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**Sleep disturbance and the change from white to red lighting at night on Old Age
Psychiatry wards: a quality improvement project**

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Abstract

Psychiatric inpatient units often maintain a degree of lighting at night in order to facilitate the observation of patients and ensure their care, but this has the potential to disrupt sleep.

Certain wavelengths of light may be less likely to disturb sleep and if such lighting still permitted observations to be conducted, patient wellbeing may be improved.

Aims and method: the purpose of this study was to explore the effects of changing from broad-band white lighting to narrow-band red lighting at night on the amount of sleep observed, 'as required' medication administered and number of falls, in an old age psychiatry inpatient setting. Qualitative data was also gathered with a staff questionnaire. We hypothesised that compared to the use of white lights, red lights would be associated with a greater amount of recorded sleep, lesser use of 'as required' medication and no increase in the number of falls (reflecting comparable safety).

Results: whilst there were no significant differences in quantitative measures recorded, the numerical change in the sleep quality parameters were in the hypothesised directions, with more sleep and less 'as required' medication administered during the red light period compared to the white light period. Qualitatively, the staff of the organic assessment unit reported that patients were sleeping better and less agitated at night.

Clinical implications: larger and more in-depth studies are required to examine the full effectiveness of using safe, sleep-enhancing lighting on hospital wards at night.

Introduction

Light at night is required by staff on inpatient wards to undertake observations of patients to ensure their wellbeing and record their sleep patterns. However, exposure to constant light at night has been shown to disrupt the circadian rhythm.¹ Sleep disturbance can lead to episodes of agitation at night and necessitate the administration of sedative medication.² Irregular light has also been shown to affect mood, even in the absence of sleep disturbance.³ Therefore, there is a tension between the need for light at night on hospital wards and the requirement to limit the disturbance to patients' sleep.

Intrinsically photosensitive retinal ganglion cells (ipRGCs) provide the primary environmental light input to the suprachiasmatic nucleus, which regulates the release of melatonin and therefore the circadian rhythm.^{4,5} IpRGCs have reduced sensitivity to wavelengths of over 600 nm⁶ so if light with wavelengths of above 600nm only were to be used at night, disturbance to circadian rhythm would, in theory, be reduced. Red light has wavelengths over 600 nm⁷ and reduced sleep disturbance with red light at night has already been demonstrated in preclinical studies,⁸ but little research has explored the effect in patient groups. Here we report on a quality improvement project in which the bedroom night-lights on two old-age psychiatric inpatient units were changed from broad-band white light to narrow-band red light. We hypothesised that compared to white lighting, red lighting would be associated with a greater duration of sleep, reduced administration of "as required" sedative medication and a comparable incidence of falls (reflecting ease of conduct of safety and wellbeing observations).

Methods

This project was conducted in on two old-age psychiatry in-patient wards at the Queen Elizabeth Hospital in Gateshead in the United Kingdom: Cragside Court (study ward 1), an organic mental illness assessment unit for people with dementia or presenting with cognitive impairment and Sunnyside Unit (study ward 2), a functional illness assessment unit for older people. Cragside Court, the organic assessment unit, comprised nine single bedrooms and three three-bed rooms, with the night lights generally left on all night as the resident patients often had nocturnal disturbance and wandering; the patients in this ward were typically considered to have a high risk of falls. Sunnyside Unit, the functional assessment ward, comprised nine single bed rooms and two three-bed rooms, with the night lights intermittently turned on (or alternatively a torch used) for only a few seconds every half hour to aid the required patient safety observations by staff. The ceiling lights in each bedroom contained two bulbs, a bright white for the daytime, and a dim white for night. The night-lights already installed on the wards used Philips Master PL-S 840 4P 9 watt, 600 lumen bulbs. These bulbs emit broad-band light (with wavelengths covering the full visible spectrum) of “warm white” colour with a measured correlated colour temperature of approximately 4000K (see Figure 1).

Intervention

During the intervention period, the bulbs used at night were covered with a purpose-designed heat-resistant red rubber filter obtained from the hospital electric goods supplier. This intervention, approved by the ward managers and enacted by the hospital estates department, changed the night-time light to a narrow-band red light containing wavelengths above 600nm only (see Figure 1). The bulbs used for daytime lights were unchanged. It was agreed that during the intervention period, staff would use only the red lights in the bedrooms between

10pm and 7am. However, if necessary for safety reasons or patient preference, individual bedrooms were allowed to revert to the original “warm white” light, effectively opting out of the project.

