LUMI SAFE

Night Light Intervention for prevention of slips and falls in MCI patients within in-patient settings

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I Introduction

Introduction to Mild Cognitive Impairment:
Cognitive decline greater than that expected for an individual's age and education level (Frank et al., 2006; Jekel et al., 2015; Langa & Levine, 2014; Paradise et al., 2015; Petersen, 2011; Sanford, 2017)

Impact — Individuals experience apathy, depression, withdrawal, and self-neglect (Zis et al., 2017)
Loss of independence and decrease in quality of life (Frank et al., 2006; Petersen, 2011; Sanford, 2017)

Symptoms — Difficulties performing instrumental activities of daily living (Jekel et al. 2015) like shopping, cooking, managing finance.
Sleep disturbances lead to issues of nightly wandering, daytime sleepiness and daytime napping and increases chances of injury due to falls.(S.Nolan et al., 2003)

Demographics — 10-20% of individuals aged 65 years or older (Langa & Levine, 2014; Paradise et al., 2015; Petersen, 2011; Sanford, 2017)

Care Partner Impact — 30% of Care Partners reported clinically significant burden through high levels of anxiety, depression, and stress (Werner, 2012)

Design Topic:

Issue Focused upon:
Sleep disturbances in MCI Patients leads to poor memory and executive functioning. (Palmer, K. et al., 2018)

Problems due to sleep cycle disruption: nightly wandering, daytime sleepiness and napping, *chances of slips and falls* (S.Nolan et al., 2003)

Common Intervention:
Biodynamic lighting positively impacts the circadian rhythm (van Lieshout-van Dal, Snaphaan, & Bongers, 2019)

Problem with Biodynamic lighting:
switched off during nighttime causing a higher risk on patient falls in the dark.

Our proposal: A design solution / *LumiSafe to be switched on* when the biodynamic lighting is tuned off.

Biodynamic lighting-OFF
LumiSafe- ON
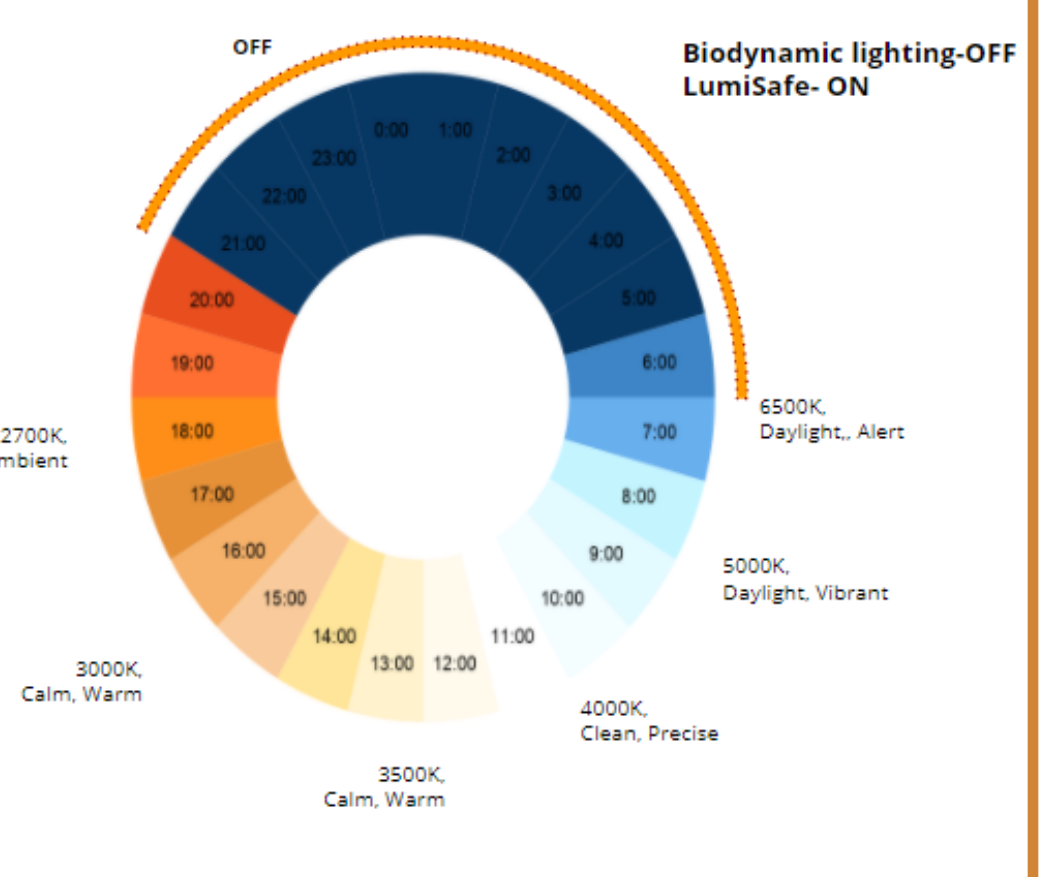
II Aim and Purpose

