# Chapter 2
# Wearable Technologies for Neonatal Monitoring

**Q. Liu**
*The Chinese University of Hong Kong, Hong Kong*

**C. C. Y. Poon**
*The Chinese University of Hong Kong, Hong Kong*

**Y. T. Zhang**
*The Chinese University of Hong Kong, Hong Kong, and Key Laboratory for Health Informatics of Chinese Academy of Sciences, China*

## ABSTRACT

*Measuring physiological parameters including heart rate (HR), breathing rate (BR), blood oxygen saturation ($SaO_2$), temperature, pulse transit time (PTT), and blood pressure (BP) in neonates can indicate incidence of adverse events during infancy and also help towards building a complete personal health record (PHR) since birth. Emerging wearable technologies, which provide non-invasive and continuous monitoring of these vital signs, can therefore be used to increase the survival rate of neonates and serve as acquisition tools for developing PHR. This chapter introduces five key technologies for the design of wearable devices: Miniaturisation, Intelligence, Networking, Digitalisation, and Standardisation. Some existing prototypes of wearable medical systems will be described at the end of the chapter.*

## INTRODUCTION

Healthcare system is now undergoing a fundamental transformation: from the conventional hospital-centred system to an individual-centred one. This transformation aims to lower costs while enhance the quality and efficiency of healthcare. Based on a health model recently proposed by the U.S. National Institute of Health (NIH, 2009), a 6-P's paradigm named p-Health has been introduced to describe the major trends in this transformation, which is a healthcare model encompassing preventive, personalised, predictive, pre-emptive, participative and pervasive elements (Zhang & Poon, 2010). Under the p-Health model, it is recommended that health information which span multiple spatial scales of the human body, down from the genetic and

DOI: 10.4018/978-1-4666-0975-4.ch002

molecular level and up to body system level, be collected as early as possible, starting at birth or even before birth. A complete set of health information is anticipated to help solving health issues that arise at different levels, from personal to global. Therefore, collecting personalised health information from neonates is essential for the future development.

Benefited from the emerging wearable technologies, physiological vital signs, such as HR, BP, can be acquired during daily activities. These parameters are also closely related to adverse events in neonates, such as sudden infant death syndrome (SIDS), bradycardia and sleep apnea. Thus, wearable technologies are also helpful to increase survival rate of neonates by providing them unobtrusive and continuous monitoring of the vital signs, meanwhile improving their comfort.

Wearable medical devices should entail the following properties: miniaturised, intelligent, networked, digitalised and standardised (MINDS). Miniaturisation of wearable medical devices can be achieved by improving sensor design, either integrating microelectronics and electrical sensors into body-worn devices, or using intelligent biomedical clothing with embedded sensing capability. On the other hand, design and implementation of application specific integrated circuits (ASICs) to perform various functions, including processing physiological signals, can also reduce the size and power consumption of wearable devices. Intelligence can be in part demonstrated by context awareness and resistance to artefacts. This can be realized by developing physiological models and sensor design. Networking is crucial for information integration and decision making based on real-time risk assessment, demands effective and reliable data transmission methods. Digitalisation requires new sampling and compression theories to handle huge volume of datasets from long-term signal monitoring. Standardisation of wearable medical devices is needed in various aspects, including the standardisation of signals to be collected by these devices, formats of how these signals are to be stored, communication protocols to be established between these devices as well as standard validation of these devices (Poon, Gu, & Zhang, 2010; Teng, Zhang, Poon, & Bonato, 2008; Poon & Zhang, 2008; Zhang, Yan, & Poon, 2007).

Wearable technologies and devices are general and not limited to neonatal monitoring. Up-to-date, more efforts have been devoted to developing wearable technologies and devices for general population, i.e., adults and elders. In order to provide a wider perspective, we will review the state-of-art technologies for designing general wearable devices in this chapter, which will serve as background for further development of wearable technologies specific for neonates. We organize this chapter as follows: the first five sections discuss technologies corresponding to each of the aforementioned properties of wearable medical devices: MINDS, while the last section introduces some representative prototypes of wearable medical system.

## MAIN FOCUS OF THE CHAPTER

### 1. Miniaturisation of Wearable Medical Devices

Miniaturisation of wearable medical devices can be realized by developing new measurement principles, incorporating advanced sensor design and adopting ASIC technologies. Smart sensor design integrates microelectronics and electrical sensors into body-worn devices and adds sensing capability into clothing. On the other hand, the use of ASICs can minimize not only the size of the wearable medical devices, but also reduce their power consumption.