Nurses' Perceived Problems and Need for Torches During Nighttime Nursing Rounds: A Content Analysis of Semi-Structured Interviews

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Objective: This study aimed to clarify the risks, as perceived by ward nurses, associated with the quality of lighting nurses use during nighttime rounds, and to identify the torch functions nurses need to optimally perform such rounds.
Methods: A semi-structured interview survey was conducted among nurses working in a university hospital. Data were collected regarding nurses' usage of torches during nighttime rounds and whether the color cast by the torches impacts their work efficiency and the risk of medical incidents. Narrative data obtained during the interviews were analyzed using Belerson's method of content analysis.
Results: Sixteen nurses participated in this study. Thereupon, 25 categories and 83 subcategories were identified regarding the impact of torchlight on nursing during nighttime rounds, and 10 categories and 38 subcategories were identified regarding the torch functions needed to optimally perform nighttime rounds. The needs included <small size and light weight>, <sufficient and appropriate illuminance for performing observations>, <sufficient and appropriate illumination range for performing observations>, and <a torch that can correctly reveal color tones>.
Conclusions: To reduce the risk of medical incidents during nighttime nursing rounds, the use of white-light torches with sufficient brightness and high color rendering is recommended.

Key words: nighttime nursing rounds, light-emitting diode (LED) torches, color rendering, medical incidents, patient safety

INTRODUCTION

Background information

Previous studies have shown that regular nursing rounds can reduce the risk of patient falls, improve patient satisfaction, and decrease the frequency of nurse calls [1–8]. In Japan, the results of patient-satisfaction surveys are not currently made available to the public, being retained within hospitals instead. However, in the US, patient satisfaction with hospital care has recently become recognized as an important metric for evaluating patient experience and now represents a key quality indicator that hospitals must monitor and report publicly [9].

Nursing rounds not only influence patient satisfaction, but also have an important impact on the quality of medical care and patient safety, as described below. In general, nurses in hospitals work in shifts to ensure there is a high level of patient safety both day and night. Nighttime nursing rounds are essential for ensuring continuity of care and include observing the state and volume of fluids from various drains, monitoring respiratory status, and checking the rates of intravenous drips. However, there are also several difficulties associated with nighttime nursing rounds, for example: 1) inadequate observation ability because of darkness in the wards; 2) the need to monitor a higher number of patients compared to day shifts, meaning nurses are busier and more prone to accidents; and 3) decreased work efficiency and increased risk of medical incidents due to working hours that conflict with circadian rhythms [10–14]. In other words, during nighttime nursing rounds patient observations are conducted in hospital rooms with low illumination and at a time when work efficiency and attentiveness are likely to be lower, meaning oversights are likely to occur. Thus, it can be assumed that the quality of illumination during nighttime nursing rounds directly affects nurses' ease of observation, and it therefore plays a very important role in ensuring patient safety. A previous survey by the present authors (unpublished) on lighting-related needs in hospitals found that the area with the greatest need for improvement is lighting for nighttime nursing rounds (representing approximately 40% of the total need). This study also found that the flashlights and penlights nurses usually use during nighttime nursing rounds have several inconveniences, such as inadequate irradiation range, illumination level, and portability while working.

In recent years, white light-emitting diodes (LEDs) have become widely used in lighting because of their high efficiency and long life [15]. As LED lights

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became more popular, they have also become more affordable and have been introduced to the medical field [15]. However, as the introduction of LED lighting in hospitals is still an evolving process, there remains a great deal of variance across hospitals and wards regarding the types of torches used during nighttime nursing rounds. Notably, the type of lighting available to nurses may affect their work efficiency, ease of performing patient observations, and, ultimately, medical safety. Therefore, the purpose of the present study was to interview active nurses and identify the risks associated with the lighting used for nighttime nursing rounds as well as the specific torch functionalities nurses require to optimally perform nighttime nursing rounds.

Definition of terms

LED torches (white-light torches that provide illumination through LEDs) have illumination intensity that is generally higher than that of traditional torches (i.e., those that provide illumination through yellow-light bulbs).