Problem Statement:
People with MCI or Alzheimer's disease often have Sleep cycle disruptions lead to problems in the sleeping pattern with symptoms such as nightly wandering, daytime sleepiness, and daytime napping. (Cooke & Ancoli-Israel, 2011) Along with these symptoms a major problem is that of injuries due to slips and falls. A common intervention to address issues of sleep cycle is the use of biodynamic lighting designs, which are implemented within in-patient settings. (van Lieshout-van Dal, et al., 2019)
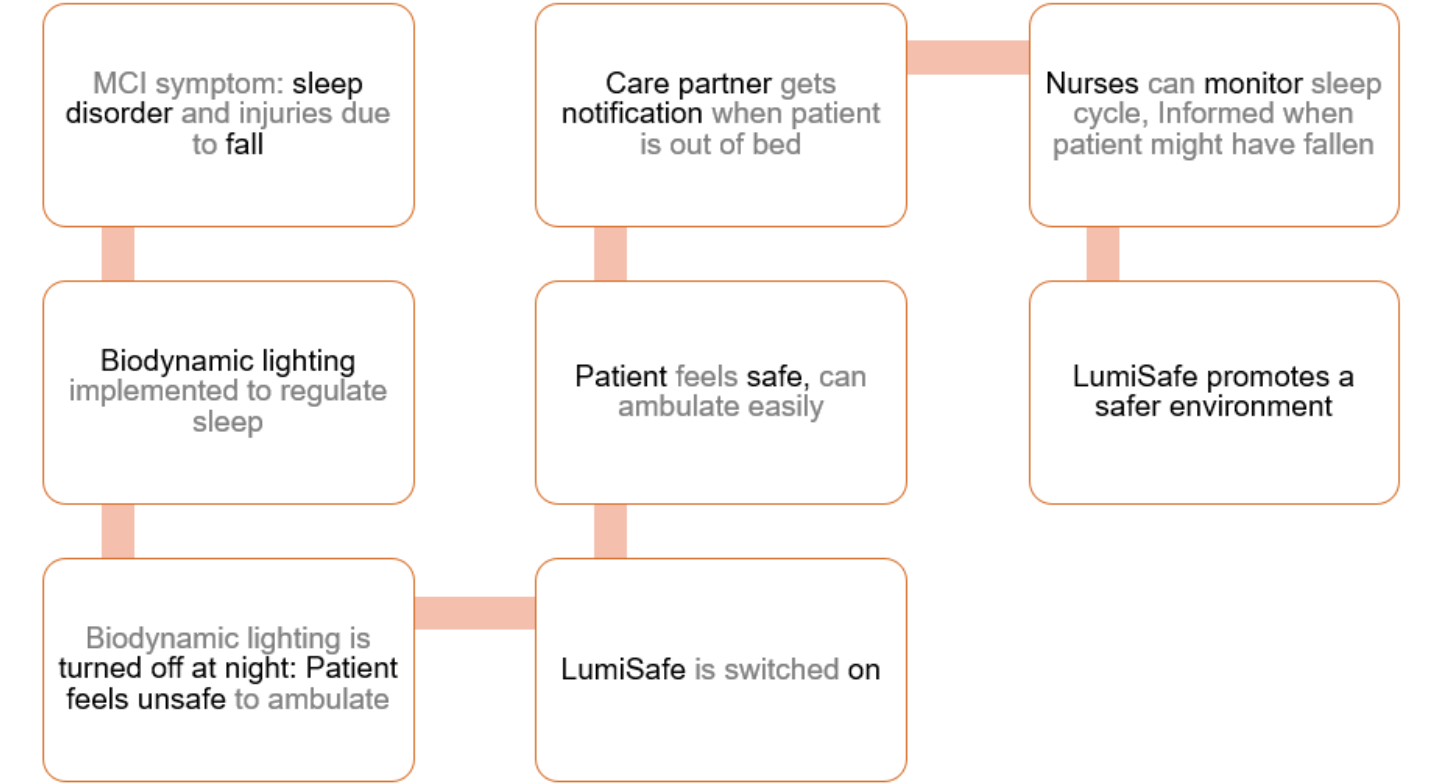
These lights are turned off during the night to allow the patient to sleep and not disturb them. However, despite the enhancement in sleep, there is an increasing risk of slips and falls when the patients try to ambulate to the bathroom etc. during the night times when the lights are turned off. Therefore, there is a need to address this issue with a comprehensive night lighting solution that gives the patient's their lost autonomy, while also helping care partners and nurses by reducing their burden.

