Improving the Living Environment in Evacuation Shelters Using Light-Emitting Diode Lanterns and Partitions

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***Abstract**: This study examines the effects of light-emitting diode (LED) lanterns and partition colors on the psychological condition of individuals in evacuation shelters. A previous questionnaire survey involving 193 participants evaluated emotional responses to four LED colors (yellow, green, blue, and red). Yellow light was most frequently perceived as calming and comfortable, whereas red light was strongly associated with tension and anxiety. Building on these emotional findings, we investigated environmental factors through an experiment involving blue, pink, and green partitions. The participants stayed inside each partition for 25 min, and their vital signs, including body temperature, pulse rate, and blood pressure, were measured every 5 min. The results indicate that blue partitions produced the most stable physiological responses, including lower systolic blood pressure and steady pulse rates, reflecting parasympathetic nervous system activation. In contrast, the pink and green partitions increased pulse rates and led to greater fluctuations, indicating higher stress. These findings demonstrate that appropriate lighting and partition colors can promote psychological stability and improve shelter environments. This study also highlights the importance of simple, low-cost environmental design strategies for stress reduction during prolonged evacuations.*

***KEYWORDS**: EVACUATION SHELTERS, LIGHT-EMITTING DIODE LANTERN COLOR, PARTITION COLOR, PSYCHOLOGICAL STRESS, AUTONOMIC NERVOUS SYSTEM, ENVIRONMENTAL DESIGN*

1. Introduction

As third-year high school students aspiring to pursue careers in nursing, we are concerned about the increasing frequency and severity of natural disasters, particularly earthquakes and heavy rainfall, which have caused substantial damage to communities in recent years. According to the Ministry of Land, Infrastructure, Transport and Tourism's "2020 White Paper on Land, Infrastructure, Transport and Tourism"[1] , the probability of a major Nankai Trough earthquake occurring within the next 30 years is estimated to be approximately 80%. This probability has gradually increased since official assessments began in 2013. Given this situation, anticipating the potential occurrence of large-scale disasters and enhancing disaster preparedness and awareness at an early stage are considered essential. To explore practical actions that can be undertaken at present, volunteer activities were conducted in March of this year in disaster-affected regions, including Sendai, Miyagi Prefecture, and the Noto Peninsula in Ishikawa Prefecture. During these activities, evacuation facilities that were actively used were visited and systematically observed.

2. Background

(1) Participation in the Miyagi Fieldwork

Participation in the Sendai Disaster-Prevention Future Forum, held at the Sendai International Center on March 8, 2025, where we provided valuable insight into disaster preparedness. This year marked the 10th anniversary of the Great East Japan Earthquake. To link experiences and lessons derived from past disasters to future prevention efforts, the event featured lectures on disaster prevention, mitigation, and first aid, along with presentations, booth exhibitions, and workshops. During the first aid lecture, participants learned techniques for immobilizing injured areas using magazines, umbrellas, and string, as well as methods for constructing a simple stretcher from a blanket to reduce mortality caused by traumatic shock during disasters. Participation in the "Sendai Framework for Disaster Risk Reduction/5 Years Until the SDGs Target Year" session enabled engagement with five organizational representatives and university students, followed by discussions on disaster prevention and mitigation. These discussions highlighted the importance of preserving disaster memory and the difficulty of increasing awareness among individuals who have not directly experienced disasters.

In addition to these presentations, the event included a tour of Arahama Elementary School, which now serves as a museum dedicated to conveying the magnitude and severity of disasters. Inside the building, the tsunami had left empty cans lodged in the ceiling of a first-floor classroom used by students, a space where such objects would not normally be trapped. The window frames bent by the tsunami, as shown in Figure 2, further demonstrate the destructive force of the disaster. These observations made disasters feel more immediate and increased the awareness that similar events could occur in our region.

