

# A new phototherapy system for Neonatal Jaundice

## Technology Development with User-centric & Universal Design

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This project is to create a phototherapy care system for jaundice babies, using LED and Fabric optics together with fiber optic sensor technology. The new design phototherapy system can not only provide a humanized service for both babies and nurses but also cut down medical care cost and release the pressure on limited medical resources.

### 1. Background

Jaundice is very common among newborns. It is caused by accumulation of unconjugated bilirubin in the blood condition and requires proper medical attention. If the serum bilirubin level rises excessively, unconjugated bilirubin becomes neurotoxic and can cause lifelong neurologic sequelae (kernicterus) or even death in infants. While 8% of the infants in the world need to get medical care, phototherapy is the primary treatment for unconjugated hyperbilirubinemia.

### 2. The Aims.

- 1) To provide a user-centric design for both babies and nurses with a highly ergonomic application.
- 2) To solve the problems of optical fabric weaving and provide a manufactural optical fabric blanket design
- 3) To come up with an effective heat dissipation solution for a big power LED
- 4) Combining fiber optic sensor technology, photovoltaic technology, digital processing and communication technology together to create a new portable measurement device.
- 5) A good feasibility for mass production.

### 3. Medicine Support

Phototherapy intends to cure neonatal jaundice with light in the blue-green spectrum (wavelengths between 430 and 490nm). There are tradeoffs in choosing the exact light for our treatment. While Bilirubin can absorb light primarily around 450-460 nm, the light with longer wavelengths can penetrate a baby's skin better. Therefore, we need design experiments to find the most effective lights in the 450-490 nm spectrum.

### 4. Existing Problems of Existing Phototherapy

Although phototherapy is not rocket science any more and most available phototherapy instruments can meet basic medical needs, it is still extremely difficult to ensure a comfortable experience for a neonate. It has been sadly revealed that, for newborn babies, phototherapy means suffering with improper temperature and humidity condition, annoying eyeshade, and loneliness when lying on uncomfortable mattress, etc. While these miserable conditions may reduce the babies into crying, struggling, skin irritation and rashes, there is high risk of throwing helpless mothers into puerperal depression.

### 5. User-Centered Design and Ergonomics in New Phototherapy System

There is real need to design an innovative system given the mounting problems in the available instruments. With light blanket, LED units, temperature and humidity monitor, and transcutaneous bilirubinometer, our system is designed to deal with the problems.

Made of side-glowing optic fabrics and reflective clothing materials, the light blanket part holds balance among form, function and manufacture. Firstly, it is convenient and comfortable for babies to wear and take off. Secondly, it is easy to produce which reduces difficulty in the weaving process. Thirdly, it is suitable for cleaning and can be easily maintained. When designing the light blanket, I am also developing a new kind of side-glowing optic fabrics, which is formed in long sheet form with parallel vein structures.

LED units form the core part of functionality. To ensure the blue conventional LED make an ideal illumination ( $450\text{nm} < \lambda < 500\text{nm}$ ), I make the following developments to ensure the security and lifetime of the heat dissipation parts and to reduce optical loss of the joint components between LED and fabric optics with a better design. Based on my previous prototypes and experiments, to combine multiple LEDs in one bulb and to use screw-type sheet copper substrates can be possible solutions. These should be tested together with an assembled blanket.

Temperature and humidity monitor is for application of the fiber optic sensor technology. Working as an accessory on light blanket, it can grasp a detailed profile well in real time and keep the system updated for users.

Transcutaneous bilirubinometer is a joint application of photovoltaic technology, digital processing and communication technology. The design of transcutaneous bilirubinometer will be focus on inclusiveness - easy to be understood and used by all users. It can examine jaundice level easily and then decide phototherapy duration time without professional hemodiagnosis.

## **6. Implementation**

User-centric industrial design

15/01 - 29/02/2016

Define design goals. Analyse user requirements and manufacture limitations, including ethnographic data of neonatal, ergonomics factors in contexts of use, security factors, material and production technology.

01/03 - 27/05/2016

Concepts design. Translate research insights into concepts (with over 40 sketches) Create visual and tangible prototypes.

30/05 - 10/06/2016

Meet with supervisors (Karl-Axel.Andersson, Per Liljeqvist) at Lund University for design appraisal and do participatory design with user groups.

13/06 - 29/07/2016

Refine design concepts.

Weaving process design

15/08 - 12/09/2016

Sourcing Manufacture for optical fabric weaving. Develop weaving process

LED illuminant engineering design and test

15/09 - 14/10/2016

Medicine experiment (cooperation with medicine PhD researchers) Use imitation skin fabric (filter) and bilirubin (receptor) to detect the best illuminant solution (intensity+spectrum).

17/10 - 23/12/2016

LED heat dissipation and optical fiber coupler design

09/01 - 24/02/2017

Material selection and CAD engineering

27/02 - 31/03/2017

LED lamps assessment.

Control Hardware Design

03/04 - 25/08/2017

Assembling Modularization and Circuit Design for Transcutaneous Bilirubinometer and Monitor (Cooperation with Ruolin Wang, PhD, Electronic Engineering researcher)

Phototherapy system test and assessment

04/09 - 09/10/2017 Make prototypes of phototherapy system

12/09 - 01/12/2017 System test and assessment.

## **7. The Innovation Value**

The phototherapy system is product with a user-centric design. Meanwhile, it can be massively produced to provide low cost, comfortable and effective treatments to babies with jaundice.

- 1) 1 Inclusiveness. The optical fabric blanket is adjustable for all neonates in the world. The portable design can suit various usage circumstances. The understandable functions can be easily operated by users.
- 2) 2 High medical efficiency. The blanket can provide a neonate with a 360° phototherapy while covering all skin areas.
- 3) 3 Security & Humanization. The intensity and time length of phototherapy can be easily adjusted with smart measurement. Users can control phototherapy conditions in real time to avoid less or over phototherapy. The system is designed to protect a neonate's eyes from phototherapy.
- 4) 4 Economic. It will save medical resources and cut down medical cost.
- 5) 5 Sustainable. The designed system can be easily maintained and recycled.