Purpose
- The purpose of this prototype is to develop a night lighting and motion sensor system that will be incorporated in an inpatient setting with biodynamic lighting already in place to help the MCI Patients regulate their sleep cycle.
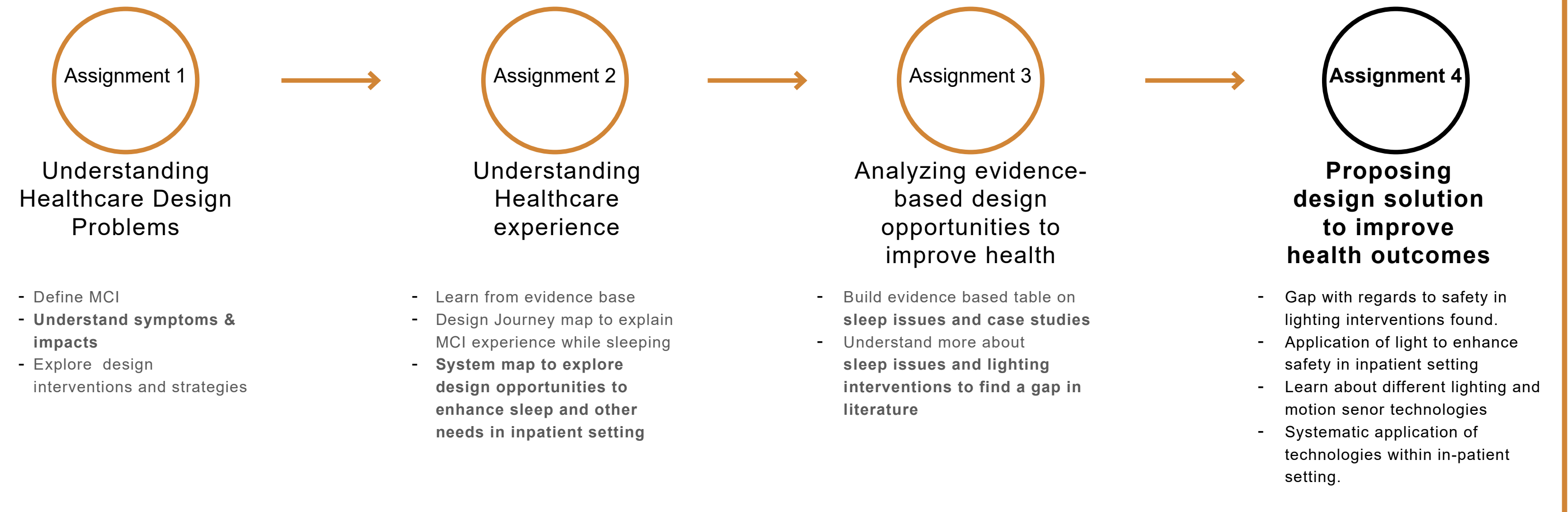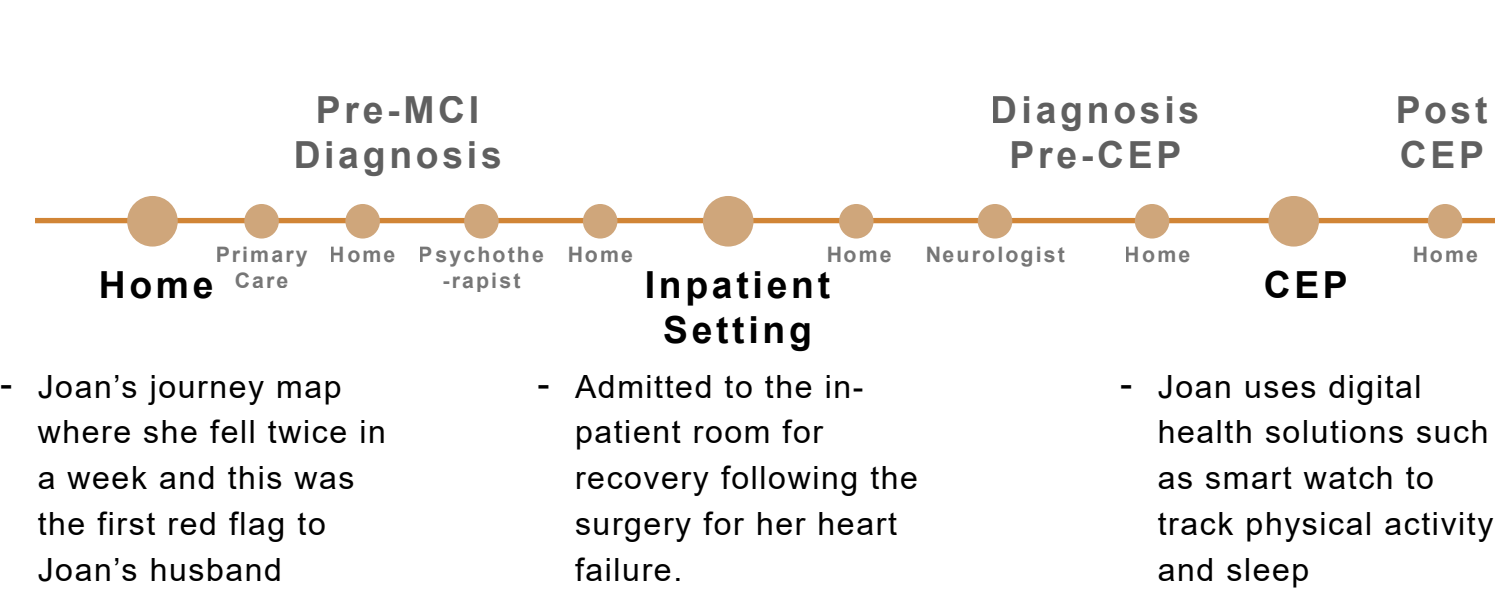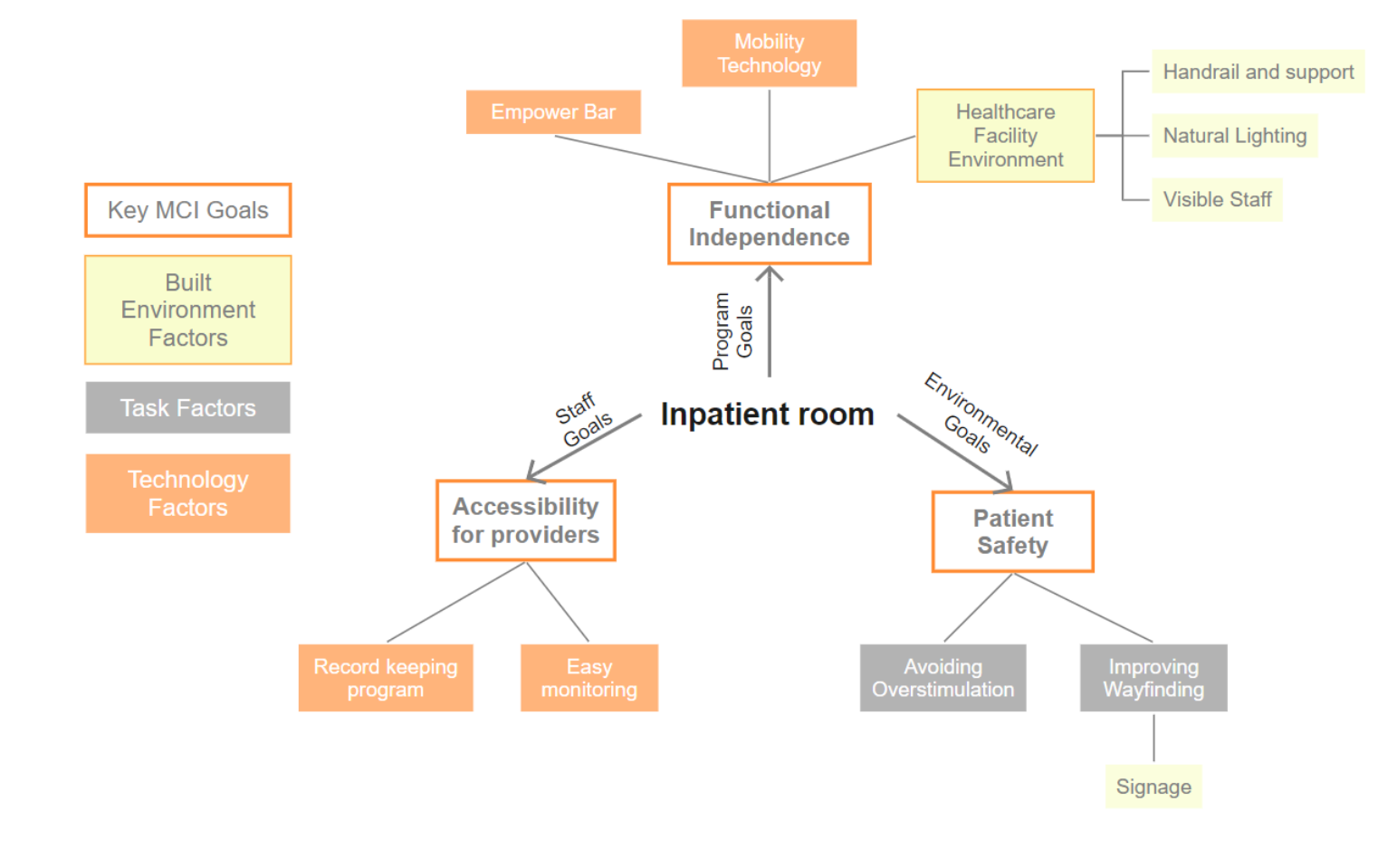
Aim
- The aim of this prototype is to make the inpatient setting safe for patients to ambulate at night when the biodynamic lights are turned off, while also helping the nurses to monitor the patient's sleep cycle and notifying the care partners about the patient's whereabouts.