***Fig. 1** Arahama Elementary School*

***Fig. 2** Exterior wall of Arahama Elementary School*

(2) Participation in the Oku-Noto Support Tour

Field observations conducted during the Oku-Noto Support Tour from March 28 to 31, 2025, provided direct experience in disaster recovery activities. In the Noto Peninsula, which was severely affected by the earthquake, participation in debris removal and community meal services (Figure 3) revealed that despite a year passing since the disaster, recovery remained stalled due to a shortage of volunteers and the extensive scale of damage (Figure 4). Restoration of lifeline services had also progressed slowly. Through conversations with affected residents, we learned about the severe living conditions following the disaster, including the absence of heating, lack of electricity, and limited access to drinking water due to water supply disruptions. These conditions were further worsened during the January snowfall. We also stayed overnight in a temporary tent inside a supermarket used as an evacuation shelter. The space lacked heating, and despite the use of sleeping bags and blankets, it remained cold and uncomfortable, while noise from nearby occupants disrupted sleep.

At that time, we realized that prolonged exposure to such conditions would have a significant impact on both physical and psychological health, and we recognized the need to develop strategies to improve the living environment.

Fig. 3 *Cooking okonomiyaki for the soup kitchen.*

Fig. 4 *Removal of soil and debris from inside a house.*

(3) Issues Revealed Through Volunteering

Life in evacuation shelters significantly differs from daily life. In addition to major changes in the living environment, disaster survivors experience the loss of loved ones, homes, and employment, leading to anxiety and stress. These conditions are likely to have adverse health effects. Nurses are expected to improve the living environment in shelters and support evacuees in maintaining their health. Based on these observations, we focused on the shelter environment and disaster-prevention supplies to identify strategies for reducing psychological stress. We observed that partitions and tents used in shelters are available in various colors. During the Oku-Noto Support Tour, staying in a tent revealed physical and psychological stress from noise, such as neighboring snoring and conversation, as well as inadequate protection against cold weather. These experiences also revealed that living in a shared environment can be a significant source of stress during evacuation.

Light-emitting diode (LED) lighting color significantly influences psychological and physiological responses, especially in emergency environments such as evacuation shelters. A questionnaire survey involving 193 participants evaluated the effects of four LED colors (yellow, green, blue, and red) using handmade plastic (polyethylene terephthalate) bottle lanterns. The results demonstrated clear differences in emotional responses to light color. Yellow light was most frequently selected as the most calming and comfortable, indicating that warm tones promote relaxation and a sense of security. Green light was also highly rated and associated with nature, freshness, and visual comfort. In contrast, blue light produced mixed reactions; while some participants reported calmness, others perceived it as cold or tense. The red light was identified as the most stressful, increasing both tension and anxiety. These findings indicate that appropriate LED color selection is essential for creating comfortable lighting environments. For practical application, yellow lighting is recommended for nighttime use, green for orientation and exit guidance, blue for task-oriented areas, and red for emergency warnings. Therefore, careful color design may improve visibility and psychological well-being in disaster situations.

In addition, heartwarming illustrations[2] (Figure 5) have been applied to white LED lanterns to promote emotional comfort among disaster-affected individuals.

Fig. 5 *Lantern with a picture painted on the side.*

Therefore, this study investigates the psychological effects of evacuation shelter partition colors and identifies those most suitable for promoting psychological stability among evacuees.

3. Research Objective

This study investigates whether different partition colors in evacuation shelters produce varying physical and psychological effects. Based on these results, this study aims to identify partition colors that minimize stress among evacuees.

4. Research Method

(1) Research Content

First, to examine the psychological effects of partition colors, participants stayed inside each colored partition for 25 min, and their vital signs were measured at designated times. Vital signs were assessed to observe changes in autonomic nervous system activity as indicators of psychological responses to partition color. The autonomic nervous system comprises sympathetic and parasympathetic components distributed throughout the body. Dominance of either system affects physiological functions and causes fluctuation of measured values. When the sympathetic nervous system is dominant, catecholamines are released, resulting in increases in body temperature, heart rate, blood pressure, and skin temperature. In contrast, when the parasympathetic nervous system becomes dominant, body temperature, heart rate, blood pressure, and skin temperature decrease. Increased stress is generally associated with an increase in body temperature, pulse rate, and blood pressure, whereas relaxation is associated with a reduction in these parameters[3,4,5].

During the experiment, partitions were placed around the desk to ensure that the selected color remained within the participants' field of view. Participants read inside each partition, and vital signs were measured every 5 min to observe fluctuations over 25 min. The experiment was conducted using three partition colors on separate days. Because partition colors can be broadly classified as warm, cool, and neutral, blue, pink, and green colors were selected.