MATERIALS AND METHODS

Ethics statement

This research protocol was approved by the Niigata University Ethics Committee (approval number: 1312), and the study design complies with the Declaration of Helsinki. All participants were informed of the purpose of the study, the data-collection methods, that participation was voluntary, that their privacy would be protected, that they would not be disadvantaged by refusing to participate in the study, and that they could withdraw their consent at any time. Finally, verbal and written consent were obtained from all participants [16].

Subjects

The target participants for this study were nurses who were actively working in a university hospital. To recruit test subjects, we placed posters in the hospital inviting nurses to cooperate with the research. To avoid the risk that nurses would feel pressurized by their supervisors to participate in the study, we asked nurses to apply on a voluntary basis, and they were reassured that the identities of the participating or non-participating nurses would be kept confidential. All ward nurses, regardless of their department, gender or years of experience, were eligible to participate in this survey.

Data collection method

Data collection was conducted through a semi-structured interview survey that was administered from October to November 2013. To avoid burdening the participants, the interviews were no more than 30 minutes in length. The content of the interviews was recorded with the consent of the participants, and verbatim transcripts were then created. All interviews were conducted in a calm, private, quiet room in the nurses' workplaces after their day shifts had ended.

The interview questions were: 1) Have you ever felt that the use of torches negatively impacted your work efficiency during nighttime nursing rounds? If so, please describe, in as much detail as possible, the incident(s) that caused you to feel this way. 2) (If the interviewees responded to question one that torches had impacted their work efficiency during nighttime nursing rounds) Did you take any actions to make your work easier? 3) Have you ever felt that the color of the torchlight used during nighttime rounds affected your work efficiency (e.g., requiring you to extend observation times as a result of inhibited visibility or a risk of misreading charts)? If so, please describe the situation(s) in question. 4) (If interviewees responded to question one that the use of torches during nighttime round torches had impacted their work efficiency during nighttime rounds) Have you ever felt that the color of the light (color tone) emitted by torches during nighttime rounds could lead to medical incidents or accidents? If so, please describe the kind of situation(s) that inspired this thought. 5) Have you ever had any formal or informal discussions with ward staff regarding the use of torches for observations during nighttime rounds?

We also asked the nurses to report their degree of satisfaction with the torches (LED torches and traditional torches) available in their wards, and (if appropriate) the torches they had purchased at their own expense; these responses were given using a five-point ordinal scale (1 = "very dissatisfied," 2 = "somewhat dissatisfied," 3 = "neither satisfied nor dissatisfied," 4 = "somewhat satisfied," and 5 = "very satisfied").

Analytical methods

Narrative data obtained during the interviews were analyzed using Belerson's method of content analysis [17]. Two researchers (Y.M. and S.M.) tabulated the interview data into subcategories, and then grouped them into categories. The sample size was determined by continually conducting interviews until data saturation was reached.

For the analysis of the nurses' satisfaction with LED and traditional torches, responses from 12 nurses who worked in wards where both LED and traditional torches were available, were examined. The levels of satisfaction with torches were evaluated by conducting a Wilcoxon rank-sum test, with $p < 0.05$ considered to indicate a significant difference. Furthermore, the correlation between total years of experience and satisfaction with LED and traditional torches respectively was assessed using Spearman's correlation coefficient (r). Statistical analyses were performed using the Statistical Package for the Social Sciences 26.0 statistical software package (IBM SPSS Japan Inc., Tokyo, Japan).

RESULTS

Interviewees' characteristics

A total of 16 nurses (one male and 15 females), all of whom were actively working in a university hospital, participated in the interviews (Table 1). The participants' mean years of experience was 8.3 (SD = 5.4, range: 2–22 years). The departments with which these nurses were affiliated were cardiovascular surgery, respiratory surgery, neurosurgery, pediatric surgery, plastic surgery, nephrology, hematology, pediatrics, respiratory medicine, neurology, general medicine, cardiology, emergency ward, ophthalmology, urology, radiology, and anesthesiology. However, the actual number of wards surveyed was seven, as some wards contained a mixture of specialties (Table 2). Some par-

Table 1 Overview of the survey participants and their light usage and preferences regarding torches.

