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Original Study

Impact of Upgraded Lighting on Falls in Care Home Residents

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A B S T R A C T

Objectives: Falls in care home residents have major health and economic implications. Given the impact of lighting on visual acuity, alertness, and sleep and their potential influence on falls, we aimed to assess the impact of upgraded lighting on the rate of falls in long-term care home residents.
Design: An observational study of 2 pairs of care homes (4 sites total). One site from each pair was selected for solid-state lighting upgrade, and the other site served as a control.
Setting and Participants: Two pairs of care homes with 758 residents (126,479 resident-days; mean age (±SD) 81.0 ± 11.7 years; 57% female; 31% with dementia).
Methods: One "experimental" site from each pair had solid-state lighting installed throughout the facility that changed in intensity and spectrum to increase short-wavelength (blue light) exposure during the day (6 AM–6 PM) and decrease it overnight (6 PM–6 AM). The control sites retained standard lighting with no change in intensity or spectrum throughout the day. The number of falls aggregated from medical records were assessed over an approximately 24-month interval. The primary comparison between the sites was the rate of falls per 1000 resident-days.
Results: Before the lighting upgrade, the rate of falls was similar between experimental and control sites [6.94 vs 6.62 falls per 1000 resident-days, respectively; rate ratio (RR) 1.05; 95% CI 0.70–1.58; $P = .82$]. Following the upgrade, falls were reduced by 43% at experimental sites compared with control sites (4.82 vs 8.44 falls per 1000 resident-days, respectively; RR 0.57; 95% CI 0.39–0.84; $P = .004$).

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Conclusions and Implications: Upgrading ambient lighting to incorporate higher intensity blue-enriched white light during the daytime and lower intensity overnight represents an effective, passive, low-cost, low-burden addition to current preventive strategies to reduce fall risk in long-term care settings.

Falls are the leading cause of injury-related death in US adults aged 65 or older.[1] The economic impact of falls is immense, with fatal falls estimated to cost $754 million and nonfatal falls $50 billion annually.[2] With an aging population, falls prevention is a major public health priority. Current interventions to prevent falls in long-term care settings typically include complex, multicomponent interventions[3] requiring significant time and resources, including multiple health care providers, infrastructure changes, and staff and resident education. Furthermore, despite an abundance of data indicating that falls in older adults can be prevented,[4–8] mortality related to falls continues to rise.[1] Barriers at various levels can contribute to suboptimal implementation of fall prevention strategies, which likely explains their lack of efficacy in pragmatic trials.[9,10] Identification of effective, passive, low-cost, low-burden interventions, such as improved lighting, may expand the range of tools available to prevent falls in long-term care facilities.

In addition to allowing us to see, light exposure induces a number of "nonvisual" responses, including direct effects on alertness, cognition, and sleep.[11] Intrinsically photosensitive retinal ganglion cells (ipRGCs) that express the photopigment melanopsin are the principal photoreceptors underlying nonvisual responses to moderate-intensity and longer-duration light exposures,[11–15] which is the typical light exposure in residential care homes. The cells are preferentially sensitive to short-wavelength (blue) light (447–484 nm, λ_{max} ~480 nm)[11]; therefore, controlling the amount of blue-light content in ambient lighting to differentially activate ipRGCs by changing light spectrum and intensity may be an approach to modulate both the nonvisual and visual benefits of light exposure.

Cognitive impairment, sleep disturbance, and visual acuity are associated with increased risk of falls in older individuals.[9,16] All of these factors are sensitive to light exposure, particularly higher intensity blue-enriched light, which during the daytime has been shown to improve alertness, cognition, and subsequent nighttime sleep,[17–20] as well as visual acuity.[21] In addition, exposure to lower-intensity blue-depleted light in the evening also facilitates nighttime sleep,[22,23] which may further improve daytime alertness and cognition the next day. These potential benefits of light have recently been tested in residential care settings to improve patient health and well-being. In a seminal randomized control trial, Riemersma-van der Lek and colleagues[24] studied 189 care home residents across 12 sites over a 3.5-year duration and found significant slowing of cognitive decline, decreased depression, and a slowing in the rate of functional limitations by half in the study arm in which the intervention increased the light intensity in the common areas during the day as compared with the control condition with standard lighting. Several additional efficacy trials of care home lighting interventions also show benefits of blue-enriched white light exposure during the day, including increased sleep duration, sleep quality, and daytime activity, and reduced depression, anxiety, and agitation.[25–28]

