


Subjective evaluation of home environment and levels of self-reported depression in middle to old age: Results from the HCHS study

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Abstract

Objectives: The immediate living environment might, like other lifestyle factors, be significantly related to mental well-being. The current study addresses the question whether five relevant subjective home environment variables (i.e., protection from disturbing nightlight, daylight entering the home, safety at home, quality of window views, and noise disturbance) are associated with levels of self-reported depression over and above well-known sociodemographic and common lifestyle variables.

Methods: Data from the Hamburg City Health Study (HCHS) were analyzed. In $N = 8757$ with available PHQ-9 depression data, multiple linear regression models were computed, with demographic data, lifestyle variables, and variables describing the subjective evaluation of the home environment.

Results: The model explained 15% of variance in depression levels, with ratings for the subjective evaluation of home environment accounting for 6%. Better protection from disturbing light at night, more daylight entering the home,

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feeling safer, and perceived quality of the window views, were all significantly associated with lower, while more annoyance by noise was associated with higher levels of self-reported depression. Results did not differ if examining a sample of the youngest (middle-aged participants: 46–50 years) versus oldest (70–78 years) participants within HCHS. **Conclusion:** Beyond studying the role of lifestyle factors related to self-reported depression, people's homes may be important for subclinical levels of depression in middle and older age, albeit the direction of effects or causality cannot be inferred from the present study. The development of a consensus and tools for a standardized home environment assessment is needed.

KEYWORDS

HCHS, housing, lifestyle, self-reported depression, subjective evaluation of home environment

1 | INTRODUCTION

Environmental psychology is, among other topics, concerned with people-environment interactions, including the question of how and to which degree physical environments are associated with human behavior, emotional state, or (mental) health. Hence, intervening at the level of changing context (environmental parameters) is hypothesized to influence human behavior and (mental) health variables. Thus, this branch of environmental psychology can be seen as a complementary approach to an individual-centered view which focuses primarily on habits and lifestyle choices, placing emphasis on the need to change within the individual. The immediate home environment has the important function of serving the essential human need of privacy, refuge, and shelter. One's home provides a relatively stable environmental context with generally large times of exposure. According to a study on 12,000 individuals from 5530 randomly selected households in Germany (originally addressing "dampness and mold" in homes), it was found that on average individuals spent 15.7 h/day at home. In comparison, the authors list 15.6 h/day in the United States, and 15.8 h/day in Canada. Older persons (with >64 years of age) and pre-school children spend most time at home, namely 19.5 and 17.6 h/day respectively. Middle-aged individuals (age: 35–64 years) spend about 15/day h at home, and young adults (age 17–34 years of age) spend least time at home (12.6–13.3 h/day), (Brasche & Bischof, 2005). In urbanized, aging, industrialized societies, the associations between the home environment and mental health might thus be particularly interesting.

Depression is a leading cause of disability worldwide, and has been meta-analytically estimated with an average pooled prevalence of depressive symptoms 31.7% in old age, however with lower prevalence in developed countries (17.1%) as opposed to developing (40.8%) countries, with very large heterogeneity across studies, and prevalence depending upon the assessment tool and sample size (Zenebe et al., 2021). Germany ranks 7th amongst countries worldwide concerning the percentage of inhabitants older than 65 (~22% of residents in 2022; *Statista Research Department*, 2024). Prevalence of depression, estimated within the scope of large population studies, has been indicated as higher in women, with for example, 11.6% in female and 8.6% in male adults within the general population (RKI, 2017). In addition, it has been shown to be highest in younger individuals, especially females

(i.e., about 13% in 18–29-year-olds; women: 16.4%, men: 8.6%) and lowest in older (≥ 65 years; 7.1%; women: 8.7%, men: 5.4%) adults. In middle age (45–64 years) prevalence was reported to be 10.8% (women: 11.9%, men: 9.6%), (RKI, 2017). Not only prevalence, but also the associative strength between known risk factors and depression differs between age groups, making it a matter of lifespan development. Schaakxs et al. (2017) for instance report that the association between low income and depression is stronger in older age, although also present in young adults. Expectations and perceptions concerning the home, as well as satisfaction, may accordingly vary with age, also based on the specific needs and social norms within the respective age groups.

