Residential Light and Risk for Depression and Falls: Results from the LARES Study of Eight European Cities

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ABSTRACT

Objectives. We examined the relationship between self-reported inadequate residential natural light and risk for depression or falls among adults aged 18 years or older.

Methods. Generalized estimating equations were used to calculate the odds of depression or falls in participants with self-reported inadequate natural residential light vs. those reporting adequate light (n=6,017) using data from the World Health Organization's Large Analysis and Review of European Housing and Health Survey, a large cross-sectional study of housing and health in representative populations from eight European cities.

Results. Participants reporting inadequate natural light in their dwellings were 1.4 times (95% confidence interval [CI] 1.2,1.7) as likely to report depression and 1.5 times (95% CI 1.2, 1.9) as likely to report a fall compared with those satisfied with their dwelling's light. After adjustment for major confounders, the likelihood of depression changed slightly, while the likelihood of a fall increased to 2.5 (95% CI 1.5, 4.2).

Conclusion. Self-reported inadequate light in housing is independently associated with depression and falls. Increasing light in housing, a relatively inexpensive intervention, may improve two distinct health conditions.

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In 2000, the World Health Organization (WHO) estimated that depression (unipolar depressive disorders) caused 4.4% of the disability adjusted life years (DALYs) worldwide and an estimated 12% of the total life years lived with disability.[1] A multinational study estimated that approximately 7% of Europeans suffered from major depression that substantially impaired their working or social lives; the prevalence of major depression ranged from 3.8% in Germany to 9.9% in the United Kingdom.[2]

Injuries are also a leading cause of the global burden of disease. In 2000, WHO ranked falls as 15th among leading causes of disease burden—accounting for an estimated 3.4 million DALYs—in adults aged 30–44 years.[3] Among the high-income countries included in that study, falls ranked as the 13th and 14th leading causes of morbidity for people aged 15–44 years.[3] Together, depression and falls constitute major portions of the global burden of disease. However, WHO recently concluded that insufficient evidence exists regarding light in housing and its relationship to mental and other health effects.[4] Falls and depression may have a commonality related to inadequate residential light, but the evidence to date has been insufficient to establish the link.

The relationship between lack of light and depression has been well documented, and the evidence that light is a potent neurobiological agent seems clear.[5,6] The role of light as a major synchronizer of circadian rhythms has been established for alertness, plasma melatonin, body temperature, and sleep/wakefulness.[7,8] Light therapy has been used to treat seasonal affective disorder (SAD) since the 1980s, when Rosenthal et al. found that artificial light was effective in treating the disorder.[6] The light intensity of 2,500–10,000 lumens per meter squared (lux) used during therapy is much brighter than normal indoor light, which is usually 300–500 lux, but not as bright as summer sunlight, which can be as bright as 100,000 lux.[9] A consensus has been reached concerning the efficacy of light to treat seasonal depression, based on independent studies from around the world that show an average decrease of 20%–25% in depressive symptoms.[10] Depressive symptoms are determined using both observer rating scales, such as the Hamilton Depression Rating Scale, and self-assessment of symptoms.[11]

Few studies have compared artificial with natural light. However, in a study conducted in Switzerland, researchers compared the use of low-intensity artificial light, defined as half an hour of artificial light at 2,800 lux, with one hour of outdoor light.[12] The study concluded that outdoor light was more effective than artificial light, with outdoor light causing a 50% reduction in depressive symptoms. A statistically significant reduction of 25% in depressive symptoms, as measured by the doctor-administered Hamilton Depressive Rating Scale, occurred in the group receiving the low-dose artificial light, although self-reported depressive symptoms did not improve for this group. In another study, low levels of light increased the likelihood of depression when depressed patients reportedly were exposed to 40% less moderate light (100 to 1,000 lux per day), compared with a non-depressed control group.[13]

Light therapy results in a rapid decrease in depressive symptoms, and few researchers have followed participants over long periods. However, in the few studies that followed patients for longer than one week, positive response rates increased with duration of the light intervention.