Measures

The measures used to assess the intervention in this project were: duration of sleep (number of times each patient was observed to be asleep on half-hourly checks); requirement for sedatives (number of times ‘as required’ medication was administered); impact on patient safety (estimated by incidence of falls). Data was collated by a single researcher (DM) from routine nursing observations and care documentation (night time observation charts, drug charts and incident reports for falls) – no change in patient monitoring was required of the nursing staff for this project. The night-time observation charts, routinely completed by nursing staff for all patients on each ward, record whether patients are seen to be asleep or awake every 30 minutes throughout the night. These charts were reviewed to determine the number of times each patient was observed to be asleep each night, and in turn the average number for all patients on each ward for the study periods before and after the intervention. The drug charts of all patients were reviewed to determine the number of occasions that staff administered “as required” medication for the indication “agitation” or “insomnia”, averaged by ward for each intervention period. The incidence of falls was determined by requesting the number of incident reports that specified “fall” for to each ward, again for both study periods. Data was first collected under the normal ward conditions for a period of six weeks. The lighting intervention was then made, followed by a scheduled six-week period of data collection. A technical difficulty with the positioning of some of the red covers rendered the data from the first week unusable, reducing the post-intervention period to five weeks. The lighting in the bedrooms was measured using an illuminance meter before and after the

intervention (presented in Figure 1 and Table 2). All measurements were taken with a Konica Minolta CL-500A illuminance meter with sensor positioned at worktable height directly below ceiling lights.

A qualitative appraisal of the intervention was conducted through the administration of a brief questionnaire to the staff completing night-time observations, and through informal verbal feedback. The goal was to assess the acceptability of the intervention. The questionnaire provided opportunity for staff to respond under two open-ended headings: “Have you noticed and change in patient’s sleep patterns, generally, since the change in lighting?” and “Please explain how performing night-time checks has changed”. All staff were asked to provide responses during the second study period.

Analysis

Descriptive statistical analysis was conducted in SPSS Version 24.0 using standard tests for the measures of sleep duration and the use of sedative medication. The data for these variables was found to deviate from a normal distribution, determined by the Kolmogorow-Smirnov and Sharpiro-Wilk tests of normality. Standard transformation procedures did not render the data suitable for parametric testing so Mann-Whitney U test was used to compare group data before and after the lighting intervention. Data on the number of incident reports describing falls during each of the study periods are presented numerically but not formally compared. Representative excerpts from the qualitative assessment of the intervention are presented verbatim.

Conduct

During the conduct of the study, staff on the functional assessment ward (Sunniside unit) were concerned that the red light was not bright enough for them to be able to carry out their usual night checks and used white light torches for observations. The quantitative data from this unit was deemed unusable for the purpose of assessing the change in light colour, but the qualitative data was appraised.

Results

Quantitative data (organic assessment unit)

During the six-week white light period, the average ward occupancy was 14.2 patients (range 10-16); in the five-week red light period, the average was 12.5 patients (range 9-16).

Contrary to our hypothesis, there was no significant difference in the observed amount of sleep during the two lighting conditions. The average number of times patients were seen to be asleep on half hourly observations was 13.9 (range 12.1 to 15.8) during white light conditions and 14.1 (range 11.2 to 15.7) in the red light conditions ($p = 0.49$, Mann-Whitney U 627.5).

Similarly, there was no significant difference in the use of “as required” medication before and after the intervention. The average use of “as-required” medication per patient, per night, was 0.34 (range 0.08 to 0.92) with white light and 0.29 (range 0.07 to 0.73) with red light. The average use of as required medication on the whole ward during the white light period was 4.8 times per night and 3.3 with red light ($p = 0.57$, Mann-Whitney U 640.0). Drug chart review demonstrated that lorazepam, clomethiazole and zopiclone were used comparably before and after the intervention.

Regarding incident reports, ten falls were recorded in the period before the intervention (white light, mean 1.67 per week) and eight after the intervention (red light; mean 1.6 per week).