There is to our knowledge no common theory about the exact variables that make up an overall home environment factor. Generally, a distinction between objective and subjective-evaluative measures can be made. Objective assessments include measurable physical properties such as for example, humidity, air quality, apartment size, the amount of daylight, or noise. Subjective assessments usually have an “evaluative” component, such as they are phrased to assess “general (dis)satisfaction,” “contentment,” or “disturbance” related to the home or specific attributes, including physical properties. In addition, housing properties can be assessed via (self-)reports or checklists, such as the type of one’s accommodation, apartment size, presence or absence of certain infrastructure (lifts, ramps, access to gardens, etc.), number of windows, maintenance status, building substance, and so on (for a comprehensive reviews on housing assessments and associations with well-being, see Evans et al., 2003; specifically for housing and wellbeing in older adults, see the review by Trecartin & Cummings, 2018). Objective and subjective measures of the home environment can be significantly related, but also seem to have distinctive, independent contributions to explained variance in relevant outcomes, such as wellbeing. For instance, a study in older residents (householders 75–79 years of age) revealed that objective (structural adequacy, maintenance quality) and subjective (overall satisfaction with housing rated by subjects) data were significantly related, but the objective data only explained 4.8–18.5% of the subjective ratings (Christensen et al., 1992). In a recent study investigating the correlations between objectively measured versus subjective ratings of environmental variables in the home across 34 care facilities in China, it was found that the magnitude of correlations varied across examined parameters (e.g., humidity, lighting, acoustic properties, and air quality), but they were all positive and most of them were significant (Mu et al., 2023). Generally, a complementary approach that integrates subjective and objective data might be an optimal solution to explain overall satisfaction with the home environment (Chen et al., 2022), and relatedly mental health outcomes. Perhaps for economic reasons, to our knowledge much of the research on home environment and mental health has relied on (self-)report data. Terminology across studies can differ, but we would argue that *housing* as a term would rather refer to the properties of the accommodation or building as well as ownership status (vs. rent), whereas *home* or more precisely *home/interior/indoor environment* would refer to properties of the private, interior living space.

In the following, a brief overview of the literature related to the home environment in relation to mental health status will be given. A study based on the World Health Organization’s Large Analysis and Review of European Housing and Health Survey (LARES) in ~6000 adult participants across eight European countries (cities) found that individuals with subjectively reported inadequate natural light in their dwellings were 1.4 times more likely to report (doctor-diagnosed) depression or were 1.6 times more likely to report three or more cardinal depressive symptoms (95% confidence intervals [CI] 1.2–1.7; 1.3–1.9), (Brown & Jacobs, 2011). A study from China, focusing on older individuals aged > 60 years (mean = 68.5; $N = 950$) assessed housing or the home environment via face-to-face interviews with Likert-type or dichotomous coding (yes–no), on four dimensions: *physical environment* (i.e., sufficiency of sunlight, ventilation, size of flat in square meters, time of residing in the respective home), *social attributes* (i.e., cohabitation with others [family members, roommates etc.], vs. living alone, frequency of visiting neighbors), *psychological attributes* (i.e., overall satisfaction with daily life; cognitive function assessment [dementia]), and *self-assessed housing environment and surrounding environment* (e.g., home vs. neighborhood cleanliness and comfort; exposure to air pollution, noise, low air pressure, humidity, or dryness), (Chen et al., 2021). The study found that after adjusting for many risk- and social factors, the OR for reporting at least moderate depression levels was 3.47 (95% CI: 1.14–10.82) for participants reporting not feeling comfortable in their homes (vs. those who reported they did feel comfortable). Low daily life satisfaction as characteristic of the housing environment was associated

with depression scores with OR = 5.43 (95% CI: 1.61–6.04). In a survey-based study in Italian students during the COVID-19 pandemic (N = 8177), Morganti et al. (2022) defined an *indoor quality index*, aggregating a set of parameters (satisfied or not), such as natural lighting, acoustics, thermo-hygro-metric comfort, need for artificial lighting during the day, “soft qualities” of the living area such as art objects or greenery/plants, and privacy during phone calls. Subsequently, poor, medium or high quality of indoor spaces categories were formed. In addition, size of accommodation was classified into small (<60 sqm), medium (61–120 sqm) or large (>120 sqm) apartments. Controlling for gender and age as covariates, it was found that poor indoor quality in all: small (OR = 4.13, 95% CI: 3.16–5.41), medium (OR = 3.25, CI 95% 2.71–3.90), and even large (OR = 3.52, 95% CI: 2.64–4.70) apartments was significantly related to moderately severe depression (PHQ-9 \geq 15). Longitudinal data from the Socio Economic Panel (SOEP; N = 50,004) assessed the association between self-rated health and satisfaction with housing as well as income satisfaction across age (20–75), controlling for a range of socioeconomic factors. Both predictors showed a positive association with self-reported health across the entire age range, whereby associations increased from young age into middle-age where they were strongest, whereafter associations declined progressing into old age. Associations were more accentuated for men than for women, and were again stronger for income than for income satisfaction (Knöchelmann et al., 2020). Dunn and Hayes (2000) established a framework in which social inequalities and their known contribution to health disparities were elucidated in terms of how strongly housing conditions, comprising *materialistic* (e.g., worth/costs of property), *physical* (e.g., sunlight exposure, noise, and indoor air quality), *subjective/psychological* (e.g., identity, satisfaction, safety, and pride of dwelling), and *social* (e.g., neighborhood “climate”) facets, contributed to health outcomes. Thereby, a vast number of socioeconomic and demographic factors were entered simultaneously into logistic regression models. Albeit in the regression on the primary generic mental health outcome no significant effects for any of the housing-related variables were identified, when instead the outcome was being *always/very often/constantly under stress*, overall dissatisfaction with the dwelling (vs. satisfaction) was a significant predictor (OR = 2.98, 95% CI: 1.46–6.10), as well as was satisfaction with the interior environment (OR = 0.34, 95% CI 0.16–0.72), and with the amount of traffic at the dwelling (OR = 0.33, 95% CI: 0.16–0.67).