The salutary effect of light has been most extensively studied in relationship to seasonal depression, although studies of light's effect on individuals with nonseasonal depression, late luteal phase dysphoric disorder, and bulimia nervosa also have shown promise.[14] Three main hypotheses have been proposed: (*1*) light's effect on circadian phase shift, (*2*) light's effect on the major monoamine transmitters, and (*3*) an individual's genetic vulnerability. However, the causal pathway for depression is undoubtedly complex, as shown by (*1*) the conflicting results of different studies, (*2*) the independent effects of light and standard antidepressant pharmacotherapy, (*3*) the mediation of the relationship between light and depression by whether daily behavior followed a predictable pattern, and (*4*) evidence of reduced retinal contrast perception in depressed compared with non-depressed individuals.[13–15] We undertook this study in part to determine if there is an association between self-reported adequacy of natural light in housing and depression.

In the United States, falls are a significant cause of home injuries across all age groups; an estimated 5.6 million nonfatal falls required medical attention in 1999.[16] Risk factors for falls among the people aged 65 years and older have been well-studied and include arthritis, foot problems, medications, and cognitive and motor impairment.[17] Environmental hazards do not seem to be strong predictors for risk of falls among the elderly, and results of environmental mitigation have been disappointing.[18]

The prevalence of falls among adults aged 18 years and older is similar to the prevalence in both older and younger people. In 1998 in the U.S., it was estimated that 38% of nonfatal, unintentional fall injuries occurring at home were among people aged 25 to 64 years.[16] To date, no studies have examined housing factors that predict falls in this age group, and more

detailed studies of precisely which housing factors are most predictive of falls are needed. Lack of adequate natural light may be one such housing factor, as poor light can prevent individuals from seeing hazards for tripping and falling in their environment.

In this article, we describe the association between self-reported natural residential light and the risk for depression and serious nonfatal falls among study participants aged 18 years and older in the Large Analysis and Review of European Housing and Health Status (LARES) survey.[19]

METHODS

Housing and health survey

From 2002 to 2003, WHO, with funding from the German Federal Ministry of Health, conducted the LARES study, a cross-sectional survey to improve knowledge of the impact of housing on the physical well-being and mental health of residents. Eight European cities participated in the survey: Vilnius, Lithuania; Geneva, Switzerland; Forli, Italy; Bonn, Germany; Ferreira do Alentejo, Portugal; Budapest, Hungary; Bratislava, Slovakia; and Angers, France. The dataset, based on 290 questions with 1,095 items, included information on the condition of 3,373 dwellings and the health status of 8,519 inhabitants. The mean response rate for all cities was 44.2% of the eligible sample of households. Forli and Ferreira had the lowest participation rate (34%) and Angers the highest (48%). The sample in each city was randomly generated from resident registries, the local tax registry, or the national health insurance registry.[20]

LARES used two questionnaires: an inhabitant questionnaire that described the residents' perception of their dwelling and a health questionnaire for each inhabitant to report on his or her health status. In addition, an inspection of the dwelling was completed by a trained inspector. The methodology of this survey has been described in more detail elsewhere.[19,21]

Health assessment

In this study, we used LARES data from health questionnaires completed by each individual resident to identify those residents aged 18 years and older who reported a fall, doctor-diagnosed depression, or three to four cardinal symptoms of depression within the past year. Symptoms of depression include self-reported sleep disturbance, lack of interest in activities, low self-esteem, and loss of appetite for two weeks or longer. This measure is highly correlated with the *Diagnostic and Statistical Manual of Mental Disorders* criteria for major depression.[22] Participants with doctor-diagnosed depression but without reported symptoms were included in the group with depression. We also used the health questionnaire data to identify those residents who reported a fall within the last year and the housing element (e.g., stairs) that was related to the fall. The inspection report provided information on whether the dwelling was a single-family home or part of a multifamily dwelling, as well as the presence and condition of interior and exterior stairs.

