



LET THERE BE LIGHT: A QUICK GUIDE TO TELEMEDICINE LIGHTING

NOVEMBER 2017



Let There Be Light: A Quick Guide to Telemedicine Lighting

Elizabeth Krupinski, PhD & Gilbert Leistner, CPPM, MCGI

**An American Telemedicine Association Human Factors SIG publication in collaboration
with the Home Telehealth and Remote Monitoring SIG**

Key Contributors in alphabetical order:

Elizabeth Krupinski, Gilbert Leistner

July 2017

This guide is a quick reference to the importance of lighting in providing healthcare services. Some pointers relate specifically to the provision of remote services, but all are applicable to most healthcare encounters. For more information and details we refer you to the references at the end of the guide.

Why is Lighting Important?

Observation and assessment of patients is essential to successful delivery of healthcare and good lighting is fundamental to observation and assessment.^{1,2} This is as true for in-person patient clinical encounters as it is for telehealth/telemedicine clinical encounters. Good lighting contributes to the social success of clinical encounters, increasing patient satisfaction in healthcare, an increasingly important measure of both clinical engagement^{3,4} and the business of reimbursement.^{5,6} Nonetheless, lighting remains an underappreciated aspect of telemedicine encounters that we illuminate in a general guide to facilitate clinical and social success (including patient satisfaction) in telemedicine and telepresence.

For the Quick Guide Series we define telepresence as the controlled synthesis of technology, environment, and human factors that govern encounters between people communicating at a distance. Telepresence encompasses the demeanor of the participants as well as the quality of the encounter involving lighting, sound/noise, and room appearance—in short, most everything that the technology of the video/audio connection can convey. Telepresence in this context is thus a statement that the participants in a telehealth encounter make about themselves that is independent of the session clinical content but one that colors the entire encounter. This applies to both patients and providers. Good lighting practices are essential for good telepresence, and related aspects such as communication and relationship/rapport between participants.^{7,8} In this

Quick Guide we will focus mostly on aspects of lighting as they pertain to telehealth clinical consultations with patients and communications between providers.

What does lighting impact?

- Performance
 - Lighting impacts fatigue, reaction time, task completion, number of mistakes, performance of visual tasks, alertness, and control of circadian rhythms/essential chemical reactions.^{1,9-13} Poor lighting (which can include too much of it) effects can be subtle and insidious.
- Efficiency
 - The economics of care model flow through and the costs of operating it.
- Comfort
 - Participant satisfaction (including rapport), concentration and attention span, mood, perception^{1,9-13}
- Some clinical assessments (e.g., neurology & gait assessment) require patients to move in their environment so lighting needs to be bright enough to accommodate safe movement as well as perception/analysis of movement from the remote site

Lighting Environments

- Ambient or fill light: light that fills the entire environment
 - Usually comes from fixtures (ceiling & wall-mounted)
- Participant or point light: light illuminating the face to reduce shadows
 - Usually table/desk top
 - In the presence of light sources that creates shadows, light that fills shadows also can be called fill light
- Lighting environments impact perceived depth: degree to which subject stands out from background
 - Best when shoulders & top of head gently illuminated

Lighting Source Options

- Artificial versus natural: lighting sources differ; people prefer natural and natural looking artificial light;¹³ sources impact perception of and preference for skin tones;¹⁴⁻¹⁶ good

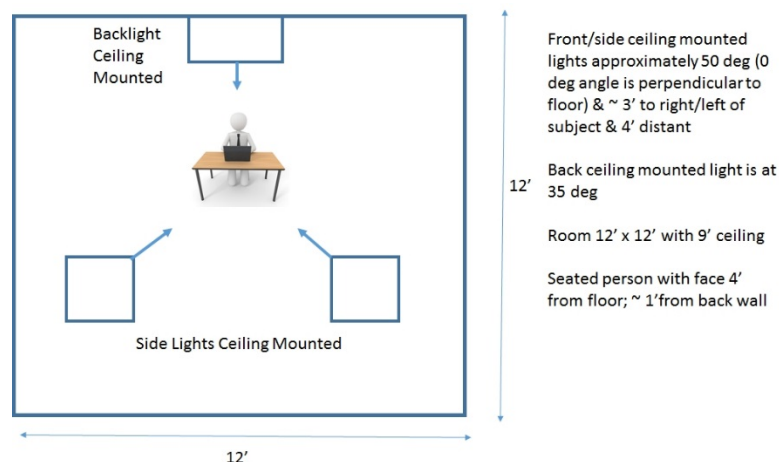
lighting impacts eye contact as well as ability to see clearly the eyes and eye movements¹⁷⁻²³