Whether a lighting intervention that incorporates dynamic lighting schedules with changes in lighting intensity and spectra across the 24-hour day can improve other health outcomes, particularly falls in older care home residents, is unknown. Therefore, the current study aimed to test whether, compared with typical static lighting, the implementation of a dynamic lighting schedule is associated with a reduction in fall rates in long-term care home residents.

Method

Study Design

The study was a prospective observational study of 2 pairs of care homes. Each pair was owned and operated by a single parent company with standardized care and therapy protocols shared between sites. One site from each pair was selected by the company to undergo lighting upgrade (experimental site), and the other site served as a control. Data were examined over a 2-year interval, for approximately 12 months before and 12 months after the lighting installation (Figure 1). This study was approved by Western Institutional Review Board (20181108) and the Mass General Brigham Institutional Review Board (2017P002429).

Lighting Intervention

The lighting intervention at experimental sites involved a change from a static lighting schedule (SLS), in which the intensity and spectrum of ambient lighting remained unchanged throughout the day and night, to a dynamic lighting schedule (DLS) in which both the intensity and spectrum of ambient lighting was modulated to alter melanopic illuminance (Figure 2), which is a measure of the strength of the stimulus on the principal photoreceptor (melanopsin) that primarily mediates the nonvisual effects of light.

Before the lighting installation, the experimental care homes used predominantly fluorescent lamps with a Correlated Color Temperature (CCT) ranging from 2700K to 3500K. The 2 control sites had a mix of 2700K and 6500K, or 2700K and 4000K fluorescent lamps, respectively. The experimental sites underwent a lighting upgrade to install the DLS. In common areas (ie, dining room and sitting rooms) and corridors the DLS consisted of (1) a graduated day setting with high-intensity, blue-enriched white light from 6 AM to 6 PM (60% maximal intensity from 6 AM to 10 AM, 100% from 10 AM to 3 PM, 60% from 3 PM to 6 PM); (2) an evening setting with low-intensity (matched for photopic illuminance to the 60% day setting), blue-depleted white light from 6 PM to 10 PM; and (3) a night setting with lower-intensity, blue-depleted white light from 10 PM to 6 AM. In resident bedrooms, the DLS consisted of a high-intensity, blue-enriched white light from 6 AM to 6 PM, and low-intensity blue-depleted white light from 6 PM to 6 AM. Occasionally, residents would attend evening activities between 7 and 9 PM in the activity room, which had nontunable, blue-enriched solid-state white light (5000K) installed. The lighting used in the upgrade was product neutral. Some aspects of the lighting schedule were programmed automatically, but simple instructions were also provided to the staff and residents on how to use the lighting manually, if necessary. The lighting installation at the 2 experimental sites was completed between September and November 2018 (Figure 1). The commercial cost of installing the lighting system throughout a facility, including in common areas such as dining, activity, TV rooms, and corridors, was approximately US$1700 per bed. The primary expectation of the care home facilities pertained to the energy and cost savings potential of solid-state lighting over the existing fluorescent lights.