Light assessment

We used the questionnaire to identify those residents who reported either "turning on a light even on bright days because the natural light is not sufficient" or "missing daylight" in the last year, both of which are indicators of natural light in the residence. We then compared this group with residents who reported that their light was adequate. Residents who responded that they did not know if they turned on the lights (n=70, including three respondents with depressive symptoms) or if they missed daylight (n=54, including nine with depressive symptoms) and residents whose questionnaires were incomplete (n=19) were excluded from the analysis because their responses could not be classified reliably. Because no physical measurements of light were included in LARES, our analysis did not include a dose-response assessment of light intensity on health outcomes.

Factors associated with falls

Participants who reported a fall within the last year were also asked about household elements and furnishings that were involved in the fall, such as stairs, kitchen utensils, pets, or toys. Participants could select more than one household element from this list.

Statistical analyses

Statistical analyses were performed using SAS® version 9.02.[23] We analyzed data for LARES participants aged 18 years or older. A bivariate logistic regression model was fitted to determine the odds that people who missed daylight or turned the light on during the day were either more likely to have depressive symptoms, to fall, or both. Because multiple residents were surveyed in the same dwelling in some instances, we used a generalized estimating equations (GEE) approach, with the robust ("sandwich") variance estimator to account for possible clustering at the building level. We used a GEE variation, the alternating logistic regression method, that used odds ratios (ORs) because these are more appropriate measures of association between dichotomous outcomes.

Confounders

We created categorical variables for variables suggested by the literature as important predictors of falls and depression, and we calculated unadjusted ORs for the exposure and outcomes of interest as well as for factors thought to confound this association. For example, we included city of residence, which would account for latitude and unmeasured cultural influences; participant characteristics such as age by decade, health status (good/excellent vs. poor/fair), disability (yes vs. no), health insurance (public/none vs. some private), low vs. high/middle income, marital status, and education level; and housing characteristics such as neighborhood and dwelling satisfaction, housing type, and tenancy. The final multivariate models adjusted for potential confounders, including gender, alcohol use, employment status, health status, education, health insurance, and income, all of which were found to be significant predictors of risk at the bivariate level using the GEE alternating logistic regression method just described. City of residence was forced into the model, but there was no correlation between city of residence, turning lights on during the day, and risk for depression or falls. City of residence also acted as a proxy for differences in the amount of sunshine per day by geographic location.

RESULTS

Of the 6,017 people meeting the study inclusion criteria as described, 784 (13.0%) were depressed, reporting either doctor-diagnosed depression or three or more of the cardinal symptoms of depression, and 450 (7.5%) reported a fall within the last year (Table 1); 131 (2.2%) participants reported both conditions (data not shown). In the 3,076 houses where more than one participant was interviewed, only the participants in one dwelling disagreed on whether the light in the dwelling was adequate.

Depression

Of those participants who met our definition of depression, the lowest percentage lived in Bonn (8.0%; n=46) and the highest percentage lived in Ferreira (28.7%; n=198) (Table 1). Compared with participants who did not report depression, those with depression were more likely to be female, be in poor health, be handicapped, feel dissatisfied with their dwelling, drink more than four alcoholic beverages a day or abstain from alcohol, be aged 70 years or older, live in Vilnius or Ferreira, have public or no health insurance, and work less than full time (Table 1).

Participants with depression were more likely to report inadequate light in their dwelling compared with those who did not have depressive symptoms (OR=1.4; 95% confidence interval [CI] 1.2, 1.7) (Table 2). The odds of reporting inadequate light among participants with doctor-diagnosed depression was 1.4 (95% CI 1.1, 1.7) for residents with inadequate vs. adequate residential light; participants with three or more major symptoms of depression were 1.6 times (95% CI 1.3, 1.9) as likely to report inadequate light compared with participants who reported adequate light (data not shown).

The association between light and depression remained statistically significant even after controlling for major confounders, including gender, health status, education, marital status, self-reported health status, handicap, age, and city of residence. In the controlled model, the estimated OR of depression, given self-reported inadequate residential light, decreased slightly from the unadjusted OR of 1.4 to 1.3 (95% CI 1.1, 1.6) (Figure).

