1	52	2.1	127	5.2	2449
Rented local authority	1011	62.0	139	8.5	85	5.2	396	24.3	1631
Rented private	1147	64.4	139	7.8	125	7.0	370	20.8	1781
Other	225	79.2	14	4.9	10	3.5	35	12.3	284
Dog ownership									
Yes	1535	86.3	43	2.4	77	4.3	124	7.0	1779
No	4565	75.6	334	5.5	244	4.0	892	14.8	6035
Car ownership									
Yes	4509	85.3	174	3.3	175	3.3	429	8.1	5287

No	1591	63.0	203	8.0	146	5.8	587	23.2	2527
<i>Area level factors</i>									
IMD									
0.00 - 10.00	1372	88.1	63	4.0	43	2.8	80	5.1	1558
10.00 - 17.10	1364	87.0	54	3.4	54	3.4	95	6.1	1567
17.10 - 26.30	1229	78.7	92	5.9	63	4.0	177	11.3	1561
26.30 - 40.60	1098	70.2	88	5.6	75	4.8	302	19.3	1563
40.60 - 87.80	1037	66.3	80	5.1	86	5.5	362	23.1	1565
Urban natural environment (excluding gardens) quintiles									
0.00 - 12.70	1056	67.6	86	5.5	96	6.1	323	20.7	1561
12.70 - 23.50	1136	72.6	99	6.3	72	4.6	258	16.5	1565
23.50 - 37.30	1229	78.7	81	5.2	51	3.3	201	12.9	1562
37.30 - 62.80	1269	81.6	70	4.5	56	3.6	161	10.3	1556
62.80 - 98.60	1410	89.8	41	2.6	46	2.9	73	4.6	1570
Garden green space quintiles									
0.00 – 8.00	1239	79.3	60	3.8	67	4.3	196	12.5	1562
8.00 - 18.00	1104	70.8	74	4.7	81	5.2	301	19.3	1560
18.00 - 29.20	1184	75.7	74	4.7	74	4.7	233	14.9	1565
29.20 - 40.90	1226	78.4	93	6.0	55	3.5	189	12.1	1563
40.90 - 71.00	1347	86.1	76	4.9	44	2.8	97	6.2	1564

Table 2 Activities in the garden by sociodemographic and area level factors (n=7814)

	Does not sit and relax; does not garden		Sits and relaxes in the garden		Gardens		Sits and relaxes in the garden; gardens		Total
	n	%	n	%	n	%	n	%	
<i>Individual demographics</i>									
Gender									
Male	1163	31.6	815	22.1	380	10.3	1326	36.0	3684
Female	1054	25.5	987	23.9	392	9.5	1697	41.1	4130
Age									
16-34	928	36.8	790	31.3	206	8.2	600	23.8	2524
35-64	857	25.9	671	20.3	319	9.6	1464	44.2	3311
65+	432	21.8	341	17.2	247	12.5	959	48.5	1979
SES									
AB	236	16.8	307	21.8	130	9.2	733	52.1	1406
C1	480	24.2	501	25.3	186	9.4	817	41.2	1984
C2	461	28.8	366	22.9	148	9.3	624	39.0	1599
DE	1040	36.8	628	22.2	308	10.9	849	30.1	2825
Work status									
Employed fulltime	753	28.4	594	22.4	239	9.0	1062	40.1	2648
Employed part-time	289	27.1	256	24.0	93	8.7	429	40.2	1067
Retired	476	21.7	378	17.3	271	12.4	1064	48.6	2189
In education/training	214	38.0	233	41.4	35	6.2	81	14.4	563
Not working	485	36.0	341	25.3	134	9.9	387	28.7	1347
Marital status									
Married/living as married	951	22.3	880	20.6	461	10.8	1977	46.3	4269
Single	897	40.6	651	29.5	176	8.0	484	21.9	2208
Separated/divorced/ widowed	369	27.6	271	20.3	135	10.1	562	42.0	1337
Children in household									
Any	655	29.6	550	24.9	207	9.4	800	36.2	2212
None	1562	27.9	1252	22.3	565	10.1	2223	39.7	5602
Ethnicity									
White British	1454	24.5	1329	22.4	581	9.8	2567	43.3	5931
Other	763	40.5	473	25.1	191	10.1	456	24.2	1883
Home ownership									
Owned outright	338	20.3	402	24.1	145	8.7	784	47.0	1669
Mortgage	433	17.7	429	17.5	299	12.2	1288	52.6	2449
Rented local authority	690	42.3	360	22.1	150	9.2	431	26.4	1631
Rented private	644	36.2	534	30.0	150	8.4	453	25.4	1781
Other	112	39.4	77	27.1	28	9.9	67	23.6	284
Dog ownership									
Yes	418	23.5	413	23.2	174	9.8	774	43.5	1779
No	1799	29.8	1389	23.0	598	9.9	2249	37.3	6035
Car ownership									