Although the studies cited above are characterized by a substantial amount of heterogeneity, they all show that housing/home variables are significantly related to mental health and well-being.

From the outlined background, the present study aimed at investigating the influence of the subjective evaluation of home environment on self-reported levels of depression in population data from the Hamburg City Health Study (HCHS), which covers middle-aged to older individuals. The current study strives to add to the knowledge of home environment factors related to mood in aging by examining a large cohort sample, adjusting for meaningful confounders (sociodemographic and lifestyle data). Subjective ratings for satisfaction with protection from disturbing nightlight, daylight entering the home, safety at home, quality of window views, and noise disturbance were examined, hypothesizing significant associations with levels of self-reported depression.

The rationale for selecting these variables among other potential variables was as follows. Concerning disturbing light at night, the relevance of good sleep for mental health is undeniable. For instance, a review on intervention trials to improve sleep conducted to quantify the effect of sleep on mental health, revealed that depression symptoms were improved by optimizing sleep with moderate effect size ($g = -0.63$), (Scott et al., 2021). Night-time light pollution constitutes a serious hazard to good sleep, and has been shown among other environmental variables to characterize urban areas in which depression, obesity, or household poverty prevail to a stronger extent compared to regions with lower light pollution (Liao et al., 2022). Concerning daylight entering the home, analyzing data from the LARES study revealed that insufficient natural light exposure at one's home was related to 1.4 times higher odds for doctor-diagnosed depression (Brown & Jacobs, 2011). Subjective safety was selected as variable representing home environment quality since it was reasoned that lack of safety would be related with higher worry and distress. The quality of window views has gained popularity since Ulrich's famous window view study in cholecystectomy patients (Ulrich, 1984), whereby those with a view on a natural scene (vs. those looking at another building) had shorter postoperative hospital stays and took fewer potent analgesics.

Window views into nature have been shown to be preferred, and related to well-being and cognitive performance, such as at the workplace (Farley & Veitch, 2001). Finally, among many different living environment variables, noise disturbance has been shown to be a robust predictor for depression levels across studies (Rautio et al., 2018).

We were generally interested in the total explanatory potential of the selected home environment variables over and above relevant control variables at the level of the individual, such as sex, age, lifestyle (incl. smoking, alcohol, exercise, media consumption), and socioeconomic status (income). The model estimated in the present study was built against the outlined background. It may be seen as a model describing associations between aspects of mental health and the immediate environment, however, not as a model that warrants causal inferences or even outlines interventions.

2 | MATERIALS AND METHODS

2.1 | Sample

Data were assessed within the scope of the population-based Hamburg City Health Study (HCHS; the largest monocentric health study worldwide), which is an ongoing study aiming at understanding the effects of environment, biology, genetics, and lifestyle potentially causing or preventing common diseases (physical and mental) over time. Ethical approval for HCHS was obtained by the local ethics committee of the Landesärztekammer Hamburg. Participants were individuals between 45 and 74 years of age at the time of recruitment, randomly drawn from the official inhabitant register of the city of Hamburg, and divided into six strata by age and biological sex (for details see Jagodzinski et al., 2020). For the current analyses, we used data from the first recruitment wave of $N = 10,000$ participants. Data were assessed between 2016 and 2018. A total of 1243 participants were excluded for the following reasons: $n = 1112$ participants had to be excluded, because they did not provide data on the outcome variable (self-reported depression, PHQ9; Kroenke et al., 2002). An additional $n = 131$ participants were excluded because they scored lower than 24 in the Mini Mental State Examination (MMSE; Folstein et al., 1975), indicating potential cognitive impairment. Hence, our final sample consisted of $N = 8757$ individuals. On average, participants were 62 years of age ($SD = 8.4$; ranging between 46 and 78 years of age), with 51% of the sample being female and $n = 4$ stating that they identified as the opposite sex.