Falls

Compared with participants who did not report a fall in the last year, those who reported falling were more likely to be female; be in poor health; be divorced, widowed, or separated; be older than 70 years of age; have low income; have a self-reported handicap; live in Bonn or Ferreira; and work less than full time. Of those participants who reported falling, the fewest lived in Geneva (5.2%, n=25) and the most lived in Ferreira (12.8%, n=89) (Table 1).

Compared with participants who were not depressed, participants with depression were more likely to also report a fall (OR=3.1; 95% CI 2.4, 4.1; n=80), although the variance of depression explains less than 2% of the variation in falls. Participants who fell were also more likely to report inadequate light than those who did not fall (OR=1.5; 95% CI 1.2, 1.9) (Table 2).

Of the 13 housing factors listed as related to a fall, most (more than 48%) were related to structural factors such as stairs (Table 3). Although 667 (16.4%) of study participants who lived in buildings with outside staircases reported that the lighting on the exterior staircase was inadequate, broken, or nonexistent, people who lived in dwellings with exterior staircases were no more likely to suffer a fall than those who lived in buildings without exterior staircases (OR=1.2; 95% CI 0.7, 2.2). However, people in buildings with inside stairs were more likely to report a fall than people without inside stairs (OR=1.7; 95% CI 1.4, 2.1). Participants who reported difficulty with stairs were more than three times as likely to fall compared with those who reported no difficulty with stairs. However,

Table 1. Characteristics of the LARES study sample, eight European cities, 2002–2003

Characteristic	*Study population* N *(percent)*	*Participants with depression* N *(percent of study population)*	*Participants with falls* N *(percent of study population)*
City			
Angers, France	633 (10.6)	60 (9.7)	51 (8.0)
Bonn, Germany	580 (9.7)	46 (8.0)	61 (10.5)
Bratislava, Slovakia	693 (11.2)	75 (10.9)	51 (7.4)
Budapest, Hungary	795 (13.2)	111 (14.0)	60 (7.6)
Ferreira do Alentejo, Portugal	698 (11.8)	198 (28.7)	89 (12.8)
Forli, Italy	831 (14.0)	80 (9.8)	40 (4.8)
Geneva, Switzerland	483 (8.0)	44 (9.2)	25 (5.2)
Vilnius, Lithuania	1,304 (21.5)	170 (13.1)	73 (5.6)
Age (in years)			
18–29	1,401 (23.3)	112 (8.1)	101 (7.2)
30–39	1,048 (17.4)	98 (9.4)	73 (7.0)
40–49	1,105 (18.4)	158 (14.3)	61 (5.5)
50–59	1,001 (16.6)	147 (14.8)	55 (5.5)
60–69	761 (12.7)	113 (15.1)	60 (7.9)
≥70	701 (11.7)	156 (22.8)	100 (14.3)
Gender			
Male	2,777 (46.2)	229 (8.7)	152 (5.5)
Female	3,240 (53.9)	555 (16.7)	298 (9.2)
Marital status			
Married	4,052 (67.3)	497 (12.4)	264 (6.5)
Separated/divorced/widowed	750 (12.5)	179 (24.2)	90 (12.0)
Single	1,215 (20.2)	108 (9.0)	96 (7.9)
Education			
Primary or less	1,202 (20.0)	288 (24.3)	130 (10.8)
Secondary	3,117 (51.8)	377 (12.2)	207 (6.6)
Post-secondary	1,698 (28.2)	119 (7.0)	113 (6.7)
Alcohol use			
Abstainer	1,315 (22.0)	266 (20.5)	133 (10.1)
Former user	253 (4.2)	68 (27.0)	26 (10.3)
Occasional user	3,786 (62.7)	360 (9.6)	248 (6.6)
1–2 drinks per day	510 (8.6)	56 (11.1)	29 (5.7)
3–4 drinks per day	111 (1.9)	17 (15.5)	7 (6.3)
>4 drinks per day	42 (0.7)	24 (41.5)	7 (16.7)
Employment			
Full time	2,649 (44.0)	229 (8.7)	131 (5.0)
Part time or unemployed	3,368 (56.0)	555 (16.7)	319 (9.5)
Self-reported health			
Good/excellent	3,376 (56.0)	171 (5.1)	186 (5.5)
Fair or poor	2,641 (44.1)	613 (23.5)	264 (10.0)
Health insurance			
Public or none	4,372 (73.0)	644 (14.8)	338 (7.7)
At least some private	1,645 (27.3)	140 (8.6)	112 (6.8)
Self-reported handicap			
Yes	693 (11.5)	195 (28.7)	110 (15.9)
No	5,324 (88.5)	589 (11.1)	340 (6.4)
Difficulty with stairs[a]			
Yes	718 (11.9)	248 (35.1)	135 (18.8)
No	5,298 (88.1)	536 (10.2)	315 (6.0)
Economic status			
Low income	2,042 (34.0)	362 (17.9)	185 (9.1)
Middle income or higher	3,975 (66.0)	422 (10.7)	265 (6.7)