Qualitative questionnaire findings

The staff on the organic assessment unit were generally positive about the use of red lighting, typical free text comments being:

- “We don’t have to point a torch in patients’ rooms at night, also, patients can see to go to the toilet”
- “We don’t need to put bright light on”
- “We don’t have to point a torch in patients’ room at night”
- “There is no need to put lights on and shine torch in patients’ bedrooms at night”
- “It is easy to check them”
- “No need to switch lights on and shine torch in patients’ bedroom at night”

The staff on the functional assessment unit, some of whom took recourse to using white light torches, were less positive and focussed on the challenges faced by the change in lighting:

- “Patients that like a darkened room to sleep find it easier to fall asleep. Staff found it more difficult to see to do the checks, so need to use torch”
- “Unable to do proper hourly checks on the patients as the red light does not allow you to see patient’s faces making it difficult to tell if they are breathing or awake”
- “Calmer lights during sleeping time. When patients get up to use toilet, unable to see clearly. If patients require assistance to change, have to put normal light on to attend needs“

- “Unable to put on low light when using commode or require attention during night”
- “Having to use torch and move closer to patients to check breathing etc and may disturb patients”
- “Unable to see patients during checks. Patients don’t like them, they cannot see if they wake. Corridor lights are too bright for red lights to be effective”

During informal interviews with staff, the majority on the organic assessment unit said that they thought patients were sleeping better and were less agitated at night following the change in lighting. On the functional assessment unit, none of the staff had been consistently using the lights due to the problems evident from the comments above.

Discussion

This quality-improvement study, conducted in two old age psychiatry inpatient units, sought to investigate the effects on sleep of changing from white to red lighting at night. On theoretical grounds, sleep should be less disturbed under narrow-band red light than under broad-band white light, which contains wavelengths that maximally stimulate the ipRGCs. Short-wavelength-enriched light is known to suppress melatonin release and sleepiness,^{9,10,11} and this may be particularly important in some clinical groups. Patients with dementia often have abnormal sleep patterns¹² and in comparison to normal aging, those with Alzheimer’s disease have more pronounced morphological changes in the suprachiasmatic nucleus, the regulator of the circadian rhythm.¹³ Sleep disturbance and the use of sedative medication are risk factors for patient falls,¹⁴ so strategies that address these risks may reduce morbidity and mortality.

We did not find any significant difference in the amount of sleep recorded or the use of “as required” medication comparing the two lighting conditions in this study, but the numerical change was in the hypothesised direction. In addition to the change in spectral content of the light, the intervention in this study reduced the overall illuminance of the light, both photopic and melanopic (that is, in both the visual and ipRGC-mediated non-visual pathways). This reduction in overall lux of the light might have been expected to reduce the extent of light-induced sleep disturbance, but also raises the question of baseline light intensity. The lack of effect of our intervention might have been due to the low illuminance levels of the existing white nightlights, potentially already below threshold for inducing sleep disturbance.

However, some studies indicate that illuminance levels of one lux or lower may be capable of suppressing melatonin in humans.¹⁵ The effects of continuous light exposure on sleep quality in the elderly, with specific measurement of both photopic and melanopic illuminance levels, have not been adequately explored. In our study, the bedroom lights were on continuously between 10pm and 7am for the majority of patients and the quantification illuminance levels (in accordance with recommendations in Lucas et al. 2014¹⁵) together with recorded amount of sleep may inform future research designs and enable comparisons of effects.

Reducing the illuminance levels on a ward might be expected to adversely impact on the ability to conduct observations and ensure patient wellbeing, so it is an important finding of this study that no increase in the frequency of falls was observed. Subjectively, the staff on the functional assessment unit felt less able to conduct their regular observations but the intervention was well received by the staff on the organic assessment unit. Here, no problems with carrying out routine observations under red light conditions were reported and the qualitative data indicated that staff were generally positive about the change, many expressing an impression that there had been improvements to patients’ sleep. Thus, a simple,

low cost intervention subjectively improved the organic assessment ward environment for patients at night, according to staff reports.