Interviewee no.	Sex	Years of experience as a nurse	Experience in purchasing torches	Torches placed in wards	Preferred torch
1	F	12	Yes*	L, T	SL
2	F	12	No	L, T	Either
3	M	5	Yes*	L	SL
4	F	7	No	L, T	L
5	F	7	No	T	T
6	F	7	No	L, T	L
7	F	9	No	L, T	T
8	F	3	No	L, T	L
9	F	2	Yes	L, T	L
10	F	6	No	L, T	T
11	F	11	No	L	L
12	F	2	No	L, T	L
13	F	16	Yes*	L, T	SL
14	F	22	No	L	L
15	F	8	Yes	L, T	Either
16	F	4	No	L, T	L

F: female; M: male; L: light-emitting-diode torches; T: traditional torches; SL: self-purchased light-emitting-diode torch.
* Nurses who were still using the torches they had purchased themselves.

Table 2 Status of torch deployment in wards and types of torches preferred by nurses

	Number of nurses (%)	Number of wards (%)
Torches available in the wards		
LED torches only	3 (18.8)	2 (28.6)
LED and traditional torches	12 (75.0)	4 (57.1)
Traditional torches only	1 (6.3)	1 (14.3)
Total	16 (100)	7 (100)
Actual torches used		
LED torches	11 (68.8)	
LED and traditional torches	2 (12.5)	
Traditional torches	3 (18.6)	
Total	16 (100)	

ticipants had previously worked in other departments; gastrointestinal surgery, endocrinology, otolaryngology, dermatology, dentistry, intensive care unit, and emergency room.

Use of torches for nighttime nursing rounds

According to the interview data, all participants in this study had experience using both LED and traditional torches, meaning they were able to compare the usability of the two torch types. Fig. 1 shows examples of the torches used in the wards. As shown in Tables 1 and 2, the availability of LED and traditional torches across the seven wards revealed the following: LED torches only: two wards (28.6%), LED and traditional torches: four wards (57.1%), and traditional torches only: one ward (14.3%). From the participants' perspective, the availability of LED and traditional torches was indicated as follows: LED torches only: three nurses (18.8%), LED and traditional torches: 12 nurses (75.0%), and traditional torches only: one nurse (6.3%).

Fig. 1 The torches used by the survey participants; a traditional yellow-light torch featuring a light bulb (left) and a white-light torch featuring a light-emitting diode (LED; right). The illumination intensity of LED torches is higher than that of traditional (i.e., non-LED) torches.

The 12 nurses who worked in wards where both LED and traditional torches were available were asked which type of torch they preferred to use. The results were as follows: eight nurses (66.7%) preferred LED torches, two nurses (16.7%) preferred traditional torches, and two nurses (16.7%) reported no preference (Table 1). In terms of degree of satisfaction with the torches used, these 12 subjects tended to be more satisfied with LED torches than traditional torches ($p = 0.075$).

Regarding the actual torches used by the 16 nurses, 11 (68.8%) used LED torches, three (18.6%) used traditional torches, and two (12.5%) used both types of torches (Table 2). We also asked them if, because of dissatisfaction with the torches available in the wards, they used torches that they had purchased at their own expense. As shown in Table 1, five nurses (31.3%) used LED torches that they had purchased at their own expense.