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Table 1 (continued). Characteristics of the LARES study sample, eight European cities, 2002–2003

Characteristic	*Study population* N *(percent)*	*Participants with depression* N *(percent of study population)*	*Participants with falls* N *(percent of study population)*
Dwelling satisfaction			
Satisfied	5,390 (90.0)	635 (11.9)	387 (7.2)
Dissatisfied	627 (10.4)	149 (23.9)	63 (10.1)
Neighborhood satisfaction			
Satisfied	5,590 (93.0)	709 (12.8)	406 (7.3)
Dissatisfied	427 (7.1)	75 (17.7)	44 (10.3)
Residential crowding			
None	1,791 (30.0)	244 (13.8)	145 (8.1)
Moderate	3,211 (53.4)	381 (11.9)	235 (7.3)
Severe	1,015 (16.9)	159 (15.8)	70 (6.9)
Light			
Inadequate	2,083 (34.6)	327 (15.8)	197 (9.5)
Adequate	3,934 (65.4)	457 (11.7)	253 (6.4)
Housing type			
Single family	1,883 (31.3)	302 (16.2)	187 (9.9)
Multifamily	4,134 (68.7)	482 (11.7)	263 (6.4)
Tenancy			
Owner occupied	4,439 (76.1)	587 (13.3)	320 (7.2)
Rental	1,555 (25.9)	193 (12.6)	127 (8.2)
Total	6,017 (100.0)	784 (13.0)	450 (7.5)

[a]Data not available for one respondent, so percentages based on n=6,016

LARES = Large Analysis and Review of European Housing and Health Status

among people reporting a fall, the absolute number of people who fell and who also reported no difficulty with stairs (n=315) was nearly 2.5 times the number of those who fell and who reported difficulty with stairs (n=135) (Table 1). Only 170 (11%) of the participants who reported difficulty with stairs lived in buildings with interior staircases, which suggests that they were more likely to have chosen to live in dwellings where they needed to use stairs less frequently.

The multivariate logistic analysis controlled for major confounders including gender, health status, education, alcohol consumption, satisfaction with residence, difficulty with stairs, presence of interior stairs, depression, and city of residence. In this model, the odds of a fall increased from the unadjusted OR of 1.4 to 2.5 times greater for people who reported inadequate light compared with those who reported adequate light (95% CI 1.5, 4.2) (Figure).

DISCUSSION

We found a 6% prevalence of doctor-diagnosed depression in the eight cities that made up the LARES sample, which is similar to that cited previously.[2] Another 7% of participants from the eight cities reported suffering from three or more of the cardinal symptoms of depression. More than one-third of the LARES participants with depression reported inadequate natural light in their dwellings. Our findings indicate that self-reported inadequate residential light is associated with risk for depression, independent of other confounders known to increase risk (such as gender, education level, or city of residence). We also found that falls were more likely to occur in homes where residents reported inadequate natural light, even after controlling for other major predictors of falls. The rate of falls identified in the LARES study was somewhat higher than the 2.1% overall rate of nonfatal falls that required medical treatment in the U.S. population reported in 1998. Fatalities from falls appear to be increasing in the U.S., rising 29.2% from 1999 to 2004.[24]