2.2 | Instruments

2.2.1 | Depression

Self-reported levels of depression were assessed with the German version of the Brief Patient Health Questionnaire (PHQ9; Löwe et al., 2004). Items are answered on a 4-point Likert-scale, ranging from 0 = *not at all* to 4 = *almost every day*. In clinical settings, a general cut-off score of 10 has meta-analytically been shown to detect clinical levels of depression with best combined sensitivity (0.88) and specificity (0.85) across studies (Levis et al., 2019).

2.2.2 | Demographic variables

Age was assessed in years, biological sex was assessed (binary variable; 0 = male, 1 = female). Income was assessed as a proxy for socioeconomic status. The question asked was "What is your net income per month in Euro?". To avoid too many missing data due to reluctance to specify the exact income, income was assessed in ordinal 17 categories with 1 = less than 500€/month and 17 = more than 8000€/month.

2.2.3 | Lifestyle variables

Smoking status was classified as binary variable with 0 = nonsmoking and 1 = currently smoking. Regular alcohol consumption, referring to the last 12 months, was assessed in five ordinal categories (0 = *never*, 1 = *once/month*, 2 = *2–4 times/month*, 3 = *2–3 times/week*, 4 = *4 times, or more/week*). Number of household members was assessed with the participant included, hence, 1 was the lowest valid answer. Time spent watching TV and time spent on the computer were assessed as 5 ordinal categories (0 = *never*, 2 = *<1 h/day*, 2 = *1–2 h/day*, 3 = *2–3 h/day*, 4 = *3–4 h/day*, 5 = *>4 h/day*). Physical activity was classified as binary variable with 0 = *no sport on a regular basis* and 1 = *sport on a regular basis*). Questions to assess the lifestyle variables were developed by the German Institute of Human Nutrition Potsdam-Rehbruecke.

2.2.4 | Home environment control variables

Participants were asked to indicate the size of their current home in square meters (sqm).

2.2.5 | Subjective evaluation of home environment

Protection from disturbing light during nighttime was assessed on a 5-point-Likert-scale ranging from 1 = *very bad* to 5 = *very good*, with higher values thus indicating better protection from disturbing light. The amount of daylight entering the flat was assessed on a 5-point-Likert-scale ranging from 1 = *very bad* to 5 = *very good*, with higher values indicating more brightness in the flat through natural light. Subjective safety at home was assessed on a 5-point-Likert-scale ranging from 1 = *very bad* to 5 = *very good*, with higher values indicating feeling safer. Overall satisfaction with the window views from the flat was assessed on a 5-point-Likert-scale ranging from 1 = *very bad* to 5 = *very good*, with higher values indicating better quality of the window view. Disturbance by noise was entered as the mean value across three items that separately assessed disturbance by any type of noise at home (a) during the week, (b) the weekend, and (c) at night, whereby each item was rated on a 4-point-Likert-scale ranging from 1 = *not at all* to 5 = *very annoyed*.

The selection of variables was made based on literature review and reasoning in the authoring team from a larger living environment questionnaire, whereby only variables were picked that addressed broader subjective evaluations of the home. The original questionnaire also included a checklist-based assessment of physical and technical characteristics of the home (e.g., type of floor, heating, and ventilation systems), as well as subjective evaluations of the surrounding district area. There were also evaluative questions related to specific physical attributes (e.g., humidity or room climate; differentiation of different noise sources in the home), which were deemed too detailed for the present study and hence omitted.

2.3 | Analyses

2.3.1 | Missing data

Only cases from the original data set ($N = 10,000$) were included who had complete PHQ-9 data ($N = 8757$).