Yes	1154	21.8	1158	21.9	552	10.4	2423	45.8	5287
No	1063	42.1	644	25.5	220	8.7	600	23.7	2527

Area level factors

IMD

0.00 - 10.00	281	18.0	337	21.6	170	10.9	770	49.4	1558
10.00 - 17.10	329	21.0	365	23.3	152	9.7	721	46.0	1567
17.10 - 26.30	411	26.3	363	23.3	160	10.2	627	40.2	1561
26.30 - 40.60	526	33.7	398	25.5	143	9.1	496	31.7	1563
40.60 - 87.80	670	42.8	339	21.7	147	9.4	409	26.1	1565

Urban natural environment (excluding gardens) quintiles

0.00 - 12.70	527	33.8	407	26.1	141	9.0	486	31.1	1561
12.70 - 23.50	517	33.0	355	22.7	166	10.6	527	33.7	1565
23.50 - 37.30	483	30.9	362	23.2	146	9.3	571	36.6	1562
37.30 - 62.80	387	24.9	343	22.0	161	10.3	665	42.7	1556
62.80 - 98.60	303	19.3	335	21.3	158	10.1	774	49.3	1570

Garden green space quintiles

0.00 - 8.00	414	26.5	334	21.4	157	10.1	657	42.1	1562
8.00 - 18.00	508	32.6	354	22.7	144	9.2	554	35.5	1560
18.00 - 29.20	467	29.8	360	23.0	165	10.5	573	36.6	1565
29.20 - 40.90	449	28.7	382	24.4	141	9.0	591	37.8	1563
40.90 - 71.00	379	24.2	372	23.8	165	10.5	648	41.4	1564

Table 3 Binary logistic regression models predicting general health, evaluative wellbeing, eudemonic wellbeing, meeting physical activity guidelines, and visiting nature once a week from garden access and use. OR = odds ratio; CI = confidence intervals; *** p < 0.001; ** p < 0.01; * p < 0.05

	Model 1		Model 2		Model 3 (incl. covariates) ^a	
	OR	95% CI	OR	95% CI	OR	95% CI
General health						
Garden access						
Private garden	1.10	0.94-1.28	0.94	0.79-1.11	0.87	0.72-1.06
Communal garden	0.76*	0.58-0.99	0.71*	0.55-0.94	0.81	0.60-1.09
Private outdoor space	0.94	0.71-1.26	0.87	0.65-1.17	0.76	0.55-1.05
No garden	1	/	1	/	1	/
Garden use						
Does not sit and relax, does not garden			1	/	1	/
Does sit and relax			1.38***	1.20-1.59	0.97	0.82-1.15
Does garden			1.13	0.98-1.32	1.56***	1.26-1.95
Does sit and relax , does garden			1.39***	1.14-1.71	1.48***	1.26-1.74
Number of observations	6907		6907		6907	
Log likelihood	-4050.66		-4039.08		-3564.14	
Nagelkerke R ²	0.00		0.01		0.19	
AIC	8109.30		8092.20		7202.30	
Evaluative wellbeing						
Garden access						
Private garden	1.43***	1.25-1.64	1.39***	1.18-1.64	1.22*	1.02-1.47
Communal garden	1.05	0.82-1.33	0.98	0.75-1.28	1.09	0.82-1.45
Private outdoor space	1.13	0.88-1.47	1.02	0.77-1.36	0.98	0.73-1.33
No garden	1	/	1	/	1	/