Comparison with previous studies

The pathogensis of depression is not well understood. However, bright-light therapy is efficacious in treating SAD and other forms of depression. A meta-analysis of 20 randomized controlled trials of light therapy for mood disorders found a significant decrease in depression severity in patients undergoing bright-light treatment.[25] Among depressed patients receiving stan-

Table 2. Unadjusted odds ratios and housing and health characteristics among adults reporting falls and depression: LARES Study, eight European cities, 2002–2003

Characteristic	*Odds ratio among those reporting falls (95% CI)*	*Odds ratio among those reporting depression (95% CI)*
Light		
Inadequate residential light vs. adequate light	1.5 (1.2, 1.9)	1.4 (1.2, 1.7)
Health		
Poor health status vs. good health status	1.9 (1.5, 2.3)	5.5 (4.6, 6.7)
Neighborhood		
Satisfied with neighborhood vs. dissatisfied	0.7 (0.5, 1.0)	0.7 (0.5, 0.9)
Dwelling		
Satisfied with dwelling vs. dissatisfied	0.7 (0.5, 1.0)	0.4 (0.3, 0.5)
Insurance		
Some private health insurance vs. public only or none	0.9 (0.7, 1.1)	0.6 (0.5, 0.7)
Income		
Middle or high income vs. low income	1.4 (1.2, 1.8)	1.9 (1.6, 2.2)
Marital status		
Divorced/widowed/separated vs. married	1.9 (1.5, 2.5)	2.5 (2.0, 3.0)
Single vs. married	1.1 (0.8, 1.4)	0.6 (0.5, 0.7)
Education		
Secondary education vs. primary or none	0.8 (0.6, 1.0)	0.8 (0.7, 1.0)
More than secondary education vs. primary or none	0.9 (0.7, 1.1)	0.4 (0.4, 0.5)
Alcohol intake		
Social drinker vs. abstainers	0.7 (0.6, 0.9)	0.5 (0.4, 0.5)
2–3 drinks per day vs. abstainers	0.7 (0.4, 1.0)	0.8 (0.6, 1.1)
≥4 drinks per day vs. abstainers	1.1 (0.6, 2.1)	1.8 (1.2, 2.7)
Employment		
Part time or unemployed vs. full time	2.0 (1.6, 2.4)	2.0 (1.7, 2.4)
Gender		
Female vs. male	1.8 (1.5, 2.1)	1.8 (1.5, 2.0)
Age (in years)		
30–39 vs. other adult ages	0.9 (0.7, 1.2)	0.7 (0.5, 0.8)
40–49 vs. other adult ages	0.7 (0.5, 0.9)	1.1 (0.9, 1.4)
50–59 vs. other adult ages	0.7 (0.5, 0.9)	1.2 (1.0, 1.5)
60–69 vs. other adult ages	1.1 (0.8, 1.4)	1.2 (1.0, 1.5)
≥70 vs. other adult ages	2.4 (1.9, 3.0)	2.2 (1.8, 2.7)
City		
Angers vs. other cities	1.1 (0.8, 1.5)	0.7 (0.5, 1.0)
Bonn vs. other cities	1.5 (1.2, 2.1)	0.6 (0.4, 0.8)
Bratislava vs. other cities	1.0 (0.7, 1.4)	0.8 (0.6, 1.1)
Budapest vs. other cities	1.0 (0.8, 1.4)	1.1 (0.9, 1.4)
Ferreira vs. other cities	2.0 (1.5, 2.6)	3.3 (2.6, 4.0)
Forli vs. other cities	0.6 (0.4, 0.8)	0.7 (0.5, 0.9)
Geneva vs. other cities	0.7 (0.4, 1.0)	0.7 (0.5, 0.9)
Vilnius vs. other cities	0.7 (0.5, 0.9)	1.0 (0.8, 1.2)
Residential crowding		
Moderate crowding vs. none	1.0 (0.8, 1.2)	0.8 (0.7, 0.9)
Severe crowding vs. none	0.9 (0.6, 1.2)	1.3 (1.0, 1.5)
Housing type		
Single family vs. multifamily	0.6 (0.5, 0.8)	0.7 (0.6, 0.8)
Rental property		
No vs. yes	1.2 (0.9, 1.5)	0.9 (0.8, 1.1)
Handicapped		
Yes vs. no	2.7 (2.2, 3.5)	3.2 (2.6, 3.8)