Light measurements were taken at the control and experimental sites in October 2018 in the common areas, including corridors, the

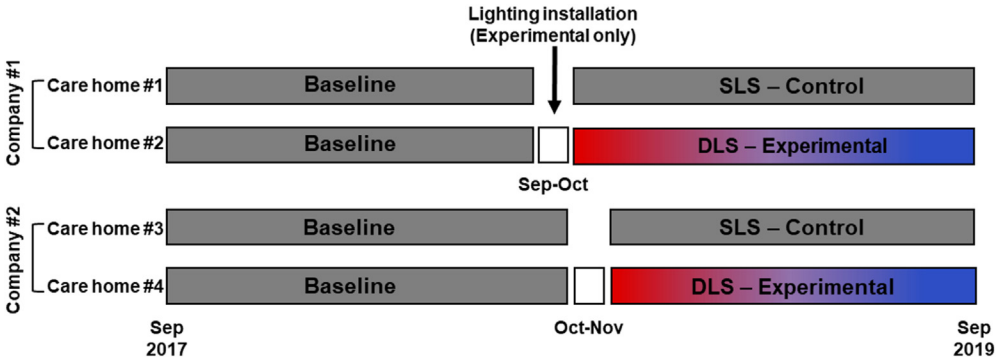

Fig. 1. Study schema. One care home from each pair underwent a lighting upgrade to install a DLS (Experimental condition), and the other maintained their traditional SLS (Control condition) throughout data collection. Data were collected from all sites before (baseline) and after the lighting installation.

dining hall and sitting rooms, and in several bedrooms at each site. Spectrophotometry recordings were made using a ColorMunki colorimeter (X-Rite) and converted to International Commission on Illumination (CIE) α-opic equivalent daylight (D65) illuminance (EDI) units, the SI units for quantifying photic stimuli for nonvisual responses.[29] Four measurements were taken in the vertical plane at a height of 137 cm, 90 degrees apart, at each measurement location. At the experimental sites, light measurements were taken for both the 100% maximal intensity day and the low-intensity night settings (n = 448 measurements). The 60% day and evening light settings in the common areas that are shown in Figure 2 were estimated based on the measured values. Given the static lighting in the control sites, only 1 set of measurements was collected (n = 220 measurements). Radiometric, photometric, and spectral characteristics of light sources at experimental and control sites are presented in Table 1.

Falls Assessment

The primary outcome was the rate of falls per 1000 resident-days. Retrospective review of medical records was used to determine the number of falls documented by care providers at each site, as recorded per the Centers for Medicare and Medicaid Services definition of nursing facility falls[30]: "*Unintentionally coming to rest on the ground, floor, or other lower level but not as a result of an overwhelming external force*." Any fall that met this definition was recorded at the time of the incident by a nurse using a structured interview and reporting tool available on the site's medical record system. Falls data were extracted from medical records by a designated nurse at each site. Exploratory assessment of injurious falls were conducted using Minimum Data Set (MDS) records. In MDS records reporting at least 1 fall, data were dichotomized into either "No injury," defined as a frequency of 1 or

