Abstract  Health care providers and governments are under pressure to maintain and improve the quality of care to an increasing volume of critical care patients at either end of the life cycle, namely premature and ill term babies together with the elderly. The provision of a service of critical care utilizing real time service-oriented architectures has the potential to enable clinicians to be supported in the care of a greater number patients that are, perhaps more importantly, located elsewhere to their intensive care units. This paper presents a review of recent research in the application of computing and IT to support the service of critical care and determines the trends and challenges for the application of real time service-oriented architectures within the domain. It then presents some case study–based research on the design of a service-oriented architecture-based approach to support two aspects of critical care namely elderly care and neonatal intensive care to provide further context to trends and opportunities.

Keywords  Realtime service-oriented architecture · Service of care · Patient journey · Neonatal intensive care units · Home care

1 Introduction  
Intensive care units (ICUs) worldwide offer support for patients in need of critical care. They boast a range of state-of-the-art medical monitoring devices to monitor a patient’s physiological parameters such as blood oxygen, blood pressure, and heart rate. Other devices such as ventilators offer mechanical life support [14]. When considering the population distribution among those requiring critical care within intensive care units, the greatest concentrations occur, not surprisingly at either ends of the life cycle, namely for the ill term and premature babies, and for the elderly. In the case of the ill term and premature babies, there is an initial need for complex real time cross correlation of medical data. As the baby ages, usually the complexity diminishes as the baby’s organs develop and they grow larger and stronger. In the case of the elderly, the reverse usually holds. Presentation with one condition will often be complicated with the development of further conditions leading to a culmination of complex real time cross correlation of medical diagnosis. Given the general opposing journeys through critical care, it is common to require remote on-going support for babies discharged from a neonatal ICU (NICU) potentially through remote home-based sensors feeding real time event-based systems. This is in addition to the remote support required from birth until the baby is transported to a NICU. Whereas with the elderly, the approach is as much as possible to delay or remove the path to ICU-based critical care, through home-based real time event-based systems.

According to Da Silveira and Guelfi [4], the benefits of utilizing computing and information technology to support health care and medicine are:

1) For the consumer: Higher quality care; Reduction in medical errors; Fewer duplicate treatments and tests;
While there are many initiatives to utilize computing and information technology to provide telemedicine, telehealth and electronic medical record solutions to improve remote care, these approaches do not address the issue of critical care. Within critical care, patients are attached to various physiological sensors and mechanical life support devices, all of which provide readings ranging between one a second for numeric data and upwards of 500 readings a second for waveform data. This continuous data stream format is not catered for within Health Level 7 (HL7), for example.

Further, recent clinical research has found that physiological parameters that are seemingly unrelated to a given diagnosis have been found to show certain behavior changes prior to diagnosis, demonstrating the potential for approaches to not only standardize transmission of this form of data, but to create systems that process this data in real time once it is received from distributed sources.

The domains of neonatal intensive care and critical care for the elderly are well suited to the service-oriented architecture (SOA) model. When an ill term or premature baby is born in a hospital without Neonatal support, contact is made with the entity coordinating Neonatal transport who assess whether transport is required. If transport to an NICU is required, support for the baby’s care is provided via telephone exchange until a specialized team arrives to transport the baby to a NICU. Once the child has developed and grown large enough and strong enough to be discharged from NICU and/or special care, the baby is then supported by NICU follow-up.

For support of the elderly, improved approaches are required to enable community nurses and clinicians to have monitoring of home-based outpatients while providing additional support to both professional and family home care providers.

When considering the model of care in both cases, the clinicians are remote to the patient on call as the need arises to provide a service of critical care.

Within this research, we define the service of care as the application of service-oriented architectures to support the provision of health care. We further define the service of critical care as a subset of the service of care where sensors and other devices are providing information about a patient at a non trivial frequency.

To date, as this paper will demonstrate, while there has been health informatics research activity in the area of critical care, there has been little research on the application of real time service-oriented architectures that are generalizable to broadly support the service of critical care.

As a result, there is great potential to utilize the principles of real time service-oriented architectures to provide next generation solutions to support critical care locally and remotely.

This paper presents a review of recent research in the application of computing and IT to support the collection/transmission/real time event processing and storage of physiological data generated within intensive care units, transport vehicles and the home. The need for access control, security, privacy and trust is also discussed together with a review of the impact of patient and clinician mobility. This information is used to assess the trends and challenges for the application of real time service-oriented architectures within the domain. The paper is structured as follows. First, Sect. 2 presents the patient characteristics and increasing demand trends for both scenarios of critical care as defined within the scope of this paper. Section 3 describes the characteristics of the data generated by the medical equipment. Section 4 considers current issues and challenges in the area of data collection. Section 5 presents the current challenge of data transmission and the potential for a service-oriented approach to address that challenge. Section 6 presents opportunities for real time temporal abstraction-based event processing to support clinicians in their service of critical care. Once the data is collected, the issues for data storage to support ongoing clinical management and research are introduced in Section 7. Section 8 discusses the need for access control, security, privacy and trust. Section 9 introduces patient and clinician location and highlights that they are not always co-located in the critical care unit. We then present in Sects. 10 and 11 some case study–based research on the design of a service-oriented architecture-based approach to support two aspects of critical care namely neonatal intensive care transfer and elderly care transfer to provide further context to trends and opportunities. The paper concludes in Sect. 12 highlighting how the trends and challenges have motivated our research in the area of a generalizable real time service-oriented architecture to support the service of critical care.

2 Patient characteristics

Premature birth, also known as Preterm birth, defined as birth before 37 weeks gestational age, has been identified as one of the most important perinatal health problems in industrialized nations [13]. A related term is very preterm birth, which is defined as a gestational age less than 32 weeks. Preterm birth accounts for 75–85% of all perinatal mortality