III Methods

Assignment 1 → Assignment 2 → Assignment 3 → Assignment 4

Assignment 1: Understanding Healthcare Design Problems
- Define MCI
- Understand symptoms & impacts
- Explore design interventions and strategies

Assignment 2: Understanding Healthcare experience
- Learn from evidence base
- Design Journey map to explain MCI experience while sleeping
- System map to explore design opportunities to enhance sleep and other needs in inpatient setting

Assignment 3: Analyzing evidence-based design opportunities to improve health
- Build evidence based table on sleep issues and case studies
- Understand more about sleep issues and lighting interventions to find a gap in literature

Assignment 4: Proposing design solution to improve health outcomes
- Gap with regards to safety in lighting interventions found.
- Application of light to enhance safety in inpatient setting
- Learn about different lighting and motion senor technologies
- Systematic application of technologies within in-patient setting.

IV Mapping the MCI Experience

Journey Map:

- Joan's journey map where she fell twice in a week and this was the first red flag to Joan's husband
- Admitted to the in-patient room for recovery following the surgery for her heart failure.
- Joan did not sleep well, and reported being stress.
- Joan uses digital health solutions such as smart watch to track physical activity and sleep

System Map:

V Design Opportunities

Design Guidelines:

Safety — Ensure safety of the patients by providing enough lighting for them to see the edge of the bed and the floor

Autonomy — Give autonomy to patients by allowing them to control the lights, its intensity and color

Design Opportunities:

Monitoring — Motion and sleep monitor (actigraphy) sensors to detect changes in the patients' circadian rhythm and their activeness

Lighting — Lights on the rail of the bed, underneath the bed, and on the mat that turn on/off in response to sensors and set to specific brightness/intensity

Notifying — Notifications sent to caregivers when patients are more active, awake, or leaves the bed