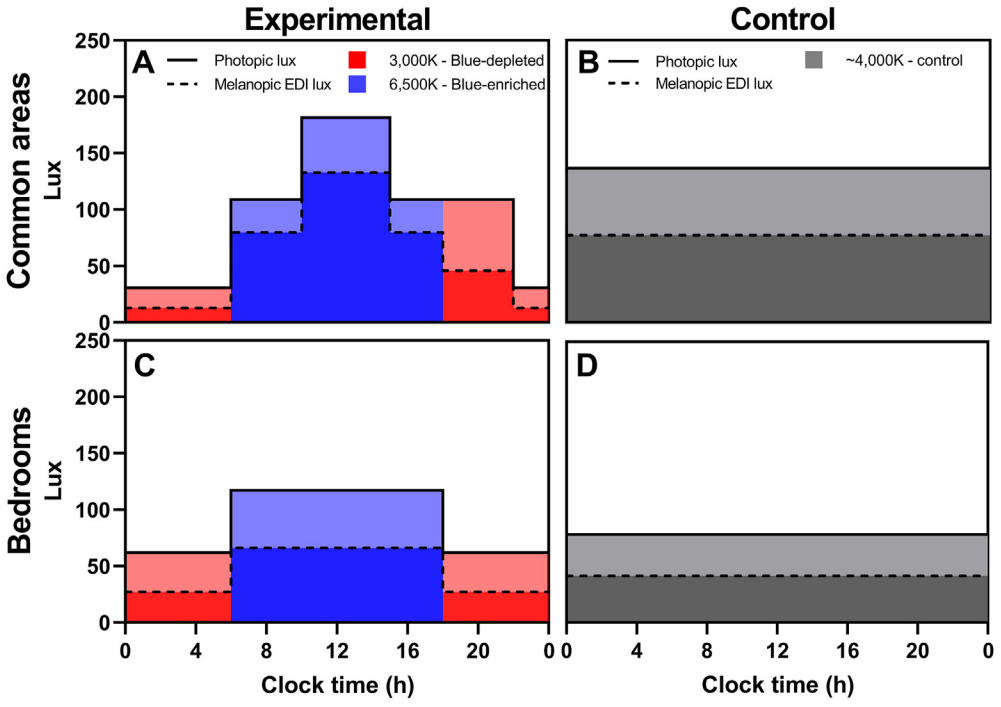

Fig. 2. Lighting schedules for control and experimental sites. Melanopic EDI, a measure of illuminance for nonvisual responses to light, measured in the experimental DLS (left) and control SLS (right) sites in common areas (A, B) and bedrooms (C, D). In contrast to the static lighting at control sites, the spectrum and intensity of light changed across the 24-hour day at the experimental sites following the lighting installation. The approximate CCT is reported in kelvins (K) for each light source.

Table 1
Measured Characteristics of Light Sources at the Experimental and Control Sites

Lighting Condition			CCT	Radiometric and Photometric Values (380–780 nm Inclusive)		Retinal Photopigment Weighted Illuminances (α-opic EDI lux)					DER
Condition	Setting	Location		Irradiance μW/cm^2	Photopic Illuminance lux	S Cone	Melanopsin	Rod	M Cone	L Cone	Melanopsin
Experimental	Day	Common areas	4712 ± 863	59.0 ± 39.8	181.5 ± 107.6	131.4 ± 94.0	132.8 ± 91.6	141.5 ± 94.4	166.8 ± 102.9	180.7 ± 107.0	0.73
		Bedroom	3440 ± 552	38.7 ± 18.9	117.2 ± 59.0	57.9 ± 38.2	66.1 ± 38.5	74.3 ± 41.6	99.5 ± 51.9	117.9 ± 59.0	0.56
	Night/Evening	Common areas	2694 ± 670	9.8 ± 16.8	30.7 ± 54.5	9.5 ± 16.0	12.9 ± 22.5	15.4 ± 27.1	24.0 ± 42.6	31.3 ± 55.5	0.42
		Bedroom	2768 ± 154	21.4 ± 11.8	62.0 ± 33.6	18.2 ± 11.2	27.2 ± 15.9	32.5 ± 18.7	49.1 ± 27.2	63.0 ± 33.9	0.44
Control	-	Common areas	3842 ± 715	38.8 ± 30.7	136.6 ± 106.5	68.6 ± 63.5	77.1 ± 66.2	88.9 ± 74.4	119.9 ± 95.6	135.0 ± 104.8	0.56
	-	Bedroom	3593 ± 445	21.8 ± 21.3	77.0 ± 75.2	33.0 ± 34.9	39.9 ± 42.5	46.9 ± 48.6	66.0 ± 65.8	76.4 ± 74.6	0.52

DER, daylight (D65) efficacy ratio.
Values represent mean ± SD.

2 + falls exclusively in the no-injury category, or "Injurious," defined as a frequency of 1 or 2 + falls in the injury and major injury categories.