LARES = Large Analysis and Review of European Housing and Health Status

CI = confidence interval

Table 3. Housing elements and furnishings involved in falls: LARES Study, eight European cities, 2002–2003

Housing factor	*Number involved in falls (n=671)*[a] N *(percent)*
Structural elements (e.g., stairs or cracks in flooring)	225 (48.6)
Electric equipment (e.g., tripping on electrical cords)	23 (5.0)
Water/sanitary system (e.g., slipping on wet surface)	15 (3.2)
Heating/cooling equipment	31 (6.7)
Kitchen equipment	56 (16.6)
Knives/silverware	104 (22.5)
Furniture/furnishings	87 (18.8)
Washing products	9 (1.9)
Gas/fumes	9 (1.9)
Food items (e.g., slipping on spilled food on floors)	6 (1.3)
Animals/pets	8 (1.7)
Toys	9 (1.9)
Other	89 (19.2)

[a]Participants could select more than one housing factor involved in the fall.

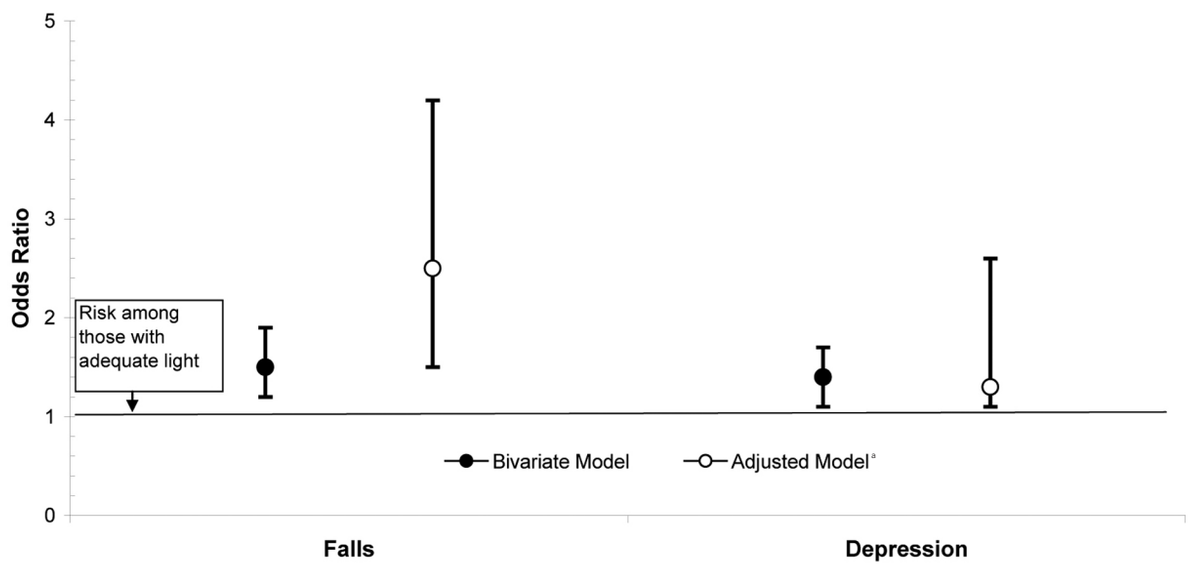
LARES = Large Analysis and Review of European Housing and Health Status

dard antidepressant medication, application of bright light resulted in a greater improvement in symptoms for patients receiving both therapies.[26] Even among healthy volunteers, application of bright-light exposure resulted in increased vitality and decreased depressive symptoms.[27] When exposure to the light was stopped, vitality decreased and depressive symptoms returned to baseline levels within two weeks. There also is evidence from human and animal models that those with depression have reduced contrast gain regardless of medication use.[15] Taken together, these studies suggest that depression may operate along multiple pathways; that light may act through a pathway not affected by pharmacotherapy; and that physiologic differences in retinal contrast gain may be unchanged despite changes in depressive symptoms as a result of either light, medication, or both. In this study, we found a relationship between self-report of inadequate natural light and depression. However, further study is needed to determine whether increasing natural light reduces symptoms despite any physiologic differences in contrast processing.