- Daylight
 - Often preferred but can be impractical in healthcare environments
 - Accessible via windows but varies depending on time of day; can induce shadows, reflections, glare that diffusers can limit
 - Can impact ambient temperature of entire rooms or specific locations where natural light falls.
- Color temperature
 - Artificial light (and filtered natural light) falls into three categories: i) warm white, ii) cool white; and iii) (artificial) daylight that govern a mood tied to the light. “Warm” light tends to yellow, “cold” to blue, and “daylight” to the spectrum. The color of light is defined in terms of the temperature in degrees Kelvin that produces that color glow in a standard metal heated to the specified temperature²⁴. 3000K for light thus means light from metal at 3000 degrees Kelvin.
- Artificial “natural” light
 - recommended as is a warm, white light (3200K-4000K)
 - Generally avoid colored room lighting (e.g., yellow, blue tint) where the color comes from color in the glass of the bulb (as opposed to the filament or emission in diodes) or where color is inherent in technology limitations—some LED (light emitting diodes) are very blue. Note: specific clinical applications may call for colored room light.
- Fluorescent: wave lengths limited to part of spectrum (mostly yellow, orange, red)
 - Preferred if done properly
 - Usually 3500 K low-end “home” use
 - Commercially can get white light 5000 K
 - Dedicated fixtures (indirect wash fluorescent fixtures) available specifically for videoconferencing
 - Available in cool white to reduce ambient heating
- Incandescent
 - Usually yellowish, typically 2800 K
- Lamps

- Useful as task lighting
- Useful to compensate for poor lighting conditions (described below)
- Suggested color temperatures
 - Shade 6500K
 - Sunlight 6000K
 - Fluorescent 5500K - 4000K
 - Twilight 4000K
 - Incandescent (tungsten) 3500K - 3000K

Lighting Placement

- Angles
 - Overhead lights typically come as pendant or recessed
 - 100% direct: direct light straight down so more intense directly under fixture compared to perimeter resulting in hot spots on camera where tops of heads & table surfaces are extremely bright & washed out, but background areas darker & shadowed –not recommended unless fill lighting is also used for balance
 - 100% indirect: direct light upward toward a ceiling (and some walls) or by refracting light off a reflective surface within fixture allowing light to be more evenly distributed – recommended
 - direct-indirect: part of light directed downward & part upward - not recommended as part directed downward creates hot spots



- Place & aim fixtures to achieve vertical illumination on subject
 - 35-40 degrees above horizontal for front lights
- Avoid traditional down lighting as creates facial shadows

- If there is only 1 light source, place as close as possible from same direction as camera
 - Multiple frontal light sources are recommended as improves “3D” effect
 - Backlighting helps the body stand out from background
- Fill lighting: purposed to reduce or remove shadows and balance color
 - Can reduce “ghoulish” look of blue shifted light.
 - Can often be accomplished with a table lamp (with shade) placed in front of subject but behind camera or to the side
- Combined lighting arrangement (ceiling + wall) ideally 60:40
- Brightness

Brightness is the amount of light that falls on an object and is mostly independent of the temperature of the light. Brightness is expressed in foot candles (the light of a standard candle measured at a distance of 1 foot), lux (the amount of light) and lumens —the amount of light per a square amount of area measured as the light is perceived by the human eye. Brightness falls with distance from the source, so adjustments must be made for location of lamps in relation wattages and lumens per the example table below. Common sense can work well in the absence of a light meter.

How Many Lumens Do You Need? More Lumens = More Light				
If you used to buy this in incandescent	Look for this much light in lumens	LED (most efficient)	CFL (more efficient)	Halogen (more efficient incandescent)
100 W	1600	up to 22 W	up to 26 W	up to 72 W
75 W	1100	up to 20 W	up to 23 W	up to 53 W
60 W	800	up to 12 W	up to 15 W	up to 43 W
40 W	450	up to 9 W	up to 11 W	up to 29 W

Output & Wattages based on most common products available for each medium screw-based light bulb. Actual output may vary by product. (Source: lumens.com²⁵)