Medication, Physical Therapy, Ambulation, and Transfer Data

Medication, ambulation, transfer, and physical therapy were assessed in an exploratory analysis from MDS records available for 562 of 758 (74%) residents who contributed to the falls dataset. Medication usage was assessed based on the number of days a resident received medications in 8 pharmacological classifications (antipsychotic, antianxiety, antidepressant, hypnotic, anticoagulant, antibiotic, diuretic, opioid) over the past 7 days. Receiving a medication on at least 1 of the 7 days counted as using that particular medication. The variables "fall-related medications," defined as receiving 1 or more medications associated with increased fall risk (antipsychotic, antianxiety, antidepressant, hypnotic, diuretic, opioid), and "polypharmacy," receiving 0, 1, 2, or 3 + medications, were calculated from MDS-recorded medication usage. The number of residents receiving physical therapy was determined by the MDS assessment of the number of days physical therapy was administered for at least 15 minutes in the past 7 days. More than 15 minutes of physical therapy on at least 1 of the 7 days counted as receiving physical therapy. Ambulation and transfer were assessed by the MDS-reported "Resident's performance" for "Locomotion on the unit—how resident moved between locations in his/her room and adjacent corridor on same floor" and "Transfer—how resident moved between surfaces including to or from: bed, chair, wheelchair, standing position," respectively. Performance for "Locomotion on unit" and "Transfer" were dichotomized into "independent/supervision only" or "requiring assistance/dependent."

Data Analysis

Differences in resident demographics, and MDS-reported medication, physical therapy, ambulation, and transfer between lighting conditions, stratified by observation interval (ie, pre/post), were assessed using Wilcoxon and Fisher's Exact tests. Rate ratios (RRs) for falls were estimated using generalized linear mixed models (GLMM) with Poisson distribution, site-level random effects, robust standard errors adjusting for possible overinflation, and log of patient days as the offset.[31] Odds ratios for injurious falls were estimated using GLMM using participant and site-level random effects and log of patient days as the offset. Exploratory analysis of the distribution in the average number of falls per resident between daytime (6 AM to 6 PM) and nighttime (6 PM to 6 AM) between the experimental and control sites, and between the intervals before and after the lighting upgrade within the experimental and control sites was assessed using GLMM with Poisson distribution and robust standard error. All analyses were conducted using SAS 9.4 (SAS Inc.).

Results

Demographic characteristics stratified by condition (experimental vs control) and observation interval (pre vs post) were not different between groups for age and sex (Table 2). The proportion of residents with dementia was higher in the interval following the lighting upgrade and the number of resident-days was higher, both before and after the lighting upgrade in the experimental condition compared with the control condition. Medication usage, including polypharmacy, was not different between control and experimental sites before or after the lighting upgrade (Supplementary Tables 1 and 2), except for antidepressant use, which was significantly lower at control sites before the lighting upgrade. The proportion of residents who received physical therapy was higher at control compared with experimental sites after, but not before, the lighting upgrade

Table 2
Demographic Information for Control and Experimental Sites Before and After the Lighting Upgrade

Demographic	Control Sites	Experimental Sites	*P*
Pre lighting upgrade			
n	224	291	—
Age, mean ± SD y	83.5 ± 10.2	82.1 ± 11.4	.24*
Females, n (%)	119 (53.1)	177 (60.8)	.09†
Dementia, n (%)‡	64 (29.4)	92 (33.3)	.38†
Resident-days, mean ± SD days	126.4 ± 150.8	151.2 ± 152.6	.02*
Post lighting upgrade			
n	203	235	—
Age, mean ± SD y	80.4 ± 12.2	80.6 ± 11.9	.98*
Females, n (%)	119 (58.6)	147 (62.6)	.43†
Dementia, n (%)§	57 (29.5)	94 (41.6)	.01†
Resident-days, mean ± SD days	98.0 ± 110.8	145.8 ± 128.7	.0003*

*Wilcoxon 2-sample test.
†Fisher's Exact test.
‡Dementia status was unknown in a subset of the patients (Control: n = 6; Experimental: n = 15).
§Dementia status was unknown in a subset of the patients (Control: n = 10; Experimental: n = 9).

(Supplementary Table 3). The number of residents requiring assistance with locomotion and transfer was significantly higher at control sites before, but not after, the lighting upgrade (Supplementary Table 4).