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VI Prototype Development

- Controllable wall light
- Motion sensor
- Lighting along the bed handrail
- Sensor-based lighting under the bed
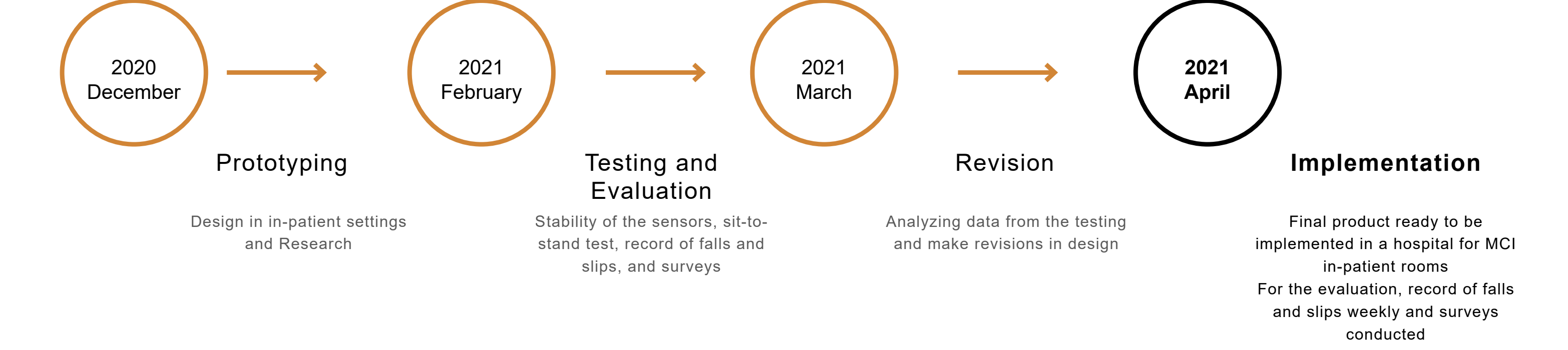- Anti-slip mat with pressure sensor and lighting around it

LumiSafe is a comprehensive night lighting system that integrates several lighting components with motion sensors. On the wall, there is a controllable wall light that allows patients to turn on the lights at night if they need. On walls near both sides of the bed, passive infrared (PIR) motion sensors will be installed. PIR is not visible and can automatically detect the body in dark environments. When a patient leaves the bed, the light under the bed and anti-slip mat is activated and caregivers are immediately notified.

When motion sensor detects that the patient has left the bed, notifications will be sent to caregivers and care partners not only to inform them that they have left the bed but also the duration that patients are away. Anti-slip mat is completely flat and sticks to the floor to prevent trip and fall, and the lighting turns on due to the PIR motion sensor. In addition, LED lighting along the bed handrail is be activated based on the patients' sleep pattern.

Activation of lighting based on sleep pattern:

Non-wearable sleep monitor sensor
Apple sleep monitor sensor to be underneath the patient's pillow or on the side of the bed to monitor the patient's circadian rhythm.

Apps and wearable devices
Monitoring sleep patterns and for activating lights. Notifications that patients are active or asleep are sent to the caregivers' apps.

Actigraphy graph (sleep pattern graph)
Obtained from sensors that track circadian rhythm. During awake periods (yellow circles), LED lights on the rails and caregivers and nurses are notified.

Motion activated sensors:

Passive Infrared (PIR) motion sensor
PIR is not visible and automatically detects the human body in dark environments. When a patient leaves the bed, the light under the bed and anti-slip mat is activated and caregivers are immediately notified.

Motion activated light under the bed
Typical sensor range: 4m (13.1feet),100°. 3000K warm light.

Notifications sent to caregivers
Caregivers are notified not only that the patients left the bed but also the duration that patients are away.