A differential pattern of missing data emerged for the independent variables. Overall, our sample consisted of 4826 complete cases, with a total fraction of missing data of 6.8%. Inspecting the true fraction of missing data per variable revealed a range from complete data for gender and age to a total of 25.8% for household income, 19.5% for alcohol consumption, and 18.6% for smoking status. The fraction for missingness varied between 4% and 5% for

all other variables. To account for the potential bias in the data due to missingness, we conducted all of our analyses under a full information maximum likelihood approach (FIML) which is equivalent to multiple imputation (MI) procedures in large samples (Asparouhov & Muthén, 2010). With FIML, all available data points are included into the analyses, preventing listwise deletion. We also conducted analyses where missing data were handled with MI to double-check. We followed the MI procedure in Mplus where MI of missing data is provided by using Bayesian analysis (Muthén et al., 2010). It has been stated in the literature that differences in the performance of FIML and MI point towards model misspecification (Lee & Shi, 2021). The results of our analyses did not differ substantially between MI or FIML, underlining the appropriateness of our approach.

2.3.2 | Model estimation

We conducted multiple linear regression analyses with different models to analyze the association between self-reported depression assessed with the PHQ-9 and the independent variables. Variables were entered in three steps to assess their potential incremental value. To assess the potential association between the subjective evaluation of the home environment over and above standard demographic variables, we entered sex, age, and income as predictor variables in a first step. In a second step, variables assessing common lifestyle factors/habits were entered: smoking status, alcohol consumption, number of household members, time watching TV, time spent on the computer, and doing sports on a regular basis. In a third step, the variables of primary interest were added: size of home (square meters), protection from disturbing light at night, quality of daylight, feeling safe at home, quality of window views, and disturbance by noise.

We conducted several additional sub-analyses. First, although the added covariates in our analyses are meant to reduce potential bias, sometimes adding covariates may even lead to greater distortion, if a collider or mediator is conditioned on (see Elwert & Winship, 2014; Rohrer, 2018, for a comprehensive discussion of this topic). The risk of introducing instead of reducing bias via the inclusion of covariates is especially given in observational data sets with no clear underlying causal model. Spurious associations sometimes may result from the erroneous inclusion of such covariates. Although there is no definite solution for this problem, one potential safeguard lies in the unadjusted analyses of the key variables of interest. We did this for our variables describing the subjective evaluation of the home environment (see Supporting Information Material S1). Second, to test whether the variables were of predictive value for individuals reporting higher levels of depression, we estimated a logistic regression with the PHQ9 sum scores categorized as a binary variable above or below the clinical threshold of the PHQ9 sum score of 10, resulting in two groups of scores 0–9: $n_1 = 8172$, 93.3% and a subgroup reporting PHQ9 levels equal of scores 10–27: $n_2 = 585$, 6.7%. Results are displayed in the Supporting Information Material 3. Third, we reran our final model in two age-extreme groups of the sample separately to shed light on potential differences of the association in middle-aged and older adults. Our general sample was age-heterogenous, covering an age range between 46 and 78 years of age. Our subsample of middle-aged adults consisted of $n = 934$ individuals, *mean age* = 49 (SD = 1.2, age range 46–50 years of age). Our old-age subsample consisted of $n = 2092$ individuals, *mean age* = 73 years (SD = 2.2, age range 70–78 years of age). Analyses were conducted in R version 4.1.1, and Mplus, Version 8.7 (Muthén & Muthén, 1998-2017).

3 | RESULTS

3.1 | Regression analyses

Descriptive statistics can be found in Table 1. Generally, all independent variables were correlated with the dependent variable when running bivariate correlations. When estimating the five key variables without

TABLE 1 Means and standard deviations for variables under study.

Variable name	M	SD	(N = missings)
Depression (PHQ-9)	3.5	3.5	
Age in years	62.09	8.42	
Sex ^a	49.3% male	50.7% female	
Income per household category ^b	11.3	3.9	(2263)
Smoking ^a	82.3% nonsmoking	17.7% smoking	(1627)
Alcohol consumption	2.34	1.2	(1711)
Use of TV	1.90	0.92	(419)
Use of PC	1.25	0.79	(406)
Physical activity on a regular basis ^a	8.5% no	91.5% yes	(226)
Household size	2.08	0.94	(516)
Size of home (m ²)	103.61	55.81	(386)
Nightlight	4.32	0.78	(372)
Brightness	4.34	0.76	(355)
Safety	4.23	0.69	(372)
Window view	4.31	0.75	(416)
Noise	0.41	0.53	(476)

Note: Missings per variable are shown in brackets, whole sample $N = 8757$.

^aPercentage in binary variable;

^bIncome is subdivided into 17 categories, ranging from below 500€ in category 1 to more than €8000/month in category 17. Categories span €250 each, 11 corresponds to €3000–€3500 per month.

adjustment, they were all significantly associated with the PHQ-9-score with all associations pointing into the same direction as in the full model. Although this is no proof of the appropriateness of our model, it adds to the plausibility of our results (Supporting Information Material 2). Model I included the variables age, sex, and income. As can be seen from Table 2, predictors exhibited a significant association, with female sex being related to higher levels of depression than males, and older age as well as higher income being associated with lower self-reported levels of depression. The demographic variables had an adjusted R^2 of 0.07, indicating 7% of explained variance by the initial “demographic” model.