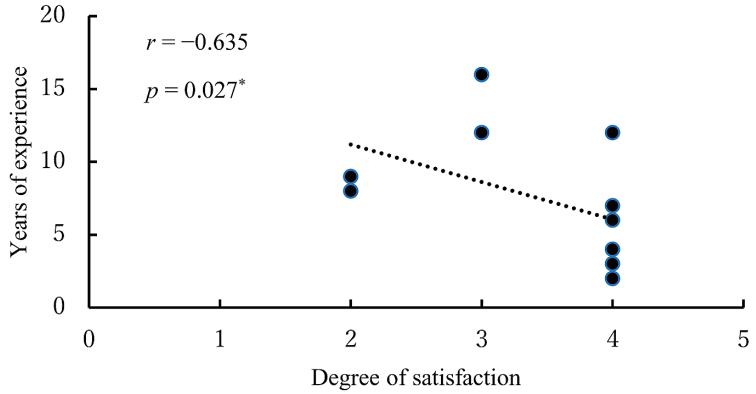

Fig. 2 Correlation between satisfaction with light-emitting-diode (LED) torches available in wards and total years of experience as a nurse (n = 12). Satisfaction with the LED torches available in the wards was significantly negatively correlated with years of experience as a nurse; the correlation between the two variables was strong ($r = -0.635$, $p = 0.027$). This analysis was performed on 12 nurses who worked in wards where both LED and traditional torches were available. Data were analyzed by applying Spearman's correlation test through the SPSS 26.0 statistical software package. *$p < 0.05$

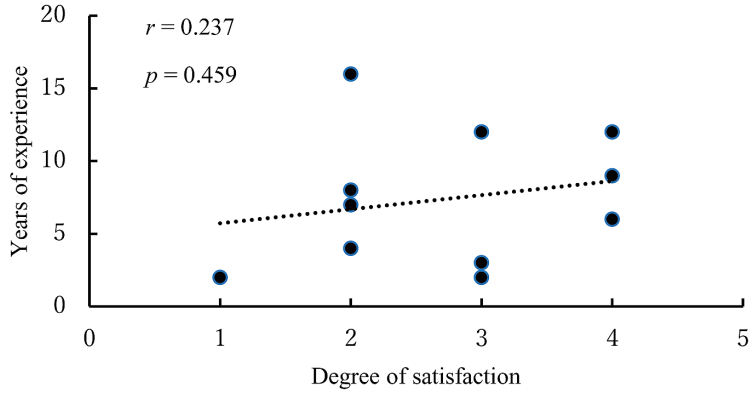

Fig. 3 Correlation between satisfaction with traditional torches available in wards and total years of experience as a nurse (n = 12). Satisfaction with the traditional torches available in the wards was not significantly correlated with years of experience as a nurse ($r = 0.237$, $p = 0.459$). This analysis was performed on 12 nurses who worked in wards where both light-emitting-diode and traditional torches were deployed. Data were analyzed by applying Spearman's correlation test through the SPSS 26.0 statistical software package.

Correlation between satisfaction with LED and traditional torches available in wards and total years of experience as a nurse

Twelve of the 16 nurses interviewed worked in wards where both LED and traditional torches were available (Table 1). Among these 12 nurses, satisfaction with the LED torches available in the wards was significantly negatively correlated with years of experience as a nurse (n = 12; $r = -0.635$, $p = 0.027$; Fig. 2). On the other hand, as shown in Fig. 3, satisfaction with the traditional torches available in the wards was not significantly correlated with years of experience as a nurse ($r = 0.237$, $p = 0.459$).

Influence of torchlight on nursing performance during nighttime nursing rounds

Regarding the influence of torches on nurses' performance during nighttime nursing rounds, we extracted 83 subcategories, which were grouped into 25 categories and 5 themes (Table 4). In the examples listed below, themes are indicated using square brackets ([ ]), while statements from the nurses are enclosed in quotation marks (" ").

Seven categories were identified regarding the effect of torches' color tone on work efficiency. The following are representative quotes from the nurses:

"Compared to the light-bulb color produced by a traditional torch, white light that is produced by an LED torch makes objects and colors around the patient more visible and makes it easier to observe the patient's condition."

"White-colored light makes it easier to perform detailed work."

