Clinical information systems in the intensive care unit

Christopher Mason
Tim Leong

Abstract

Clinical information systems (CIS) are used to collect, process, and present data for use in patient care. Common applications in the intensive care unit are charting, computerized physician order entry (CPOE), clinician decision support (CDS), and health information exchange. Benefits of CIS include increased efficiency, increased quality of care, and improved data availability, structure, and security. Possible risks include certain errors, reduced speed and efficiency, and loss of data security. Implementation of a CIS should follow a project management approach with a well-defined scope, involvement of clinicians, workflow analysis, and understanding of the limited life span of technical systems.

Keywords Clinical information systems; electronic medical records; health informatics; intensive care

Royal College of Anaesthetists CPD Matrix: 1G01

Learning objectives

After reading this article, you should be able to:

- describe the structure of a clinical information system
- explain the benefits of a clinical information system
- explain the disadvantages of a clinical information system
- categorize the processes involved in implementing a clinical information system in terms of project management
- identify risks of an unsuccessful implementation of a clinical information system

Intensive care medicine is a technology-dependent speciality that generates large amounts of data which require collection, processing, presentation, and interpretation to be useful in the care of patients. Health informatics is the field that concerns itself with the collection, analysis and movement of this data to support healthcare. In intensive care, a clinical information system (CIS) is the collection of technologies that perform these tasks. With increasing technological sophistication, clinical information systems have become more capable. Additionally, users' experience and expectations of technology have developed with the proliferation of smartphones, tablets and modern operating systems. An understanding of the features of a CIS and how users may interact with the system while delivering care is important as these systems become more integrated into clinical practice.

What is a clinical information system

A clinical information system is any computer system that collects data from patients, clinicians, or other systems and presents information for use in clinical practice. The simplest forms of CIS emulate paper charts: the clinicians manually input data and the system stores and present these data. More complex systems may process data into more meaningful information (e.g. alerts and predictions) and provide support for clinical decisions. Figure 1 shows information flows between the CIS, the users and other systems.

Inputs

Inputs are data sources for the CIS. They may be manual or automated. Manual input is performed by clinicians and may include numerical data (e.g. vital signs), structured text (e.g. admission diagnosis, prescribing) or free text (e.g. progress notes). Automated input may come from patient care equipment (e.g. monitors and ventilators) or from other computer systems (e.g. pathology and radiology systems, and electronic medical records). In general, automated systems are preferable as they reduce errors and staff workload at the expense of increased cost and technical challenges.

Processing

Processing of data improves their usefulness to clinicians. Processing may be simple or complex, depending on the capabilities of the CIS. Simple processing includes identifying abnormal values (e.g. vital signs, pathology values) and performing simple calculations (e.g. fluid balance). More complex processing uses rules, algorithms and machine learning to interpret data on behalf of clinicians. Predictive algorithms and severity of illness scores (e.g. APACHE) can be automated using CIS data. As the technology underlying CIS becomes more capable, data processing will be able to provide more support to clinical decision making by integrating disparate data and interpreting data more intelligently. However, these rules and algorithms should be tested rigorously to ensure clinical validity and safety.[1]

Outputs

Output is the movement of data from the CIS. Data may be output for direct use of clinicians, to other computer systems (e.g. electronic medical records), or to external users (e.g. researchers, external clinicians). Outputs may be either 'pulled' (i.e. the user requests data from the system) or 'pushed' (i.e. the system sends data to the user). Pull information may include assessing charts, reading notes, etc. Pushed information may include deterioration alerts, warnings, etc. Note that the presentation of data affects how users will respond (e.g. user interface differences can make data easier to interpret, alert frequency and type will change how users respond).[2]

Christopher Mason ***MBBS*** *is a Senior Registrar at the Alfred Hospital, Melbourne, Australia. No conflicts of interest.*

Tim Leong ***MBBS (Hons) FCICM DDU (Crit Care) and ProfCert HSM*** *is a Consultant Intensivist at the Alfred Hospital, Melbourne, Australia. No conflicts of interest.*