Anti-slip mat with pressure sensor and edge lighting
Completely flat and sticks to the floor to prevent trip and fall and the lighting turns on as the patient tries to leave the bed. It is made from memory form to prevent patients from severe injuries when they fall. It also has pressure sensor so when the patients step on it, the sensor notifies the caregivers and nurses.are away.
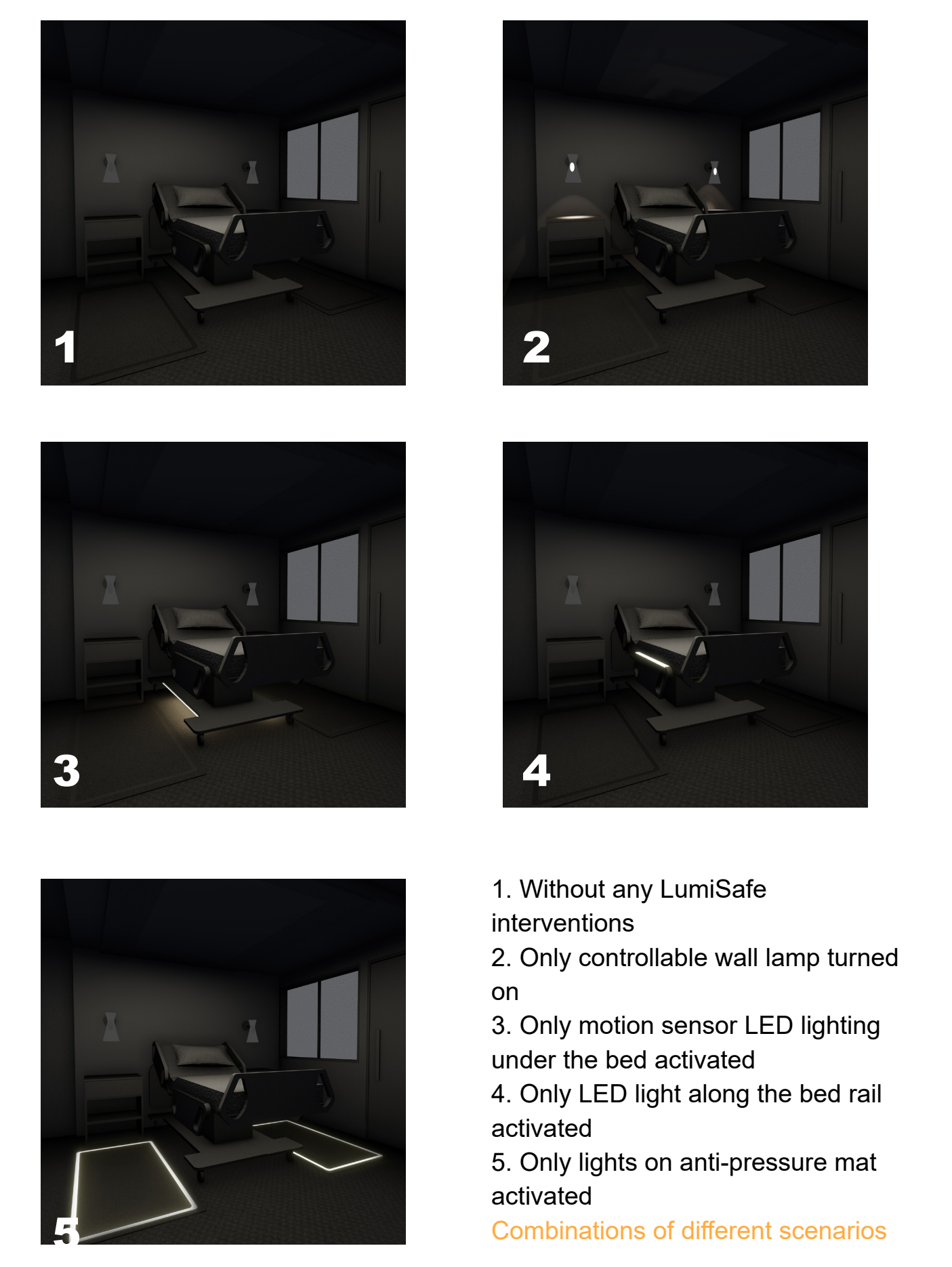

VII Evaluation and Testing

Detailing workplan :

2020 December — Prototyping
Design in in-patient settings and Research

2021 February — Testing and Evaluation
Stability of the sensors, sit-to-stand test, record of falls and slips, and surveys