Two categories were identified regarding the impact of torchlight color on medical incidents. The following are representative quotes from the nurses:

Table 3 Survey participants' satisfaction with torches

Interviewee no.	Ward	LED torch purchased with personal funds[a]	LED torches available in the ward[a]	Traditional torches available in the ward[a]
1	E9	3[b]	3	3
2	E10		4	4
3	E11	4[b]	1	Not available
4	W10		4	2
5	E6		Not available	2
6	W6		4	2
7	E10		2	4
8	W6		4	3
9	E10		4	3
10	W10		4	4
11	E11		4	Not available
12	W6		4	1
13	W6	4[b]	3	2
14	E4		2	Not available
15	E9		2	2
16	W6		4	2

[a] A five-point scoring method with points ranging from 1 to 5 (1 = "very dissatisfied," 2 = "somewhat dissatisfied," 3 = "neither satisfied nor dissatisfied," 4 = "somewhat satisfied," and 5 = "very satisfied").
[b] Nurses who were using a light-emitting-diode torch they had purchased themselves were asked to report their level of satisfaction with their torch.
LED: light-emitting diode

"Light bulb color makes it difficult to overlook the presence of blood and to properly observe its properties."

"There have been cases when I did not notice blood, for example, or waste fluid in a gastric tube, or something mixed in urine until sunrise."

The theme [Inappropriate illuminance can cause medical incidents] comprised seven categories. The following are typical narratives:

"There is low illuminance at night, meaning it takes time to determine whether the infusion line is disconnected."

"At night, it is difficult to distinguish urine with bilirubin from normal urine."

"Low illuminance increases the time required to perform observations."

The theme [Advantages of traditional torches] comprised three categories. The main narratives are as follows:

"Traditional torches are less likely to disturb the patient's sleep."

"Traditional torches are very good at creating a wide beam of light."

The theme [Advantages of LEDs] comprised six categories. The major narratives are as follows:

"If you use an LED torch, the colors of the waste liquid from thoracoscopic drains can be appropriately observed."

"LED torches are easy to carry and the batteries last longer."

The torch functions required by nurses for nighttime nursing rounds

Thirty-eight subcategories were identified in regard to the torchlight functions nurses need to optimally perform nighttime nursing rounds, and these were grouped into 10 categories. Taken together, these data present the ideal torchlight functions for nighttime nursing rounds. Table 5 presents the detailed findings in this regard, the categories being indicated by angle brackets (< >).

Nurses felt that <a torch that leaves both hands free> would be ideal for them to conduct their jobs efficiently and ensure cleanliness. Further, <small size and light weight> are also important, as this would allow nurses to easily carry the torch. Moreover, <sufficient and appropriate illuminance for performing observations> and <sufficient and appropriate illumination range for performing observations> are essential features required to make accurate observations. Adaptability, such as being <capable of adjustment (illuminance, illumination range, illumination angle, etc.)>, and <a torch that can correctly reveal color tones> are also necessary for accurate observations. Regarding general needs for torchlights, <no need to replace batteries, good maintainability>, <torches should have a good design and good functionality>, and <a headlight that does not damage hair or make-up> were mentioned by the nurses. Additionally, there should be enough torches for the entire nursing staff, as evidenced by the following category: <I would like hospitals to make LED lights with full functions available for each member of the night-shift staff>.

DISCUSSION

Characteristics of the nurses surveyed and their use of torches during nighttime nursing rounds

In this study, we interviewed nurses to investigate whether differences in the color tone and brightness of torches used for nighttime nursing rounds impact work efficiency and patient safety. Concurrently, we examined the torchlight-related functions nurses require to optimally perform nighttime nursing rounds.

The subjects were sourced from seven wards in a university hospital. Of these seven wards, four wards (57.1%) were equipped with both LED torches and traditional torches, two (28.6%) were equipped with LED torches only, and one was equipped with traditional torches only (Table 2). However, as nurses are regularly

Table 4 Nurses' experiences regarding the use of torches during patient rounds.

