Quantifying Glare in Newborn Care Due to Phototherapy Devices

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Background

Glare is an optical phenomenon described as the inhibition of an individual's ability to view a scene due to the presence of a disruptive light source. It is an issue prevalent, especially at night, in newborn care due to the neonatal phototherapy devices. Phototherapy is a common treatment for neonatal jaundice in hospitals. Although small in number, the phototherapy devices used in newborn care act as bright sources of light in otherwise dim, ambient light-controlled environments and thus can cause glare. Studies have shown that exposure to the blue light emitted from phototherapy and other devices, described as a high energy visible (HEV) light, can have adverse effects on nearby individuals, such as the alteration of one's circadian rhythm, suppression of melatonin, or sensation of nausea. (1-2) It is, therefore, important -to limit the phototherapy light exposure for clinicians to minimize the risk. While glare is, by nature, subjective, there are some quantitative methods to characterize it. These methods apply to both categories of glare: disability and discomfort glare.

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Disability Glare

Disability glare is the loss of retinal image contrast resulting from intraocular light scatter in the presence of a bright light source. This type of glare tends to reduce an individual's ability to discern contrast by throwing a veil of light over the field of vision. (3) This effect is more significant near the light source. All disability glare is caused by an imperfection in the optical media (e.g., cornea and lens) causing non-uniform passage of light from the source to an individual's retina.

Disability glare can be experienced in many settings. A common example is an obstruction in an individual's view that can occur while driving on a bright sunny day as a result of the reflection of light off nearby vehicles. There is no gold-standard test for disability glare. An example of a current test for disability glare is reading a vision chart with and without a source of glare - such as a pen torch. Another test involves a more sophisticated device that projects stimuli directly on to the retina to measure light scattering.

Disability glare can pose a serious risk when the individual experiencing it is not at rest and where the sudden loss, in contrast, affects that individual's navigation or motor skills. In some clinical settings, clinicians turn off the bright phototherapy devices while they assess a patient undergoing phototherapy, to minimize this risk. However, repeated interruptions in treatment can prolong the treatment time for patients.

Discomfort Glare

Discomfort glare is described as "glare which causes discomfort without necessarily impairing the vision of objects." (4)

The quality of lighting in a room is dependent on the average luminance on the floor and the uniformity of luminance across the room. In a hospital setting, neonatal phototherapy devices contribute to the lighting system of a room. Clinicians practicing in a setting with blue light exposure may experience discomfort glare.

Typically, the subjective evaluation of discomfort glare is performed using the DeBoer scale [5]. The DeBoer scale is a subjective, nine-point scale in which the participant rates glare from Unbearable (1) to Just Noticeable (9) as depicted below.

DB	Classification
9	Just Noticeable
8	...
7	Satisfactory
6	...
5	Just Permissible
4	...
3	Disturbing
2	...
1	Unbearable

Table 1: DeBoer Scale

To make this evaluation quantitative and to understand the influence of four specific factors on discomfort glare, Bullough et al. conducted a series of indoor and outdoor experiments. (6) The four factors are:

- The Illuminance from the source, EL,
- The luminance of the source (LL),
- The Illuminance from the area surrounding the source (Es)
- The Ambient illuminance (EA)

The group determined that discomfort glare is most highly influenced

by illuminance and went on to develop a model that uses the EL, ES, and EA to quantify disability glare. The model further feeds into the De-Boer rating scale to yield a discomfort glare score, as shown in equation 1 and equation 2. (5)

$$DG = log(E_L + E_S) + 0.6\, log\left(\frac{E_L}{E_S}\right) - 0.5\, log(E_A)$$

Equation 1: Disability Glare Model

$$DB = 6.6 - 6.4\, log(DG) + 1.4 log(\frac{50{,}000}{L_L})$$

Equation 2: DeBoer Scale Model

Comparison of Glare Emissions Between Marketed Phototherapy Devices

Methods

For this study, three, currently-marketed phototherapy devices, NeoLight Skylife™, Natus neoBLUE®, and GE Giraffe® Spot PT Lite were evaluated. Two white plane surfaces were oriented perpendicular to the width and length of the phototherapy devices under investigation at a distance of 50 cm from the center of each light source. Each plane was comprised of 23 points for the measurement of luminance and illuminance from the phototherapy devices (Figure 1). These 23 points represent the glare field that an observer would experience adjacent to a phototherapy device.

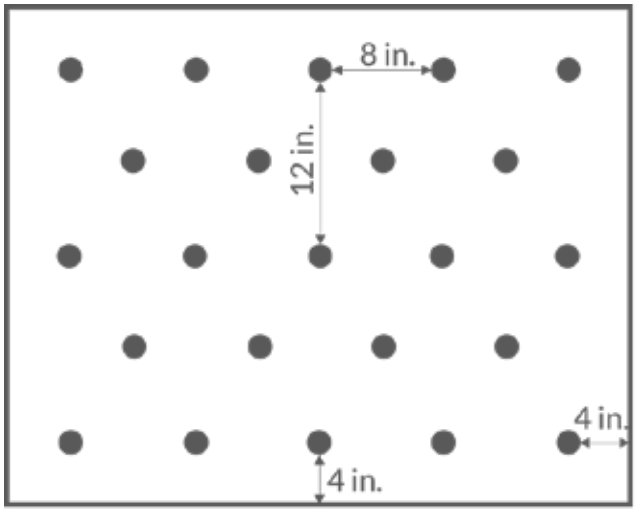

Figure 1: Measurement Grid on Observer Plane

A lux meter was positioned at each of the 23 measurement points and pointed towards the phototherapy device with the help of an attached laser pointer to measure the luminance values (LL). Ambient illuminance without the phototherapy device was also measured from the four corners of each observer plane, and the averaged values were discounted from the corresponding measurements made at the 23 points on each of the two observer planes.