Limitations

The main limitation of this study was the small sample size, making it possible that we failed to detect a genuine difference before and after the intervention due to inadequate statistical power. As this quality improvement project was carried out on an in-patient ward rather than a dedicated sleep laboratory, it was not possible to control for other variables and allow for clear conclusions to be drawn from the data collected. The amount of light that patients were exposed to at night would have varied due to sources other than the night lights, such as lights in the corridors, toilets and outside the building. Comparisons were made at a group level as admission and discharges during the study period altered to composition of the wards.

Different patients will have naturally different sleep/wake cycles and direct comparison between the patients on the ward during the period before and after the intervention cannot be made. There will also have been other factors influencing sleep disturbance in the patients on the ward, such as noises on the ward and patient illnesses. Another limitation is that different members of staff will have different methods of performing night checks, varying accuracy in recording their observations and different thresholds in the administration of “as required” medication. However, but the study duration was sufficient that these should not be a major confounding factor, night staff shifts rotating through both study periods.

It is unclear why staff members on the different units had contrasting views on the intervention. Those on the functional assessment unit reported that they had inadequate level of lighting for their duties, highlighting that the majority want to be sure that the patients under their care were breathing, rather than whether they simply appeared to be asleep. The

perception was that red lighting precluded this. It is possible that staff on the functional unit were required to be more vigilant for suicidal behaviour in the context of depressive illnesses, and so facing more sophisticated observation demands. Advances in lighting technology, such as tuneable LED light sources (generating light spectra with minimal short-wavelength, ipRGC-stimulating content but maximal visibility¹⁶) have the potential to improve acceptability and applicability of narrow-band lighting.

Conclusions

Our findings demonstrate that in some settings, it is feasible and acceptable to change the bedroom lighting at night for patients and staff on old age psychiatric wards. However, this small study did not demonstrate significant quantitative changes to support the theoretical basis for such an intervention.

Future prospective, randomised, controlled studies are required to examine the full effectiveness of using alternative lighting on hospital wards at night, ideally using larger sample sizes and better environmental controls. Such studies should prioritise safe nursing care and the engagement of staff in the intervention, as well as making use of technological advances to ensure that the alteration of the lighting levels permits adequate and acceptable visibility.

We anticipate that this study will be of interest to psychiatric nurses due to the common practise of regular night checks and their risk of inducing sleep disturbance amongst psychiatric inpatients. Psychiatric nurses are in an excellent position to explore improvements to the inpatient ward environment and the intervention described in this study would be suitable for nurse-led research.

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Declarations

The authors declare no conflicts of interest.

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Figure 1: Spectral power distributions of lights before and after intervention. Black line = original, unfiltered Philips PL-S lightbulb; Coloured lines = spectra emitted from Philips PL-S lightbulbs after application of the red filter, taken from two different bedrooms in the Cragside unit (red = room A; magenta = room B).

	White light conditions Mean (range)	Red light conditions Mean (range)	U value	P value
Number of times seen to be asleep	13.9 (12.1-15.8)	14.1 (11.2-15.7)	627	0.49
“As required” medication administered	0.34 (0.08 - 0.92)	0.29 (0.07 - 0.73)	640	0.57

Table 1: Sleep quantity and use of sedative medication before and after intervention.

Location	Photopic illuminance (Y) (lux)			Melanopic illuminance (W) (equivalent units)		
	Daytime	Night-time White light	Night-time Red light	Day time	Night-time White light	Night-time Red light
Room A by door		24.58	0.38		10.10	0.04
Room A by bed	392	10.89	0.11	165	4.35	0.01
Room B by door		23.29	0.30		9.50	0.02
Room B by bed	348	5.29	0.13	145	2.02	0.02

Table 2: Illuminance levels of lights before and after intervention. Photopic illuminance is reported in lux (lumens/m²), calculated from irradiance measurements of the light spectra, $I(\lambda)$, recorded in W/m². Melanopic illuminance is reported in equivalent units, using the melanopic spectral sensitivity curve $W(\lambda)$ (Lucas et al. 2014) and the photopic conversion factor. Note that both $W(\lambda)$ and the photopic spectral sensitivity curve $V(\lambda)$ are both adjusted for pre-receptoral filtering in the standard observer, and integral-normalised to 100. Thus, $Y (lux) = 683 * \int_{\lambda} I(\lambda) * V(\lambda)$ and $W (Wlux) = 683 * \int_{\lambda} I(\lambda) * W(\lambda)$.