Subcategory (83)	Category (25)	Theme (5)
White light illuminates objects clearly White light makes it easy to observe patients' respiratory conditions (Two additional subcategories)	White light makes objects appear bright and clear, and makes it easy to perform observations and other work	Effect of torchlight color on work efficiency
White light makes it easy to observe color tones (Three additional subcategories)	White light makes it easy to observe the color tone of urine, blood, etc.	
LED torches make illuminated areas appear white in color and makes it difficult to perform observations (One additional subcategory)	LED torches make objects appear whitish in color	
Light-bulb color makes it difficult to observe blood tone Light-bulb color inhibits observation of skin color and wounds (Two additional subcategories)	Light-bulb color is similar to urine, blood, and skin color, making it difficult to observe the color tones of these objects	
Light-bulb-colored torches do not show the color of urine; observation under white light is required, which takes extra time and effort (One additional subcategory)	Trying to observe the color tones of urine using light-bulb-colored torches creates difficulties and stress	
Light-bulb color does not make objects bright and clear Light-bulb color is different from white light, and makes it difficult to perform observations (One additional subcategory)	Light-bulb colors make it difficult to observe objects vividly and clearly, and perceive color tones	
The different color tones produced by torches have no influence on work efficiency or color observation (One additional subcategory)	The different color tones produced by traditional torches and LED torches do not affect work efficiency	
When necessary, colors can be confirmed by turning on the main electric lights, meaning there are no medical incidents due to the color of torch lights (Three additional subcategories)	Torches' color tones have little impact on medical incidents	Impact of torches' color tone on medical incidents
Light-bulb color does not reveal the presence of blood, and makes it difficult to correctly determine the characteristics of blood samples When compared to light-bulb color light, white light allows nurses to detect blood and drug leakage faster (Five additional subcategories)	The color tones cast by torches impact the risk of medical incidents	
When the light is placed to keep both hands free, the illumination of the observation area becomes low, making it difficult to conduct a clean procedure (Four additional subcategories)	Low illuminance makes it difficult to work and conduct a clean procedure	Inappropriate illuminance can cause medical incidents
At night, it is difficult to distinguish between urine with bilirubin and normal urine (Four additional subcategories)	Low illuminance makes it difficult to distinguish subtle color differences	
There is low illuminance at night, meaning it takes time to determine whether the infusion line is disconnected	Low illuminance means it is difficult to immediately determine whether the infusion line is disconnected, etc.	
When checking the fixation of gastric tubes, it is easy to overlook something because it is not possible to make observations close to patients' faces	Excessively high illuminance means the area around patients' faces cannot be observed without disturbing the patients	
It is easy to perform tasks such as changing drips when the area is brightly illuminated When the illuminance is low, it takes longer, when compared to daylight hours, to observe hard-to-observe areas (Four additional subcategories)	Low light reduces work efficiency	
Low illuminance causes stress (traditional torches)	Low light can be stressful	
Low illuminance increases the time required to perform observations (traditional torches) (One additional subcategory)	In low-light environments, it takes longer to complete tasks	

The patient is not dazzled (traditional torches) Flashlights are less likely to wake patients	Compared to LED torches, traditional torches do not dazzle patients and are less likely to disturb their sleep	Advantages of traditional torches
Light-bulb color is soft on nurses' eyes	Do not dazzle nurses (traditional torches)	
As they shine widely, traditional torches are easier to use than LED torches (Three additional subcategories)	Traditional torches illuminate a wide area and are easy to use	
LED torches provide the necessary illuminance to perform observations (Four additional subcategories)	LED torches provide sufficient illumination for nighttime nursing rounds and patient observations	Advantages of LED torches
LED torches can correctly reveal hematuria (Three additional subcategories)	LED torches make it easy to observe color tones	
Can be adjusted so that pinpoints of light are created, making it easier to work (LED torch) (Two additional subcategories)	LED torches are bright, and the range that the lights illuminate is exactly right	
The battery lasts longer (LED torch) (Two additional subcategories)	LED torches have low power consumption, meaning less inconvenience regarding the need to replace batteries	
Small and easy to hold (LED torch) Easy to carry (LED torch) (Four additional subcategories)	LED torches are lightweight, compact, and have an easy-to-carry shape	
Hard to break, even if dropped (LED torch)	LED torches are highly durable	

LED: Light-emitting diode

Table 5 The torch-related functions nurses required to optimally perform nighttime nursing rounds.