There were 834 total falls recorded in the 2-year interval across the 4 study sites. In the data collection interval immediately preceding the lighting upgrade (data from 515 residents), the rate of falls was not different between the experimental and control sites (6.94 vs 6.62 falls per 1000 resident-days, respectively; RR 1.05; 95% CI 0.70–1.58; P = .82; Table 3). In the interval following the lighting upgrade (data from 438 residents), the rate of falls was 43% lower in the experimental compared with the control condition (4.82 vs 8.44 falls per 1000 resident-days, respectively; RR 0.57; 95% CI 0.39–0.83; P = .004; Table 3). Consistent with the main finding, exploratory analysis of MDS-reported falls showed that the odds of a resident having an MDS record reporting an injurious fall appeared lower at the experimental sites after the lighting upgrade, but this did not reach statistical significance (OR 0.60; 95% CI 0.24–1.56; P = .29).

The rate of falls remained significantly lower in the experimental condition following the lighting upgrade after adjustment for age, sex, and proportion of residents with dementia (5.34 vs 9.22 falls per 1000 resident-days, respectively; RR 0.57; 95% CI 0.36, 0.90; P = .02). In an additional model adjusting for age, sex, dementia, physical therapy, ambulation transfer, and medication, there was a nonsignificant trend for a lower fall rate following the lighting upgrade (4.06 vs 6.61 falls per 1000 resident-days, respectively; RR 0.61; 95% CI 0.34–1.10; P = .10).

Table 3
Total Falls, Patient Days and Fall Rate for Control and Experimental Sites Before and After the Lighting Upgrade

	Number of Falls	Number of Patient Days	Fall Rate/1000 Patient Days [95% CI]
Pre lighting upgrade			
Control sites	190	28,305	6.6 [5.6–7.9]
Experimental sites	297	44,005	6.9 [4.8–10.1]
Post lighting upgrade			
Control sites	174	19,903	8.4 [6.6–10.1]
Experimental sites	173	34,266	4.8 [3.6–6.4]

Fall rates are reported for the unadjusted models.

In addition to showing that overall fall rates were lower in the experimental sites, exploratory analyses showed that the distribution of falls by time of day among individuals who fell (n = 247) was significantly different (P = .004) between the control and experimental sites in the 12 months following the lighting upgrade. During this interval, 58% of falls occurred during the nighttime (6 PM to 6 AM) at the control sites, whereas at experimental sites most falls (55%) occurred in the daytime (6 AM to 6 PM). There was no difference in the distribution of falls between the sites before the lighting upgrade.

Discussion

The current study evaluated the fall rate in residential care homes following installation of a dynamic lighting program as compared with standard static lighting. Compared with the control sites, we found that the lighting upgrade at the experimental sites was associated with a 43% reduction in the rate of resident falls in the year following installation.

The reduction in fall rate associated with the lighting upgrade is potentially substantial. Fall prevention interventions in older adults generally have achieved more modest reductions, often with more complex and resource-intensive interventions. For example, meta-analyses of randomized clinical trials have shown 20% to 30% reductions in the RR of falls with targeted multifactorial, multicomponent, exercise, or high-dose vitamin D supplementation interventions.[4–7,32] A passive intervention that requires little active effort by either the staff or residents is a promising addition to current preventive strategies to reduce falls.

Falls in older individuals are a complex problem with multiple intrinsic (eg, cognitive impairments) and extrinsic (eg, environmental hazards) contributors,[10] some of which may be sensitive to light. Global cognitive impairment in older adults is associated with increased odds of falls and fall-related injuries.[33] Acute blue-light or blue-enriched white light exposure improves cognition,[19] and in the care home setting has been shown to attenuate cognitive decline.[24] Furthermore, increased exposure to light in care home residents has also been shown to improve sleep duration, sleep quality, and daytime activity, and reduce depression, anxiety, and agitation,[24–28,34,35] all factors that may in turn contribute to reducing the risk of falls. In addition to the nonvisual effects of light on cognition, sleep, and mood, enhanced lighting during the day likely also improves visual acuity, another factor that influences fall risk.[10]