In model II, we added common lifestyle factors/habits to the analyses. Overall, the inclusion of the variables added approximately 2% of explained variance ($R^2 = 0.092$), with the additional predictors exhibiting an overall significant model contribution. On a single predictor level, smoking and number of individuals living together in the household were not associated with levels of self-reported depression. Lower levels of alcohol consumption were related to higher levels of reported depression. Both, time spent on the computer and watching TV, were positively associated, whereas physical activity on a regular basis was significantly related to lower levels of self-reported depression.

In model III, we additionally added the variables of interest that described the participants' subjective evaluation of home environment and home environment control variables (perceived protection from disturbing light during the night, feeling safe at home, amount of daylight entering the home, perceived quality of the window view, disturbance by noise, and size in square meters). The inclusion of variables reflecting the subjective evaluation

TABLE 2 Regression coefficients and standard errors for depression with corresponding *p* Values.

Variable	Model 1			Model 2			Model 3		
	<i>p</i> Value	Coef.	Standard Error	<i>p</i> Value	Coef.	Standard Error	<i>p</i> Value	Coef.	Standard Error
Age	<.001	-0.07	0.01	<.001	-0.07	0.01	<.001	-0.06	0.01
Sex: female	<.001	0.81	0.07	<.001	0.97	0.08	<.001	1.06	0.07
Income (Household)	<.001	-0.19	0.01	<.001	-0.15	0.02	<.001	-0.10	0.02
Smoking				.091	0.18	0.12	.091	0.20	0.11
Alcohol				.003	-0.1	0.04	.011	-0.09	0.04
Household size				.510	-0.03	0.05	.706	-0.03	0.05
PC				<.001	0.30	0.06	.001	0.26	0.06
Physical activity				<.001	-0.89	0.17	<.001	-0.84	0.16
TV				<.001	0.30	0.05	<.001	0.27	0.05
Sqm ^a							.112	1.17	0.87
Nightlight							<.001	-0.33	0.06
Brightness							.000	-0.24	0.06
Safety							<.001	-0.50	0.06
Window view							.005	-0.18	0.06
Noise							<.001	0.83	0.09
R ² adjusted	.071			.092			.152		

^aSquare meter.

of home environment of participants added 6% of explained variance to the model. Overall, the final model explained roughly 15% of variance in self-reported levels of depression. As can be seen in Table 2, higher levels of perceived safety, lower levels of noise, higher protection from disturbing light at night, satisfaction with window views as well as more sunlight during daytime were all associated with lower levels of self-reported depression. Interestingly, the variance explained by our variables reflecting the subjective evaluation of the home environment, was larger than the variance explained by known influential lifestyle variables, pointing towards the importance of (perceived) quality of one's home environment in the context of depression.

To shed some light on the question whether our environmental key variables were of predictive value for individuals above or below the clinical threshold of the PHQ9-cut-off of 10, we re-estimated our model within a logistic regression framework with the outcome being the PHQ9-sum-score above or below the clinical threshold. We found that for self-reported levels of depression, only four out of our five key variables were of predictive value, namely perceived safety, brightness, noise, and protection from disturbing night at light (results are shown in the Supporting Information Material 3).

The analyses based on the two "extreme" age groups basically resembled the results of the whole sample. Although descriptive differences between estimates emerged between the groups, they were not significant, hence, conclusions referring to substantial age differences are not warranted from the results of the present study (see Supporting Information Material 1).