Garden use						
Does not sit and relax, does not garden			1	/	1	/
Does sit and relax			1.72***	1.48-1.99	1.14	0.97-1.34
Does garden			1.27***	1.09-1.48	1.05	0.85-1.29
Does sit and relax , does garden			1.16	0.95-1.42	1.48***	1.27-1.74
Number of observations	7814		6907		6907	
Log likelihood	-4964.10		-3803.21		-3635.70	
Nagelkerke R ²	0.01		0.03		0.09	
AIC	9936.20		7620.40		7345.40	
<hr/>						
Eudaimonic wellbeing						
Garden access						
Private garden	1.15*	1.00-1.31	1.18	0.97-1.43	1.01	0.82-1.25
Communal garden	0.89	0.70-1.13	0.75	0.55-1.02	0.83	0.60-1.15
Private outdoor space	1.02	0.79-1.31	0.98	0.70-1.40	0.92	0.64-1.33
No garden	1	/	1	/	1	/
Garden use						
Does not sit and relax, does not garden			1	/	1	/
Does sit and relax			2.22***	1.87-2.65	1.29**	1.07-1.55
Does garden			1.45***	1.21-1.74	1.53***	1.19-1.98
Does sit and relax , does garden			1.69***	1.32-2.17	1.88***	1.56-2.26
Number of observations	5173		5173		5173	
Log likelihood	-2763.89		-2723.1		-2606.83	
Nagelkerke R ²	0.01		0.04		0.10	
AIC	5535.80		5460.20		5287.70	

Meeting physical activity guidelines						
Garden access						
Private garden	1.24*	1.06-1.46	1.08	0.91-1.28	1.01	0.84-1.22
Communal garden	1.00	0.75-1.32	0.96	0.72-1.27	1.00	0.74-1.33
Private outdoor space	1.74***	1.32-2.29	1.65***	1.24-2.17	1.54***	1.15-2.05
No garden	1	/	1	/	1	/
Garden use						
Does not sit and relax, does not garden			1	/	1	/
Does sit and relax			1.38***	1.21-1.59	1.00	0.85-1.17
Does garden			0.99	0.85-1.15	1.24*	1.01-1.51
Does sit and relax , does garden			1.18	0.97-1.43	1.44***	1.24-1.67
Number of observations	7814		7814		7814	
Log likelihood	-4430.79		-4414.63		-4256.31	
Nagelkerke R ²	0.00		0.01		0.07	
AIC	8869.60		8843.30		8586.60	
Visiting nature once a week						
Garden access						
Private garden	1.52***	1.33-1.73	1.14	0.99-1.32	0.98	0.83-1.14
Communal garden	1.28*	1.01-1.62	1.16	0.91-1.47	1.25	0.97-1.60
Private outdoor space	1.33*	1.03-1.71	1.17	0.90-1.50	1.00	0.77-1.30
No garden	1	/	1	/	1	/
Garden use						
Does not sit and relax, does not garden			1	/	1	/
Does sit and relax			1.92***	1.70-2.17	1.26***	1.10-1.44

Does garden		1.36***	1.20-1.55	1.36***	1.14-1.62
Does sit and relax , does garden		1.33***	1.13-1.58	1.90***	1.66-2.16
Number of observations	7814	7814		7814	
Log likelihood	-5338.68	-5280.95		-5029.76	
Nagelkerke R ²	0.01	0.03		0.11	
AIC	10716.00	10576.00		10134.00	

^acontrolling for gender, age, SES, work status, marital status, children in household, home ownership, dog ownership, IMD, urban natural environments (excluding gardens), garden green space. See Supplementary Materials (Tables S1-S5) for full details.