- Should be at least 592 lumen²) & ideally about 807 lumen) on subject faces
- Should be uniform across field of view
- Glare, reflection
 - Avoid surfaces that reflect undesirably (e.g., glass desktops; glass framed pictures)
 - Be mindful of :
 - The effect of clothing-- white lab coats or colored scrubs

- Light emitting devices such as computer screens, tv monitors, smart phones
 - Light blue recommended
- Beam spread
 - Variable beam angles and dimmable lights are useful
 - Narrow beam spreads are useful with subjects sitting close to a reflective wall to increase contrast
 - Wide beams are useful with dark walls and/or subjects at a distance to increase lighting on surroundings
- Avoiding shadows
 - Shadows impact perception of skin tone, eye color, hair color, facial expressions
 - Task (desktop) lighting can be adjusted to avoid
 - If only fixed lighting available having subjects move or adjust their position helps avoid shadows

Walls & Backdrops

- Color impact
 - Light needs to be adjusted to produce best results for fullest range of skin tones
 - Neutral to blue hue walls; medium contrast; soft texture; avoid stark white.
 - Use matte instead of glossy where practical
 - Background & clutter
 - Avoid clutter in the background
 - Avoid moving backgrounds (curtains) that disrupt light patterns or distract attention
 - A “pop-up” screen (either single color like a wall or with your program logo) behind your chair can help block clutter
 - Brightest object in picture should be faces & darkest the background
 - Ideal value range is between 3:1 to 2:1 ratio of light hitting the face vs. light on the background
- Windows
 - Uncontrolled window light can distort encounter through bright light, changes in lighting as sun, clouds, move; create silhouetting
 - Use sheer drapery to soften light

- Well-chosen artificial light can compensate for time of day, weather

Lighting & Cameras

- Image control
 - Camera quality impacts its capability to adjust to different lighting conditions
 - High-end videoconferencing cameras typically have automatic gain (electronic way to boost brightness images) & white point balance
 - Lower-end desk-top cameras might have some limited tools to adjust image quality as lighting changes
 - Particularly important when consulting with patients in their homes as these cameras are commonly used
 - a. Should note limitations before consultation begins
 - White balance: camera control that adjusts camera's color sensitivity to match prevailing color of ambient light (cooler)
 - Can be set automatically or manually
 - Professional cameras can be set to match exactly light source
 - Automatic is easy but prone to color shifts
 - Manual option: shoot "white card" & press white balance button that adjusts red, green & blue signals so card appears "white" without any color cast
 - Need to perform every time with different lighting conditions
 - Placement
 - Avoid placing camera facing a doorway
 - Avoid placing camera facing a window
 - Avoid placing camera directly facing light source(s)
 - For videoconferencing place light sources and camera to optimize eye contact¹⁷
 - For specific clinical applications (e.g., teledermatology) optimize according to case requirements¹⁶

Different populations

- Aging & other eyes
 - Use ambient lighting that is uniform because older eyes take longer to adjust to changes in light levels

- Use higher levels of light because normal age related changes within the eye restrict light coming in & absorb the light so more light is needed to compensate
- Minimize glare because light scatters within eye causing increased sensitivity to glare & loss of the ability to see subtle details at lower light levels
- Use light that helps distinguish colors because the lens of the eye yellows with age so proper lighting can help compensate
- Use light fixtures that do not flicker or hum

REFERENCES

¹Applications in Focus: Lighting for Healthcare.

<https://www.yumpu.com/en/document/view/4592088/lighting-for-healthcare-thorn>. Last accessed March 1, 2017

²Tanuja S, Shailesh KR. Computer aided lighting requirement analysis and design for a health care facility. *Intl J Comp Applic* 2013;78:12-18.

³MacAllister L, Zimring C, Ryherd E. Environmental variables that influence patient satisfaction. *Health Envts Res Design J* 2016;10:155-169.

⁴Mohammed K, Nolan MB, Raijo T, Shah ND, Prokop LJ, Varkey P, Murad MH. Creating a patient-centered health care delivery system: a systematic review of health care quality from the patient perspective. *Am J Med Qual* 2016;31:12-21.

⁵Consumer Assessment of Healthcare Providers & Systems (CAHPS).

<https://www.cms.gov/Research-Statistics-Data-and-Systems/Research/CAHPS/>. Last accessed Feb 3, 2017.

⁶Elliott MN, Beckett MK, Lehrman WG, Cleary P, Cohea CW, Giordano LA, Goldstein EH, Damberg CL. Understanding the role played by Medicare's patient experience points system in hospital reimbursement. *Health Aff* 2016;35:1673-1680.