4 | DISCUSSION

This study aimed at assessing the potential association between the subjective evaluation of home environment over and above known demographic variables and lifestyle variables on levels of self-reported depression in a large sample of middle-aged and older adults in Hamburg, Germany. Overall, we found a significant association between the subjective evaluation of home environment and levels of self-reported depression over and above sex, age, income (socioeconomic variables) and lifestyle/habit-related (smoking, alcohol consumption, household size, PC and TV consumption, physical activity) variables. As hypothesized, we found disturbing nightlight and noise disturbance to be associated with higher levels of self-reported depression, whereas satisfaction with the window view, brightness (daylight entering the home), and perceived safety were associated with lower levels of self-reported depression. Before discussing these associations in depth, we will briefly turn to the discussion of socioeconomic status, demographics, and lifestyle choices, as well as the apartment size. Higher income and older age were associated with lower levels of self-reported depression. Also, females were more likely to report higher levels of depression. This is in line with existing meta-analytical literature, where females have been consistently found to exhibit higher levels of depression across all age groups (Salk et al., 2017). Also, age has been associated with lower levels of depression, however, not without inconsistencies (Jorm, 2000). Interestingly, alcohol consumption was negatively related to levels of depression, indicating that larger amounts of alcohol were related to lower levels of self-reported depression. While this might seem counterintuitive at first, we offer the following explanation. The detrimental effect of (excessive) alcohol consumption is, of course, well-documented and known. However, moderate drinking has also been found to exert beneficial effects, not only on health but also on mood, stress reduction, and self-reported well-being (Peele & Brodsky, 2000). In our sample, alcohol consumption was not excessive, hence stress reduction, and mood stabilization might have been the predominant underlying mechanisms of alcohol consumption in the present sample. Also, alcohol could be consumed in company, hence social integration might be a confounder of the relation in our study that was not controlled for. Lastly, it is also possible that individuals with higher self-reported levels of depression underreport their actual consumption. Interestingly, the size of the accommodation was not significantly associated with levels of self-reported depression.

All variables reflecting the subjective evaluation of home environment (i.e., better protection from disturbing light at night, more daylight entering the home, feeling safer, lower levels of noise, and quality of window views) were significantly associated with self-reported levels of depression, over and above sociodemographic and common lifestyle variables. Overall, our final model explained roughly 15% of variance with 6% being attributable to the evaluation of the current living environment (7% of variance was explained by sociodemographic and 2% by lifestyle factors). The home environment variables thus explained more variance than lifestyle variables, such as smoking, alcohol consumption, physical exercise, or media consumption.

Our findings in general are similar to those of an Italian COVID-19 survey study, investigating university students during lockdown, who were asked about 'indoor quality' and depression levels (Amerio et al., 2020). The authors found that poor views and "scarce indoor quality" (i.e., low integrated self-report score across a set of parameters such as natural light vs. need for artificial lighting, decoration, plants, privacy, etc.) were related to higher levels of self-reported depression. However, as opposed to the present study, (small) apartment size <60 m² was significantly associated with higher depression levels, whereas in the HCHS data we were unable to replicate any association. Perhaps, this is explicable by the fact that our analyses were controlled for income, which was not controlled for in the study by Amerio et al. (2020). Also, the fact that the sample in the study by Amerio et al. (2020) was assessed in a lockdown-situation might explain this effect, while individuals in our study were free to leave their apartment whenever they wanted. Objectively measured nightlight has been reported as one risk factor for reporting depression in older adults (Obayashi et al., 2013). Results from our study support those findings in as such that individuals subjectively reporting better protection from light at night also report lower levels of depression. Generally, the negative association between nightlight and mood has been suggested to originate in its negative effect on the natural biological rhythm, which might be reflected in our self-reports. Higher levels of reported

satisfaction with daylight entering the home were associated with lower levels of self-reported depression. This seems reasonable as light (artificial as well as daylight) is well known in the context of treatment of depression. Exposure to bright light is even established as a therapeutic intervention (Benedetti et al., 2003; Wirz-Justice et al., 2021). Our results underline the beneficial “everyday effect” of light on mood, being in one's home. Not only light (and protection from disturbing dimensions of light) were associated with lower levels of self-reported depression, but also the perceived quality of the window view, which is in line with previous findings concerning the positive psychogenic effects of higher-quality (natural) window-views (see Farley & Veitch, 2001). In our study, we assessed disturbance by noise on an aggregate level and found overall lower levels of noise to be related to lower levels of self-reported depression. This result on a subjective level and specifically for the home environment confirms the meta-analytical finding that the objective degree of traffic noise pollution is proportionally related to depression levels (Dzhambov & Lercher, 2019). The last aspect was perceived safety of the home. We found greater levels of perceived safety to be associated with lower levels of self-reported depression. Perceived safety, however related to the neighborhood, has already been associated with lower levels of self-reported depression in older individuals (Roh et al., 2011). As the home environment serves the essential human need of providing privacy, refuge, and shelter, the evaluation of this very environment as “safe” might buffer stress and provide a space to relax; whereas a home environment perceived as unsafe might actively contribute negatively to levels of depression on its own.