The following conditions were considered during the experiment.

1. To enable comparison, the experiment was conducted with two participants.
2. In evacuation shelters, partitions are used to separate families;

therefore, this situation was simulated in the experiment. Furthermore, given that the dominance of either the parasympathetic or sympathetic nervous system generally affects the body for approximately 20 min, the participants were stationed within the partitions for a 25-minute reading period.

3. Reading was selected because the restoration of lifeline services is often slow, making the use of electronic devices difficult. Therefore, reading was considered a simple and practical form of entertainment in such environments.

Fig. 6 Partition installation

Fig. 7 Experiment in progress

(2) Condition Setting

The experiment was conducted in a classroom to maintain stable temperature, humidity, and airflow. Initially, a gymnasium used as an evacuation shelter was considered. However, due to the mid-July timing and the physical condition of the student researchers, the classroom was selected as it better satisfies these requirements.

(3) Experimental Materials and Equipment

Blue, pink, and green partitions; an electronic blood pressure monitor; a pulse oximeter; a thermometer; a desk; a chair; a tape measure; and books.

5. Results

(1) Results for Participant A

Table 1: *Changes in Vital Signs Under the Blue Partition (26.1°C and 50% Humidity)*

Curtain Color ●Blue	Body Temperature (°C)	Pulse Rate (beats/min)	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)
Immediately before the start	35.9	65	99	59
5 min after the start	36.4	66	96	55
10 min after the start	36.6	69	93	51
15 min after the start	36.3	68	99	49
20 min after the start	36.9	67	85	56
25 min after the start	35.9	65	85	56

Participant A’s impression: No notable changes were reported from the beginning to the end, and a calm state was maintained throughout.

Table 2: Changes in Vital Signs Under the Pink Partition (26.8°C and 50% Humidity)

Curtain Color ●Pink	Body Temperature (°C)	Pulse Rate (beats/min)	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)
Immediately before the start	36.6	81	98	67
5 min after the start	36.1	79	98	64
10 min after the start	35.9	74	96	55
15 min after the start	36.3	72	92	59
20 min after the start	36.8	80	94	47
25 min after the start	36.5	83	90	50

Participant A’s impression: A calm state was maintained during the first 5–10 min; however, tension increased at the end.

Table 3: *Changes in Vital Signs Under the Green Partition (25.1°C and 52% Humidity)*

Participant A’s impression: There was no particular change from the start to the end, and he remained calm throughout.

Curtain Color ●Green	Body Temperature (°C)	Pulse Rate (beats/min)	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)
Immediately before the start	36.5	87	96	64
5 min after the start	36.4	76	93	51
10 min after the start	36.1	83	91	62
15 min after the start	37	82	97	60
20 min after the start	36.9	76	94	57
25 min after the start	36.9	91	87	58

(2) Results for Participant B

Table 4: Changes in Vital Signs Under the Blue Partition (26.1°C and 50% Humidity)

Curtain Color ●Blue	Body Temperature (°C)	Pulse Rate (beats/min)	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)
Immediately before the start	36.3	79	98	60
5 min after the start	36.7	68	104	62
10 min after the start	36.6	69	97	65
15 min after the start	36.7	65	95	62
20 min after the start	36.7	71	102	63
25 min after the start	36.5	79	94	68

Participant B's impression: A calm state was maintained throughout the experiment, with no notable psychological changes reported.

Table 5: Changes in Vital Signs Under the Pink Partition (26.7°C and 50 Humidity)

Curtain Color ●Pink	Body Temperature (°C)	Pulse Rate (beats/min)	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)
Immediately before the start	36.7	75	115	71
5 min after the start	36.8	74	102	61
10 min after the start	36.8	74	101	64
15 min after the start	36.5	80	109	64
20 min after the start	36.9	74	102	62
25 min after the start	36.6	85	115	67

Participant B's impression: Approximately 15 min after the start, the surrounding noise became bothersome, and a desire for the experiment to end quickly was reported.