MATLAB was used for data processing, wherein the grid was reconstructed, and the luminance values measured at each of the two observer planes were used to evaluate the corresponding DB scores using Equation 1 and Equation 2. Interpolation was then used to obtain a continuous field of DB scores across each of the two observer planes.

The process was repeated for each of the three phototherapy devices. The process was repeated for each of the three phototherapy devices. The resulting two observer DB score plots were rendered next to the 3D CAD models and are presented in the following section.

Results and Discussion

The following figures represent the glare experienced by an observer 50 cm away from each phototherapy device. The discomfort glare experienced intensifies as the color in the observer planes shift from blue (least discomfort – DB Score 9) to red (most discomfort – DB Score 3).

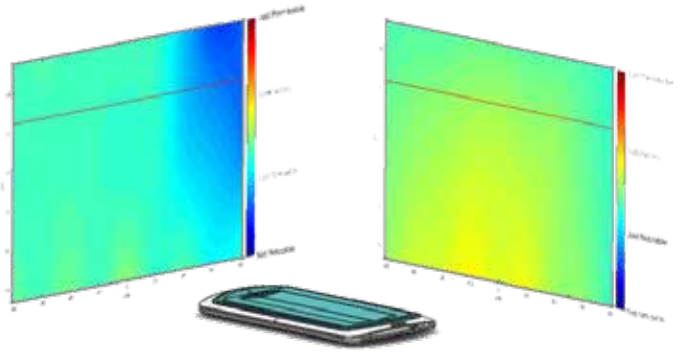

Figure 2: Skylife™ Glare Field

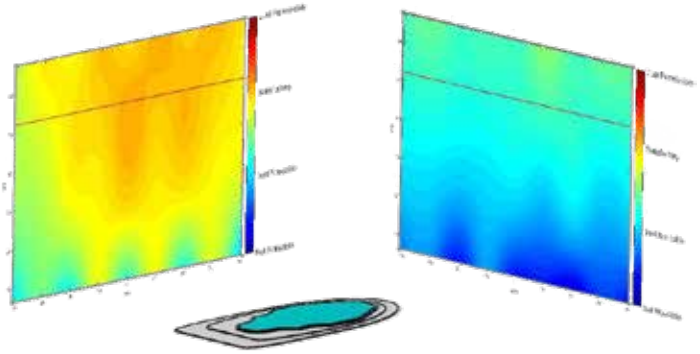

Figure 3: Natus® neoBLUE® Glare Field

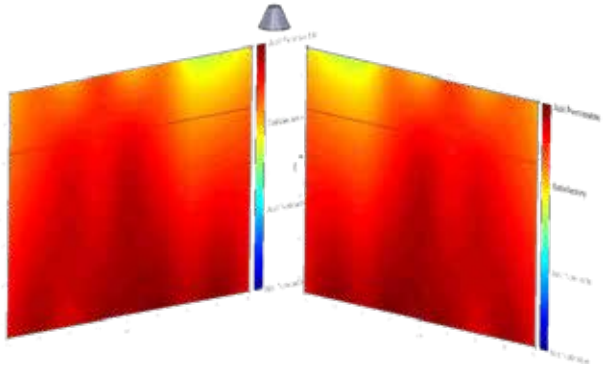

Figure 4: GE Giraffe® Spot PT Lite™ Glare Field

The horizontal red line shown on each of the observer planes indicates the average eye-line for clinicians.

It is evident from these figures that the glare associated with NeoLight Skylife™ is less than that with Natus neoBLUE® and GE Giraffe® Spot PT Lite. The GE Giraffe® Spot PT Lite device had a glare far greater than that of the other two devices. This could be because the –

NeoLight Skylife™ and Natus neoBLUE® devices have a bottom light source that is much closer to the patient than in the GE Giraffe® Spot PT Lite. The bottom light source configuration provides efficient treatment dose delivery while minimizing the stray light emitted.

In addition to the bottom light source configuration, the novel utilization of a 3D light channeling mechanism for the Skylife™ device further reduces its glare score. Overall, the Skylife™ phototherapy device is found to have the lowest glare score while maintaining the highest phototherapy dosage.

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Conclusion

Phototherapy devices emit HEV light. The glare associated with devices which emit HEV light should be minimized to mitigate potential long-term exposure effects for individuals who work near the devices on a routine basis. It is, therefore, imperative that phototherapy devices - both overhead and under baby units – incorporate inherent design features to minimize the stray treatment light leaking past the intended target, i.e., jaundiced infant, into the treatment room. Due to the potential impact on its clinicians, hospital management must consider glare when purchasing phototherapy devices go- forward. Similar devices should be compared to determine which device minimizes this unwanted effect of light.

The method outlined in this paper can be standardized to evaluate the glare produced by any phototherapy device. In this study, the glare produced by three devices - Natus neoBLUE®, GE Giraffe® Spot PT Lite, and NeoLight Skylife™ - was evaluated with the described method.

Skylife™, due to its 3D light channeling mechanism, demonstrated the least glare for an individual in the vicinity of the device while producing the highest dose of phototherapy in the study and thus is the top-rated device.

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Disclosure: The authors are co-founders of NeoLight LLC and have a financial relationship with NeoLight LLC.

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