When taking a closer look at potential age differences, our extreme-group analysis did not exhibit significant differences between middle-aged and older adults. Although previous studies did find age-differential associations between known risk-factors and depression, we could not show that for the variables of the subjective evaluation of home environment in our study, applying an extreme group approach. This contradicts results from a large study in which effects of socio-demographic variables on ratings of housing satisfaction were tested, including $N = 1.29,000$ individuals from 71,000 households from Australia, whereby the same objective housing reality was rated more favorably with increasing age and as a function of other sociodemographic factors (Tomaszewski & Perales, 2014). It is also possible that the association between home environment variables assessed in the present study and depression is age-independent. When interpreting the results, one has to bear in mind that the standard errors in the younger group were larger than in the older group. Standard errors are a measure for the precision of the estimate. Hence, the larger standard error in the younger subsample point to a less precise estimation in this sample, leaving it an open question whether age-related effects are truly absent or are not detectable due to the estimation being less precise.

4.1 | Limitations

Our results come from cross-sectional data. Hence, causal inferences forbid themselves. It remains an open question how the association between levels of self-reported depression and the subjective evaluation of home environment is built. There generally is the question of social causation versus social selection, with the degree of which of the two competing hypotheses apply may depend upon the type of mental illness under investigation (see Mossakowski, 2014). Thus, possibly, individuals who live under poorer conditions show diminished levels of wellbeing or are more likely to develop mental illness. On the other hand, (liability towards) mental illness may deem individuals to experience a decline in their socioeconomic status, such as professional status or income (e.g., Hakulinen et al., 2019), which deems them more likely to live under poorer housing conditions. Also, individuals with worse mental health status may experience the same housing conditions less favorably than those with better mental health status. The results of our study are not suitable for causal interpretation, hence the underlying causal direction of the associations found in the present study cannot be established. To learn more about the direction of the association, longitudinal studies are necessary. To our knowledge, the field of housing quality and indoor quality generally lacks a common theory and standardized definition of indicators, and hence, there is no standard

procedure to assess related parameters. This needs to be addressed by the scientific community. On a more general note, instead of focusing on a few home environment characteristics, it may be advisable to include all available data on housing and the interior (home) environment, including both subjective and objective data, and analyze them concurrently in a broader prediction model, or even include all available data on modifiable factors that could be related to depression. These then should be analyzed applying a data-driven approach to screen and identify relevant factors among an exhaustive selection of potential predictors—ideally relying on prospective data, and testing reverse causation (e.g., see Choi et al., 2020). Concerning representativeness of the sample, self-selection (i.e., subsequent agreement to participate) assumedly affects the sample composition resulting in, inter alia, lower rates of individuals with meaningful self-reported depression levels according to a clinical cut-off (about 6.7% of available cases, 4.8% in middle-aged, 1.9% in older individuals) in the present study. This bias is assumedly present, although participants in HCHS are initially contacted and identified by a random sample from the official inhabitant register. Results of a representative German national health study reported higher depression rates: for those between 45 and 64 years of age, 10.8%, and for adults 65 years or older, 7.1% (RKI, 2017). On a more general note, potential bias in self-reports are possible which cannot be verified by objective measures. Our results are further limited by the fact that we did not analyze other than linear forms of potential association between variables. Future studies could, for example, test whether the size of accommodation might be non-linearly associated with self-reported levels of depression. It seems conceivable that sqm might be better described by a quadratic term and, hence, this should be considered. We also did not include any interactions; however, future studies should potentially consider testing them based on a clear rationale. Furthermore, analyses by age groups as applied in the present study to test whether the associations differ between a middle-aged versus older age subsample are not the ideal solution to assess age-related differences. Additionally, critical identity variables such as ethnicity or gender identity may interact with the subjective perception of home (e.g., such as by differential expectations concerning adequate accommodation), whereby effects may also be explicable in terms of socioeconomic inequality (see Tomaszewski & Perales, 2014), which in turn contributes to mental health inequality. Although cultural background, migration experience, and variables on social and cultural identity and ethnicity are assessed in HCHS, their operationalization was not suited for use in the present study. Hence, future studies should specifically include critical identity variables as relevant sociodemographic covariates.

5 | CONCLUSION

The present study contributes to the fastly developing field of environmental psychology, investigating the association between the subjective evaluation of home environment and mental health. About 6% of variance in subclinical depression levels were attributable to home environment variables, over and above sociodemographic and lifestyle variables. As this is the environment one spends most time in, it may be a worthwhile endeavor to further investigate the impact of this relatively stable context, however, more sophisticated theoretical models of what constitutes one's home, including subjective and objective data, are needed to systematically push forward this research area.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

As data are part of the larger, ongoing Hamburg City Health Study, any data sharing requests should be addressed to the Hamburg City Health Study directly, to learn more about how to obtain data for (re-)analyses.

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PEER REVIEW

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