Novel Lighting Strategies for Optimizing Circadian Health and Alertness in Shiftworkers (New Project)

University of California San Diego
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Project Summary

Timeline:
Start date: 10/1/2017
Planned end date: 9/30/2019

Key Milestones
1. Baseline assessment of circadian health and alertness in hospital night shiftworkers (9/30/18)
2. Development of two new, evidence-based LED technologies for optimizing circadian and acute alerting effects of light (9/30/19)
3. Test the efficacy of novel lighting interventions for optimizing circadian health (9/30/2019)

Key Partners:
- UCSD
- BIOS
- flux
- Suburban Hospital/Walter Reed
- NIH

Budget:
Total Project $ to Date:
• DOE: $345,036
• Cost Share: $123,000

Total Project $817,125
• DOE: $653,625
• Cost Share: $163,500

Project Outcome:
Develop and establish the efficacy of two novel light-based circadian interventions for optimizing sleep, health, alertness, performance and quality of life in hospital nightshift workers.
Challenge

• 15 million individuals work outside a regular 9-5 shift (U.S. Department of Labor)

• Increased risk of accident & injury (Folkard & Tucker, 2003)

• Myriad physiological & psychological consequences (Evans et al. 2013; Brown et al., 2009; Lawson et al., 2011)

• Compromised alertness, performance and health costs ~$200 billion annually (Kerin & Aguirre, 2005)

• Single most important reason given for premature attrition from the field of emergency medicine (American College of Emergency Physicians, 2010)

• Limited practical solutions due to the complexity of the issue
  - Need for around-the-clock hospital care; Work-hour restrictions; Heterogeneity of shiftworker physiology; Light response depends on circadian clock time
Approach

Combines two evidence-based lighting interventions that address two different responses:

**Circadian Phase Resetting, architectural**
- maximize input during desired day
- minimize input just before and during desired bedtime

**Acute Alerting, individual**
- light for alerting ONLY
- only when KSS ≥6 and/or increased reaction time on PVT (*need based*)
Impact

- Development of two new LED technologies as well as a method for titrating light based on need
- Better understand the circadian and acute alerting effects of light in a real-world application
- Improved circadian health and alertness in hospital night shiftworkers as demonstrated via:
  - Increased sleep duration, quality and regularity (actigraphy and diary)
  - Adjustments in hormone profiles (melatonin and cortisol fluctuations)
  - Increased alertness (PVT and KSS)
  - Increased quality of life/more effective turnover communication
- Better understand hospital staff engagement and acceptability

### Light Source

<table>
<thead>
<tr>
<th>Light Source</th>
<th>CCT (K)</th>
<th>Melanopic lux (m-lux)</th>
<th>Photopic lux (lux)</th>
<th>m-lux/lux</th>
<th>CRI</th>
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<tbody>
<tr>
<td>LA sky at 2 PM</td>
<td>5107</td>
<td>1.12e+3</td>
<td>662</td>
<td>1.69</td>
<td>100</td>
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<tr>
<td>3500K fluorescent</td>
<td>3562</td>
<td>50.4</td>
<td>100</td>
<td>0.504</td>
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<tr>
<td>BIOS blue-enriched</td>
<td>3483</td>
<td>93</td>
<td>100</td>
<td>0.931</td>
<td>84.26</td>
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<tr>
<td>Alert ONLY</td>
<td>TBD</td>
<td>~30</td>
<td>100</td>
<td>~0.30</td>
<td>&gt;80</td>
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Progress

Early stages:

Phase 1. Baseline assessment of sleep, circadian health and alertness in shiftworkers

- IRB protocol has been drafted and approved (NMCSD/NIH “One Protocol”)
- Preliminary baseline assessment of dayshift and nightshift workers at hospital:

Phase 2. Adapt new BIOS lighting technologies for installation in a hospital setting

- Technological development with BIOS, including finalizing SPDs and creating a simple mechanism for switching SPDs of architectural lighting via dimming
- Meetings between UCSD, BIOS and hospital facility administrators have begun to identify the optimal location and method of installation
- Various brands and tints of blue blocker glasses have been characterized with flux, in order to select the best option for the study (leading to a manuscript in process)
Stakeholder Engagement

Early Stages:

- Collaboration between researchers (UCSD, NIH), industry (BIOS, flux) and healthcare facilities (Suburban Hospital, Water Reed Med Center, NIH Clinical Center)

- Regular meetings with all immediate collaborators and additional coordination with Suburban Hospital’s Director of Capital Renovation Planning & Space Management, Director of Facilities Management, Vice President/Chief Nursing Officer, Director of Professional Practice and Quality, CAPRES Divisional Coordinator as well as Walter Reed’s USN EMS/Disaster Regional Medical Director

- Attendance/presentation at DOE SSL workshops and other academic and industry meetings (e.g. IES, SRBR, SLEEP)

- Plans to include a formalized sub-study to develop lighting interventions that are not only effective for our defined purpose but also feasible, practical and acceptable to this population
Remaining Project Work

Phase 2.

• UCSD and hospital(s) will finalize the optimal department for data collection

• Facilities and BIOS will finalize the fixtures and plans for installation

• Radiometric measurements will be taken before and after the new architectural lighting has been integrated. Additional measures related to subjective experience, including visual comfort, chromatic discrimination and observer preference, will be collected for light sources and may guide further modifications.

Phase 3.

• Data collection will begin in late summer/early Fall and will implement a randomized, cross-over design.

• Data collection will occur across ~1.5/2 months, including:
  - 2 weeks of baseline assessment under standard fluorescent lighting
  - 2 weeks of BIOS blue-enriched LED architectural lighting
  - 2 weeks of BIOS architectural + Alert ONLY individualized lighting (as needed)

• Processing and analysis of data will be completed as well as dissemination of results via conference presentations and peer-reviewed publications
Thank You

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References


Project Budget

**Project Budget**: FY18: 468,036; FY19: 349,089

**Variances**: Personnel costs have been shifted (later start at increased percent time due to administrative delays as well as necessary changes to study site)

**Cost to Date**: 1814.72

**Additional Funding**: Seeking additional (non-DOE) funds to cover transportation to/from work for duration of study

### Budget History

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<th>FY19 SEPT 30 2019 (planned)</th>
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<td>Cost-share</td>
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# Project Plan and Schedule

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<th>FY2019</th>
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<td><strong>Past Work</strong></td>
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<td>IRB Protocol Approval</td>
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<tr>
<td>Phase 1: Baseline Assessment (Go/No-Go)</td>
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<tr>
<td><strong>Current/Future Work</strong></td>
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<td>Analysis of Results</td>
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