Limitations

The LARES dataset does not allow for adjustment of potentially important differences in individual behaviors that may improve or limit exposure to natural light,

Figure. Odds ratios for falls and depression among adults with inadequate residential light: LARES Study, eight European cities, 2002–2003



[a]Falls adjusted for health, income, marital status, alcohol consumption, employment, gender, age, city, multifamily dwelling, handicap, and difficulty with stairs. Depression adjusted for health, dwelling satisfaction, insurance type, income, marital status, education, alcohol consumption, employment status, gender, age, city, multifamily dwelling, handicap, and residential crowding.

LARES = Large Analysis and Review of European Housing and Health Status

including working outdoors, vitamin D consumption, or other factors. Prospective studies are needed that are explicitly designed to elucidate the impact, if any, of these factors.

The results of this study also may have been affected by misclassification bias in either the exposure of interest (self-report of adequate light) or the health outcomes (falls and depression). The adequacy of residential light was determined using a qualitative measure collected during in-person interviews rather than actual light measurements. This may have introduced some misclassification in that artificial light was sufficient in some units. Nonetheless, in models controlling for major predictors of falls or depression, including age, alcohol consumption, handicap, and general health status, self-reported inadequate natural light was an independent predictor of both conditions.

The data collection instrument has not been evaluated for external validity. However, given that there was only one case out of 3,076 where more than one participant living in the same dwelling disagreed on the adequacy of light, we are confident of the internal validity of the data. We measured depression with a validated index of depressive symptoms that correlate well with the criteria in the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*.[22,28] Because this index relies on self-report of symptoms, it is likely that it results in some misclassification. However, doctor-diagnosed depression showed a very similar association with exposure to inadequate light, suggesting that the effect of misclassification is small.

These cross-sectional data cannot establish conclusive causality, and it is possible that participants who met our definition of depression may have been more likely to consider the light in their homes to be inadequate. Although our self-reported adequacy of light does not permit comparisons between light in different residences, given that there was general agreement of the adequacy of light within households where more than one person was interviewed, the evidence from this large population-based survey suggests that self-reported inadequate natural light may contribute to at least two important health conditions—depression and injury from falls—typically viewed as unrelated to each other.

This analysis emphasizes the value of large, cross-sectional population surveys that measure both health and housing conditions; however, such surveys are exceedingly rare. For example, in the U.S., two large population surveys are conducted that measure housing and health separately: the American Housing Survey (AHS) and the National Health Interview Survey (NHIS). Yet, AHS does not record health information, and NHIS does not record housing data, which makes identifying housing and health connections unnecessarily difficult. Future surveys should link housing and health data in a single survey such as LARES to enable identification of housing factors that either contribute to or cause adverse health conditions, or contribute to or cause improved health. Such surveys can also play an important role in identifying promising longitudinal trials and other means of investigation that assess the effects of interventions and elucidate in a robust way causal pathways. Based on the LARES analysis presented in this article, a longitudinal trial that determines whether improved light decreases depression and prevents injuries is clearly needed.

CONCLUSION

Inadequate light was associated with risk for depression and falls, both of which contribute substantially to the global burden of disease. This association remained statistically significant after controlling for confounding variables. Given the magnitude of the problem and the inexpensive nature of the intervention, further investigation is needed. Such studies should determine whether either improved window placement and construction, which if it occurs during the design phase is not cost prohibitive, or increased exposure to sunlight by planned outdoor activities reduces the risk of depression and falls in people who report inadequate residential light. To help prevent depression and falls, housing codes and inspection systems should routinely assess whether residents report that the light in their dwelling is adequate.

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