Participant B's impression: After 20 min, the surrounding noise became bothersome, and the bell increased anxiety. The concern that the experiment had not ended led to restlessness.

(3) Changes in Body Temperature, Pulse Rate, and Blood Pressure

***Table 6:** Changes in Vital Signs Under the Green Partition (25.8°C and 53% Humidity)*

Curtain Color ●Green	Body Temperature (°C)	Pulse Rate (beats/min)	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)
Immediately before the start	37.2	79	100	57
5 min after the start	36.9	73	103	66
10 min after the start	36.9	82	108	64
15 min after the start	36.8	79	99	63
20 min after the start	36.7	92	103	60
25 min after the start	36.7	88	113	70

1. Body Temperature

The body temperature of participant A decreased when the partition was pink, whereas that of participant B decreased when the partitions were pink and green. With the other partition colors, body temperatures increased between the beginning and the end of the experiment.

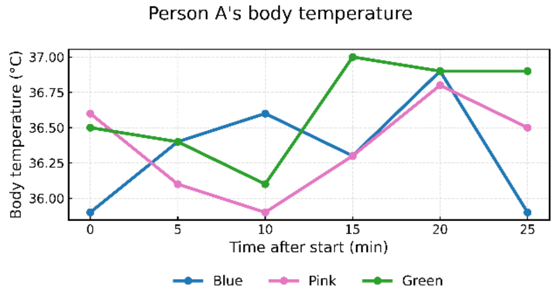

***Fig. 8** Changes in participant A's body temperature.*

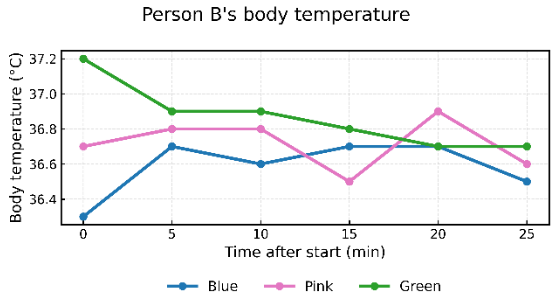

***Fig. 9** Changes in participant B's body temperature.*

2. Pulse Rate

Figures 9 and 10 show that the pulse rates of participants A and B experienced minimal changes under the blue partition; however, they increased under the pink or green partitions.

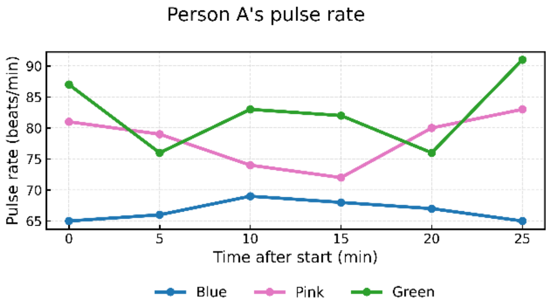

Fig. 10 *Changes in participant A's pulse rate.*

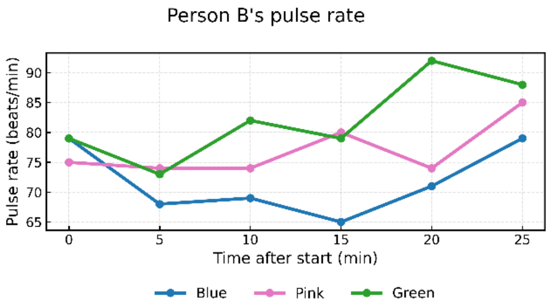

Fig. 11 *Changes in participant B's pulse rate.*

Figures 10 and 11 show the change in the pulse rate immediately before the start and 25 min after the start.

*Values in parentheses indicate the magnitude of change, with the value immediately before the start set as 0 and compared with the value after 25 min.

Participant A
Blue: 65 beats/min → 64 beats/min (−1 beat/min)
Pink: 81 beats/min → 83 beats/min (+2 beats/min)
Green: 87 beats/min → 91 beats/min (+4 beats/min)

Participant B
Blue: 79 beats/min → 79 beats/min (0 beats/min)
Pink: 75 beats/min → 85 beats/min (+10 beats/min)
Green: 79 beats/min → 88 beats/min (+9 beats/min)

3. Blood Pressure

Figures 12 and 13 show that the systolic blood pressure of both participants A and B was lowest under the blue partition.