Although the risk factor(s) affected by the lighting intervention in the current study cannot be identified, our exploratory analysis suggests that it is likely not related to brighter lighting and better visual acuity, as the intervention condition was associated with fewer falls overnight when lighting levels were dim. Moreover, despite the rate of falls being lower in the care homes with the lighting upgrades compared with the control sites, there was a trend toward more falls during the daytime, when lighting levels were brighter in the experimental sites, further suggesting that the overall reduction in fall rate is not explained by better visual acuity. A more likely explanation, therefore, is improved nonvisual responses associated with the lighting intervention, such as changes in sleep and cognition, as documented in previous trials.[24–28] Based on previous studies on the effects of light exposure in care home residents, the lower number of falls at night may be linked to more time in bed overnight and better sleep among residents,[25,26,28] whereas the higher number of falls during the day may be linked to increased daytime activity[28,35] providing greater opportunity for falls. Although supported by the results of previous studies, further investigation is required to test these hypotheses directly. Similarly, additional studies are required to identify the falls-related risk factors most improved by incorporating a DLS in care homes and to determine the spectral sensitivity of these underlying physiologic factors. This will inform optimization of the

timing, intensity, and spectrum of ambient lighting to reduce falls in the older individuals.

Although the current study is the largest to investigate the effects of light in a care home setting, it has several limitations. Given the nature of the intervention, the sites were not blinded to the experimental conditions, and the site from each pair of care homes that received the upgrade was not randomly assigned. In addition, light has multiple physiological effects that may underlie the improvement in falls reported herein, including enhanced cognition, sleep, and visual acuity. The current observational study did not measure light exposure at the individual level for each resident and was not designed to examine the mechanisms by which light reduced falls, therefore future studies addressing this limitation are required. Another limitation of the study is that we were unable to directly assess other potentially important outcomes such as fall severity, including whether a fall was injurious or not, or the contribution of other potential mediators and explanatory variables of fall risk, including medication, ambulation, and physical therapy during the study interval. Analyses of MDS-reported medication usage, physical therapy, ambulation, and transfer (see Supplementary Tables 1–4), however, suggest that differences in these factors between control and experimental sites likely do not explain the lower fall rate following the lighting upgrade. Given that MDS records are collected intermittently, are not contemporaneous with the falls data, and only indirectly estimate the variables of interest, these data should be interpreted with caution. Future studies require continuous assessment of these outcomes to determine whether these factors directly mediate or explain the improvement in fall rate observed in the current study.

Conclusions and Implications

Given the superior energy efficiency of solid-state lighting,[36] many care home facilities will likely choose to upgrade their lighting in the future to make substantial energy cost savings. Such upgrades offer potentially large additional benefits to resident health and well-being provided the intensity and spectrum of new lighting is considered appropriately. Even a modest reduction in falls resulting from lighting upgrades would be impactful, given the devastating ramifications of falls for aged care resident health and the associated economic burden. The potential benefits observed in the current study behooves long-term care facilities to consider implementing this noninvasive, safe, passive, and relatively inexpensive intervention to help reduce the consequences of poor lighting on resident health and safety.

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Supplementary Table 1
The Number and Percentage of Residents With MDS-Recorded Medication Usage Control and Experimental Sites Before and After the Lighting Upgrade