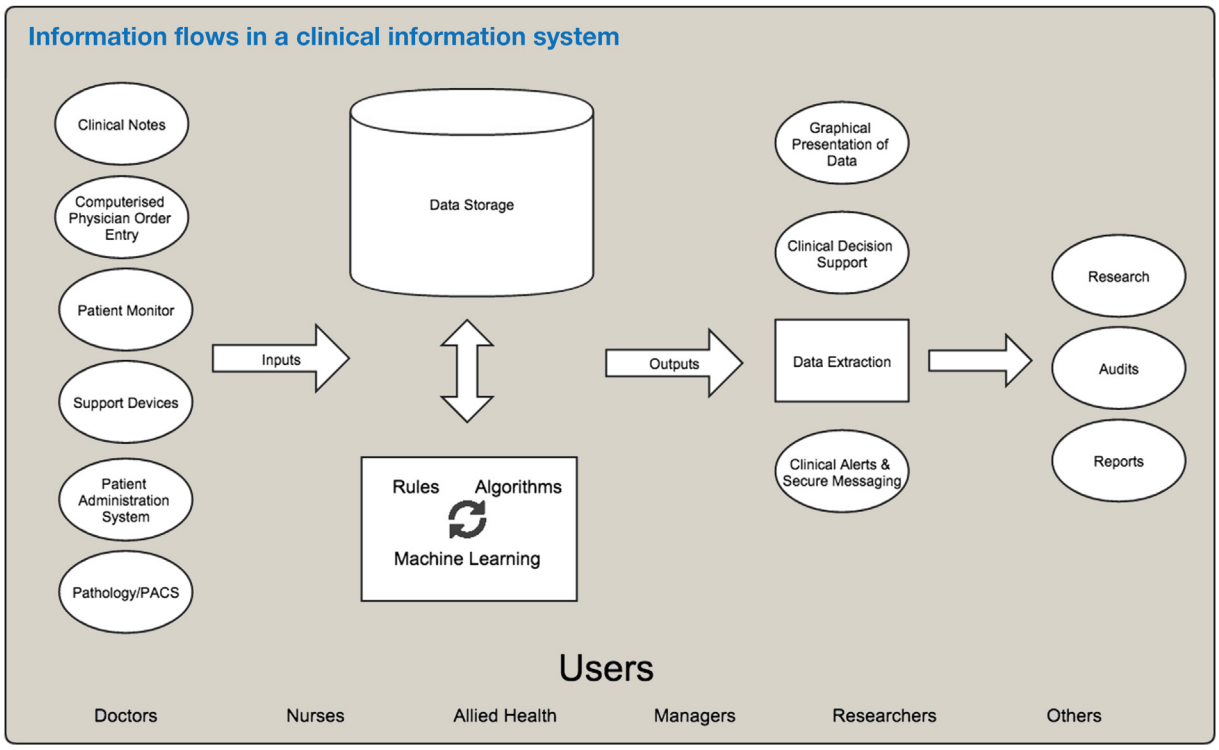

Figure 1

Components of a clinical information system

Hardware

Hardware is the physical manifestation of a computer system. In intensive care, the CIS hardware may include:

- point of care infrastructure: bedside terminals, tablets and smartphones
- servers: computers that store and process data and host various applications
- interfaces between clinical equipment (e.g. monitors and ventilators) and the CIS
- network hardware: including routers, cables and wireless infrastructure that allows networked communication
- peripherals: including printers and scanners.

Software

Software is the set of programs used in a CIS to collect, process and output data and information for use. Software includes:

- **Operating systems**: These provide the platform upon which the CIS is built. Operating systems include low-level instructions for the use of hardware (drivers), as well as the user environment. Common operating systems include Microsoft Windows and a variety of UNIX-based systems. Platform choice is dependent on a variety of factors including cost, hardware compatibility, security needs, and user familiarity.
- **Applications**: Applications form the core experience of the CIS. ICU applications may be part of hospital information system (HIS) suites or they may stand alone. They may be offered by IT vendors, or open-source or they may be created in house for institution specific purposes. Applications are commonly used for a number of indications, including:
  - **Charting**: The collection of patient data and presentation in a meaningful fashion. Data collected may include physiological parameters (e.g. vital signs and neurological observations), interventions and daily plans. Data are then presented in a usable format depending on the structure of the data and the needs of the clinicians.
  - **Computerized physician order entry**:[3] CPOE allows clinicians to make orders (e.g. medications, investigations and referrals) by input into the CIS.
  - **Clinician decision support**:[4] Rules, predictive models and machine learning can be used to process data and use the resulting information to assist with clinical decision making.
  - **Health information exchange**: The process by which data and information is moved within and between organizations. Data mobility may be for the benefit of individual patients (e.g. by providing information about their ICU stay to other providers or institutions), for populations (e.g. by providing information to registries for research purposes) and for organizations (e.g. by providing activity information to governments and insurers).
  - **Secure messaging**: Allows transmission of information such as results, referrals, and requests between clinicians. Secure messaging should prevent data loss and should be traceable within the system.

Benefits of a clinical information system

- **Increased efficiency**: A well-implemented CIS improves efficiency by reducing the time taken to obtain and access data, by presenting data in formats that are more useful,