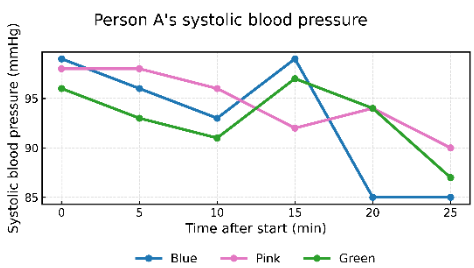

Fig. 12 *Changes in participant A's systolic blood pressure*

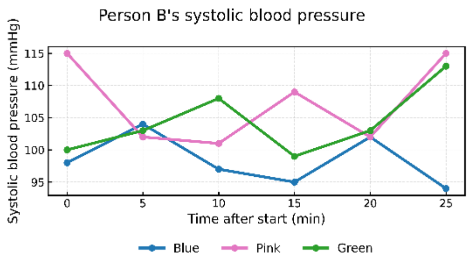

Fig. 13 *Changes in Participant B's Systolic Blood Pressure*

• Changes in values immediately before and 25 mins after the start are shown in Figures 12 and 13

*Values in parentheses indicate the magnitude of change, with the value immediately before the start set as 0 and compared with the value after 25 min.

Participant A
Blue: 99mmHg → 85mmHg (−14mmHg)
Pink: 98mmHg → 90mmHg (−8mmHg)
Green: 96mmHg → 87mmHg (−9mmHg)

Participant B
Blue: 98mmHg → 94mmHg (−4mmHg)
Pink: 115mmHg → 115mmHg (0)
Green: 100mmHg → 113mmHg (+13mmHg)

6. Discussion

The autonomic nervous system, a component of the peripheral nervous system that regulates the internal organs, comprises two divisions with opposing functions.

The sympathetic nervous system prepares organs and tissues for increased physical activity and is particularly active during physical exercise, mental arousal, or anxiety. When activated, the heart rate and respiration increase, the bronchi and pupils dilate, and digestion is suppressed. Blood vessels also constrict, leading to increased blood pressure and increased sweating.

In contrast, the parasympathetic nervous system is active during relaxation. Activation reduces heart rate and respiration while constricting the bronchi and pupils. Gastrointestinal motility and digestive secretion are promoted, supporting digestion and absorption.

Therefore, when the sympathetic nervous system is dominant, catecholamines are released, leading to increases in body temperature, heart rate, blood pressure, and skin temperature. In contrast, when the parasympathetic nervous system is dominant, the body temperature, heart rate, blood pressure, and skin temperature decrease.

Based on the body temperature results, both participants A and B showed decreases under the pink partition. Under the blue partition, increases were observed in both participants A and B. Under the green partition, participant A's body temperature increased, whereas that of participant B decreased. Body temperature generally decreases when the parasympathetic nervous system is dominant; thus, the results indicate that parasympathetic activity was enhanced under the pink partition. However, the increase under the blue partition, which has been associated with parasympathetic dominance in other studies, may be explained by air retention within the partition, leading to increased humidity during breathing.

The pulse rate results indicated increases for both participants A and B under the pink and green partitions, indicating sympathetic dominance.

Blood pressure results show that systolic blood pressure for both A and B was lowest under the blue partition, indicating that this condition may most strongly promote parasympathetic activity.

Based on subjective impressions, participant A remained calm throughout the experiment regardless of the partition color, whereas participant B became impatient under the pink and green partitions, resulting in greater physiological fluctuations.

7. Conclusion

This study demonstrates that both LED lighting and partition colors influence the psychological condition of individuals living in evacuation shelters. An evaluation using blue, pink, and green partitions revealed that the blue partition produced the most stable physiological responses, including lower systolic blood pressure and stable pulse rates, indicating parasympathetic activity and a relaxed state. These findings indicate that appropriately selected lighting and partition colors can reduce psychological stress and improve shelter environments. Although the study was conducted on a limited scale, it highlights the potential of simple, low-cost environmental design strategies to support evacuees' mental well-being. Further studies under realistic shelter conditions are required to establish practical guidelines for disaster preparedness and shelter management.

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