Subcategory (38)	Category (10)
A torch that leaves both hands free for easy aseptic manipulation Headlights mean both hands are free (Two additional subcategories)	A torch that leaves both hands free
Small and easy to carry Light-weight torches are good.	Small size and light weight
Strong lights are not necessary for observations of patients' breathing Torches must be bright enough for patient observations (Three additional subcategories)	Sufficient and appropriate illuminance for performing observations
The torch should be able to provide 360° illumination wherever it is placed The torch should not provide excessive illumination	Sufficient and appropriate illumination range for performing observations
It should be possible to adjust the illuminance and irradiation range It should be possible to adjust the angle of the beam of light to illuminate the required area (Three additional subcategories)	Capable of adjustment (illuminance, illumination range, illumination angle, etc.)
The torch should have a long battery life The torch should be chargeable When the battery is low, the illuminance should remain at the level required (One additional subcategory)	No need to replace batteries; good maintainability
A fully featured torch would make my job easier I want LED torches to be available for each member of the night-shift staff There is an insufficient number of LED torches available (Two additional subcategories)	I would like hospitals to make LED lights with full functions available for each member of the night-shift staff
Headlights do not look good. The torch should be sturdy and durable The torch should have an easy-to-stand, difficult-to-knock-over shape (Two additional subcategories)	Torches should have a good design and good functionality
Headlights are not preferred because they affect hairstyles Headlights are not preferred because they damage makeup	A headlight that does not damage hair or makeup
The torch should allow you to correctly perceive colors When looking at fluid in-out balance, it is important to report to the doctor the correct color of the patient's urine	A torch that can correctly reveal color tones

LED: Light-emitting diode

transferred between wards, all subjects had previously used both LED and traditional torches, hence they were appropriate for this study. There have been very few studies on the torches used by nurses during nighttime nursing rounds; it is therefore difficult to compare the results of the present study with those of previous studies. However, considering the widespread use of LED lighting in general society, it seems that the replacement of traditional torches with LED torches in the medical field is progressing relatively slowly.

The data presented in Tables 1 and 2 suggest that nurses prefer LED torches to traditional torches. In addition, most of the 12 nurses who worked in wards where both LED and traditional torches were available, tended to be more satisfied with LED torches than traditional torches ($p = 0.075$). However, according to one of these nurses, "the number of LED torches installed in the wards is fewer than the number of night-shift workers, meaning, in some cases, nurses are forced to use traditional torches." It can therefore be reasonably expected that the number of nurses using LED torches would have been higher if a sufficient number of LED torches had been available for the personnel. In Japan, LED torches are currently widely used, inexpensive, and available for purchase by the general public. However, only five nurses (31.3%) in our sample had purchased LED torches at their own expense to improve the quality of their observations during nighttime nursing rounds (Table 1). This indicates that some nurses continued to use the traditional and LED torches placed in the wards, even when they were not satisfied with them. Furthermore, all nurses who are still using the torches that they purchased at their own expense gave a satisfaction score of less than three out of five regarding the LED torches available in their wards (Table 3). It consequently is clear that the LED torches provided in wards do not fully meet the various needs of nurses.

On the other hand, satisfaction with LED torches decreased as the number of years of experience as a nurse increased (Fig. 2); this suggests that, with experience, nurses develop observation skills that are not dependent on the performance of a torch. However, this finding was not obtained from a sufficient number of nurses to afford generalization.

Although they do not fully meet the needs of the medical field, LED torches have many advantages over traditional torches, such as high luminous efficiency, low power consumption (longer battery life), compact size, high-quality color rendering, durability, and long lifetime [15, 18–21]. In fact, the nurses who responded to our interview survey generally perceived LED torches to be superior to traditional torches (Table 4).