⁷Stans SEA, Dalemans RJP, deWitte LP, Smeets HWH, Beurskens AJ. The role of the physical environment in conversations between people who are communication vulnerable and health-care professionals: a scoping review. *Disabil Rehabil* 2016;5:1-12.

⁸Davidson KW, Shaffer J, Ye S, Falzon L, Emeruwa IO, Sundquist K, Inneh IA, et al. Interventions to improve hospital patient satisfaction with healthcare providers and systems: a systematic review. *BMJ Quality Safety* 2016;Online First doi:10.1136/bmjqs-2015-004758

⁹Ulrich R, Zimring C, Quan X, Joseph A, Choudhary R. Role of the physical environment in the hospital of the 21st century. <https://www.healthdesign.org/chd/research/role-physical-environment-hospital-21st-century>. Last accessed Jan 16, 2017

¹⁰Joseph A. Center for Health Design: The Impact of Light on Outcomes in Healthcare Settings, https://www.healthdesign.org/sites/default/files/CHD_Issue_Paper2.pdf. Last accessed Feb 13, 2017.

¹¹Boyce P, Hunter C, Howlett O. The benefits of daylight through windows. <http://thedaylightsite.com/wp-content/uploads/papers/DaylightBenefits.pdf>. Last accessed Feb

¹²Edwards L, Torcellini P. *A literature review of the effects of natural light on building occupants* (Technical report). Golden, CO: National Renewable Energy Laboratory. <http://www.nrel.gov/docs/fy02osti/30769.pdf>. Last accessed Feb 13, 2017.

¹³Heerwagen JH, Orians G. Adaptations to windowlessness: A study of the use of visual decor in windowed and windowless offices. *Envt Behav* 1986;18:623-639.

¹⁴Quellman EM, Boyce PR. The light source color preferences of people of different skin tones. *LEUKOS J Illum Engin Soc N Am* 2002;31:109-118.

¹⁵Jost-Boissard S, Avouac P, Fontoynt M. Preferred color rendition of skin under LED sources. *LEUKOS J Illum Engin Soc N Am* 2015;12:1-15.

¹⁶McKoy K, Antoniotti NM, Armstrong A, Bashshur R, Bernard J, Bernstein D, Burdick A, Edison K, Goldyne M, Kovarik C, Krupinski EA. Practice Guidelines for Teledermatology. *Telemed e-Health J* 2016;22:981-990.

¹⁷American Telemedicine Association: A Concise Guide for Telemedicine Practitioners: Human Factors Quick Guide Eye Contact. <http://www.americantelemed.org/home>. Last accessed Feb 13, 2017.

¹⁸Goldstein F, Glueck D. Developing Rapport and Therapeutic Alliance During Telemental Health Sessions with Children and Adolescents. *J Child Adolesc Psychopharm* 2016;26:204-211.

¹⁹Shortridge A, Steinheider B, Ciro C, Randall K, Costner-Lark A, Loving G. Simulating Interprofessional Geriatric Patient Care Using Telehealth: A Team-Based Learning Activity. <https://www.mededportal.org/download/461972/data/esr10415.pdf>. Last accessed October 9, 2016.

²⁰Neumann M, Bensing J, Mercer S, Ernstmann N, Ommen O, Pfaff H. Review Analyzing the "nature" and "specific effectiveness" of clinical empathy: a theoretical overview and contribution towards a theory-based research agenda. *Patient Educ Couns* 2009;74:339-46.

²¹Dwyer K. Unexpected surgical complication, lack of empathy triggers a lawsuit. <https://www.rmfi.harvard.edu/Clinician-Resources/Case-Study/2010/Unexpected-Surgical-Complication-Lack-of-Empathy-Triggers-a-Lawsuit>. Last accessed August 20, 2014.

²²Chavooshi B, Mohammadkhani P, Dolatshahee B. Telemedicine vs. in-person delivery of intensive short-term dynamic psychotherapy for patients with medically unexplained pain: A 12-month randomized, controlled trial. *J Telemed Telecare* 2017;23:133-141.

²³Howell SJ. Empathy & Its Role in Quality Care. *Osteopath Fam Physic* 2016;8:20-23.

²⁴Westinghouse. <http://www.westinghouselighting.com/color-temperature.aspx>

²⁵ <https://www.lumens.com/how-to-s-and-advice/what-are-lumens.html>