Pharmacological Classification	Pre Lighting Upgrade					Post Lighting Upgrade				
	Control (n = 133)		Experimental (n = 257)		Fisher's Exact *P* Value	Control (n = 116)		Experimental (n = 219)		Fisher's Exact *P* Value
	No	Yes	No	Yes		No	Yes	No	Yes	
Antipsychotic	117 (88%)	16 (12%)	218 (85%)	39 (15%)	0.45	105 (91%)	11 (9%)	186 (85%)	33 (15%)	.18
Antianxiety	109 (82%)	24 (18%)	204 (79%)	53 (21%)	0.59	96 (83%)	20 (17%)	181 (82%)	38 (17%)	1.00
Antidepressant	86 (65)	47 (35)	118 (46)	139 (54)	<.001	67 (58)	49 (42)	108 (49)	111 (51)	.17
Hypnotic	131 (98)	2 (2)	255 (99)	2 (1)	.61	116 (100)	0 (0)	218 (99.5)	1 (0.5)	1.00
Anticoagulant	93 (70)	40 (30)	180 (70)	77 (30)	1.00	80 (69)	36 (31)	156 (71)	63 (29)	.71
Antibiotic	87 (65)	46 (35)	173 (67)	84 (33)	.73	78 (67)	38 (33)	150 (68)	69 (32)	.81
Diuretic	64 (48)	69 (52)	141 (55)	116 (45)	.24	57 (49)	59 (51)	116 (53)	103 (47)	.57
Opioid*	86 (65)	47 (35)	144 (57)	108 (43)	.16	73 (63)	43 (37)	118 (54)	101 (46)	.13
Fall-related medications†	23 (17)	110 (83)	36 (14)	221 (86)	.46	19 (16)	97 (84)	29 (13)	190 (87)	.51

*Data on opioid use missing for n = 5 residents at experimental sites pre lighting upgrade.
†Indicates residents receiving at least 1 medication associated with increases risk of falls (antipsychotic, antianxiety, antidepressant, hypnotic, diuretic, opioid).

Supplementary Table 2
The Number and Percentage of Residents With Polypharmacy at Control and Experimental Sites Before and After the Lighting Upgrade

No. of Medications	Pre Lighting Upgrade		Post Lighting Upgrade	
	Control (n = 133)	Experimental (n = 252)*	Control (n = 116)	Experimental (n = 219)
0	23 (17)	35 (14)	19 (16)	29 (13)
1	42 (32)	72 (29)	38 (33)	72 (33)
2	50 (38)	83 (33)	38 (33)	64 (29)
3+	18 (14)	62 (25)	21 (18)	54 (25)
χ^2 *P* value	.0852		.5149	

*Data missing for n = 5 residents at experimental sites pre lighting upgrade.

Supplementary Table 3
The Number and Percentage of Residents With and Without MDS-Recorded Physical Therapy at Control and Experimental Sites Before and After the Lighting Upgrade

Physical Therapy	Pre Lighting Upgrade					Post Lighting Upgrade				
	Control (n = 133)		Experimental (n = 257)		Fisher's Exact *P* Value	Control (n = 116)		Experimental (n = 219)		Fisher's Exact *P* Value
	No	Yes	No	Yes		No	Yes	No	Yes	
Received at least 15 min of physical therapy on at least 1 day in the past week	23 (17)	110 (83)	59 (23)	198 (77)	.2380	26 (22)	90 (78)	85 (39)	134 (61)	.0023

Supplementary Table 4
The Number and Percentage of Residents With and Without MDS-Recorded Locomotion and Transfer Impairment at Control and Experimental Sites Before and After the Lighting Upgrade

Ambulation/Transfer	Pre Lighting Upgrade					Post Lighting Upgrade				
	Control (n_{loco} = 128; n_{trans} = 132)		Experimental (n_{loco} = 247; n_{trans} = 253)		Fisher's exact *P* Value	Control (n_{loco} = 114; n_{trans} = 115)		Experimental (n_{loco} = 215; n_{trans} = 216)		Fisher's Exact *P* Value
	Indp.	Assist.	Indp.	Assist.		Indp.	Assist.	Indp.	Assist.	
Locomotion on unit	15 (12)	113 (88)	68 (28)	179 (72)	.0004	22 (19)	92 (81)	41 (19)	174 (81)	1.000
Transfer	9 (7)	123 (93)	39 (15)	215 (85)	.0151	11 (10)	104 (90)	19 (9)	197 (91)	.8420

Assist. = Assistance; Indp. = independent; N_{loco} = number of participants in locomotion analysis; N_{trans} = number of participants in transfer analysis.