Project Details	
Project Code	MRCNMH25Br Chakkarapani
Title	Contactless vital signs and movement monitoring and brain development in extremely premature infants- a translational study
Research Theme	Neuroscience & Mental Health
Summary	Currently used wired contact-based sensor system for vital sign monitoring in extremely premature babies, born before 28 weeks of pregnancy, could damage their skin and impede skin-skin contact with their parents, affecting parent-infant bonding. Further, babies' early movement patterns could help us understand how their immature brains are developing. This project will validate a contactless system using mmWave radar technology to measure heart rate, breathing rate, and movements in preterm animals, and in preterm babies during intensive care and skin-skin contact. We will characterise the movement patterns and explore their associations with brain development.
Description	**Background** Approximately 2 to 5 out of every 1,000 pregnant women deliver their babies before 28 weeks of gestation 1. These extremely premature babies have thin, fragile skin and immature organs, including the brain, and require intensive care. Currently, the standard for intensive care vital sign monitoring involves wired contact-based sensors, which can damage the delicate skin and impede kangaroo care (skin-to-skin contact between parent and infant). Kangaroo care is essential for improving the baby's physical health, aiding breastfeeding, and promoting parent-infant bonding, all of which enhance the development of the baby's immature brain. 2 Extremely premature babies also exhibit a variety of movements and twitches, which have been shown by M Ashby's group to activate the somatosensory cortex in animals. 3 There are ongoing studies on contact-based wireless vital sign monitoring 4 and camera-based contactless vital sign monitoring, which requires a bright light. 5 However, the neonatal intensive care environment mandates light and dark cycles to promote the development of the babies, making continuous camera-based monitoring impractical. Additionally, capturing the movements of extreme preterm babies is crucial to understanding their role in brain development. Researchers have used a contactless system using millimeter-wave frequency-modulated continuous wave (FMCW) radars to measure heart rate, breathing rate, and movements in adults. 6 **Key Research Question:** How does contactless FMCW radar technology-based heart rate and breathing rate monitoring compare with standard wired contact-based sensor monitoring in preterm rodents and extreme preterm infants undergoing intensive and kangaroo care? Additionally, how do the movements captured using contactless FMCW radar relate to brain activity on the somatosensory cortex? **Specific Objectives:** 1. Evaluate the FMCW Radar-Based Contactless System: • Measure heart rate, breathing rate, and movement. • Establish the safety of FMCW radar on the skin in rodents used for brain development research.

2. Obtain Feedback from Parents and Healthcare Workers:
• Gather views and feedback regarding the use of contactless FMCW radar in the neonatal intensive care environment.
3. Compare Monitoring Systems:
• Compare the FMCW radar-based contactless system with the currently used wired contact sensor-based monitoring in measuring heart rate and breathing rate in extreme preterm infants undergoing intensive care and kangaroo care.
4. Characterize Movement Patterns:
• Characterise the movement patterns of extreme preterm infants during the first week after birth.
5. Examine the Association with Brain Activity:
• Investigate the relationship between early movement patterns and EEG activity on the somatosensory cortex.

Methodology

The student will collaborate with the supervisors to optimise the existing design and signal processing of the FMCW radar contactless monitoring system, while also obtaining ethics approval for the clinical aspect of the study. The student will gather feedback from parents and staff regarding the project and the design of the contactless system, using this input to refine the study design.

The student will recruit 30 extremely preterm infants (born before 28 weeks of gestation) of both sexes and various ethnicities. We will simultaneously record heart rate and breathing rate data using both the contactless FMCW system and the routinely used wired contact-sensor-based system on infants receiving intensive care for up to 4 days, as well as during kangaroo care with their parents. Additionally, we will measure multichannel EEG along with behavioural data on whether the infant is awake or asleep, under the supervision of Dr. Poorun and Prof. Goodfellow.

In the first 4 days after birth, extremely preterm infants are at high risk for developing intraventricular haemorrhage. We will use movement and heart rate characteristics to explore the association with regional brain EEG and the occurrence of intraventricular haemorrhages. We have existing partnerships with industry leaders (e.g., Masimo and Texas Instruments), which we will leverage to translate the contactless system into clinical practice.

Areas for Student Ownership:

• Optimising the mmWave radar-based contactless system design
• They will be able to take ownership of the movement and EEG analysis and develop their own research direction.

References

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4. Scholten, A.w.J et al. Pediatr Pulmonol. 2023;58(12):3574-3581.
5. Svoboda, L et al. Front Pediatr 2022:10:897961
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