2021 March — Revision
Analyzing data from the testing and make revisions in design

2021 April — Implementation
Final product ready to be implemented in a hospital for MCI in-patient rooms
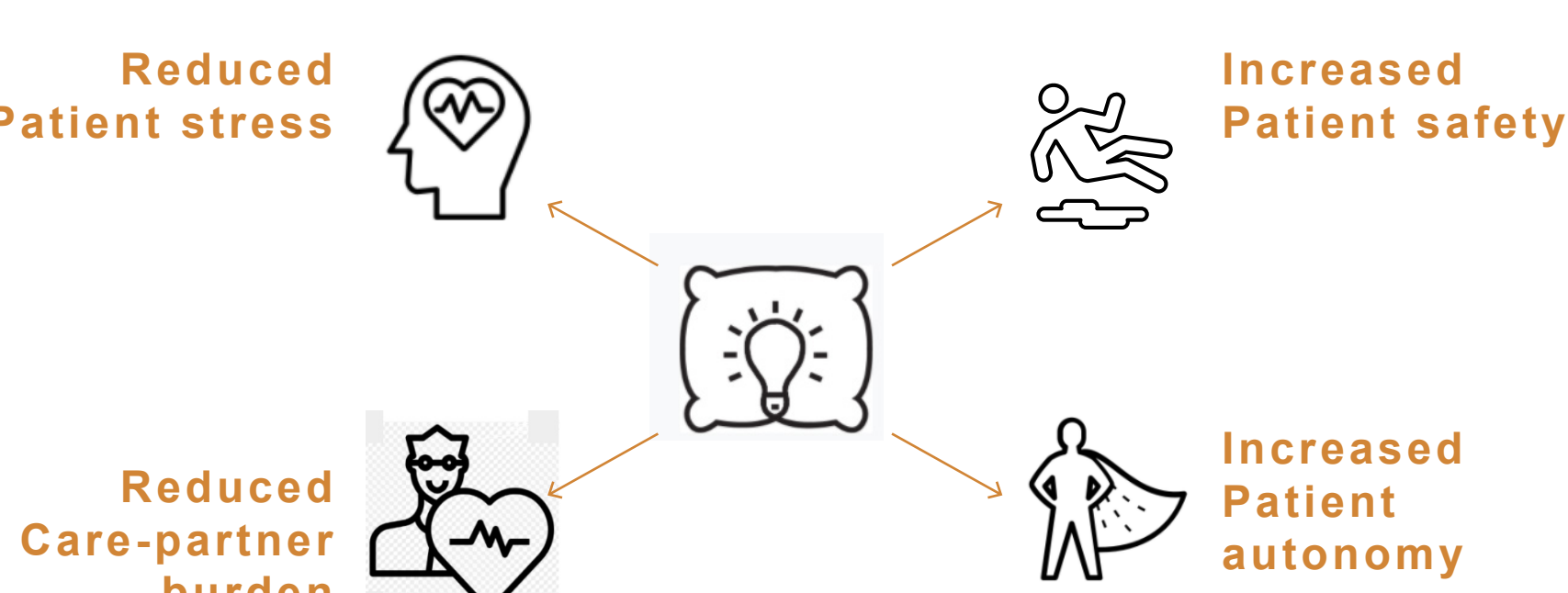For the evaluation, record of falls and slips weekly and surveys conducted

Methods:

1. Number of reported falls and slips every week
Reported by the sensors

2.Standardized sit-to-stand (STS) test in-patient setting (Figueiro et al., 2008)
Participants are asked to sit on the bed with their feet on two force plates
Sway velocity shows how stable people are during the STS task
Affected by the visual information presented by different scenarios
Three STS trials under every scenario

3. Surveys asking how the caregivers and patients feel about LumiSafe.
Conducted during the testing/evaluation and after implementation
5-point scale; 1 strongly disagree, 5 strongly agree
e.g.) I like the motion sensor feature on the anti-slip mats' lighting

Force plates

5 different scenarios for testing

1. Without any LumiSafe interventions
2. Only controllable wall lamp turned on
3. Only motion sensor LED lighting under the bed activated
4. Only LED light along the bed rail activated
5. Only lights on anti-pressure mat activated
Combinations of different scenarios

VIII Conclusions

Outcomes:
- Reduced Patient stress
- Increased Patient safety
- Reduced Care-partner burden
- Increased Patient autonomy

Future Goals:
For the future, LumiSafe wishes to use the results from the evaluation and testing phase to further enhance the design prototype. Using the information, we gain from the surveys and testing combination of different lighting scenarios we will be able to make the design as cost effective as possible. Secondly after the implementation of the prototype within the in-patient setting, the sensors may be able to collect data on not only the sleeping patterns, but also time the patient takes to return to bed and keep the lights switched on for that duration and eventually dim the lights after the patient is in a sleeping position. Through this feedback mechanism system, we will be able to provide more autonomy to the patients.

IX References

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