Assessment of the torch-related problems that occur during nighttime nursing rounds, and analysis of the causes

We identified two main problems with the torches currently used by nurses during nighttime nursing rounds: 1) Inconsistencies in the color tone of the torches (e.g., yellow or white tone). Such inconsistencies may result in varying perceptions regarding the characteristics of body fluids. Such perceptual variances concerning the color tone of skin and blood and urine samples may impact judgments, and consequently increase the risk of medical incidents. 2) Technical limitations in existing torch designs make it difficult for nurses to selectively modify the intensity and spread of the illumination to suit specific situations. As a result, nurses may be unable to avoid disturbing patients' sleep, which could negatively impact the quality of patient care.

The first issue mentioned above, torch-induced variations in judgments regarding the characteristics of body fluids, is potentially very serious, as inaccurate judgements of patient samples can have a serious negative impact on patient safety. Through content analysis of our interview data, we identified several medical care problems that may result from the use of inappropriate torches. We highlight three elements (and provide clarifying quotations from interviewees) below that should be focused on to improve the efficacy of torches on nighttime nursing rounds.

1. Torchlight color

"Inappropriate torchlight color makes it difficult to convey color information to physicians."

"White-colored light makes it easy to see leakage of blood and urine."

"Delays in noticing problems during nighttime nursing rounds may result in medical incidents."

2. Intensity of torch illumination

"If the illumination intensity is low, work during nighttime nursing rounds may be more difficult, and hygiene may be negatively impacted."

"If the illumination intensity is low, it may be difficult to perceive differences in colors."

"If the illumination intensity is too high, it can be difficult for nursing staff to observe the areas around patients' faces."

3. Technical limitations of current torch designs

"It is difficult to adjust the intensity and spread of the illumination."

"If the light is too bright, there is a risk of disturbing patients' sleep."

"Inadequate illumination may result in important details being obscured during nighttime nursing rounds."

During surgery, surgeons wear medical goggles that feature LEDs with a white spectral distribution, which renders the intrinsic colors of flesh, such as skin, blood, fatty tissues, and internal organs [15]. Similarly, for nighttime nursing rounds, lights with similar color-rendering properties would be ideal for the early detection of minute amounts of blood in urine samples. Our research results suggest that the use of traditional (yellow-light) torches during nighttime nursing rounds can increase the risk of medical incidents as a result of difficulties discriminating between color tones in biofluids (urine and blood), wounds and facial pallor. In particular, some interviewees suggested that using traditional torches makes it difficult to make correct clinical assessments. Furthermore, the cone cells of the human eye do not function well in low illumination, which creates difficulties regarding color discrimination [22]. Therefore, to ensure accurate color perception it is important to use torches with appropriate

illumination intensities. This would also help improve work efficiency. Thus, both color rendering and illuminance are essential torch characteristics that influence nurses' ability to provide optimal patient care during nighttime nursing rounds. The results of our survey of the nurses' satisfaction with LED and traditional torches respectively suggest that LED (white-light) torches are more appropriate for nocturnal rounds.

In conclusion, to reduce risks to patient safety, white-light (LED) torches with appropriate illumination intensity and high color rendering should be used during nocturnal rounds. This finding should particularly be noted by hospitals in which traditional torches with low correlated-color-temperatures are provided in wards.

Limitations and future challenges

As a result of the small number of facilities and subjects examined in this study, there are limits to the generalizability of the results. However, because we obtained a good overview of torch-related problems in the context of nighttime nursing rounds and the torch-related needs of nurses, we plan to conduct further research to: 1) develop prototype torches that fulfill the needs of nurses; 2) apply these torches in clinical settings, obtain opinions from the nurses who use them, and improve the prototype models based on this feedback; and 3) present the exact specifications of the types of torches that are most appropriate for nursing settings.

AUTHOR CONTRIBUTIONS

Conceptualization, Y.M., A.N., and K.U.; methodology, Y.M., A.N., and K.U.; investigation (interview), Y.M.; data curation, Y.M., and K.U.; analysis, Y.M. K.U. and A.N.; writing — original draft preparation, Y.M. and S.M.; writing — review and editing, Y.M., S.M., A.N., and K.U.; supervision, K.U.; project administration, Y.M. All authors have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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