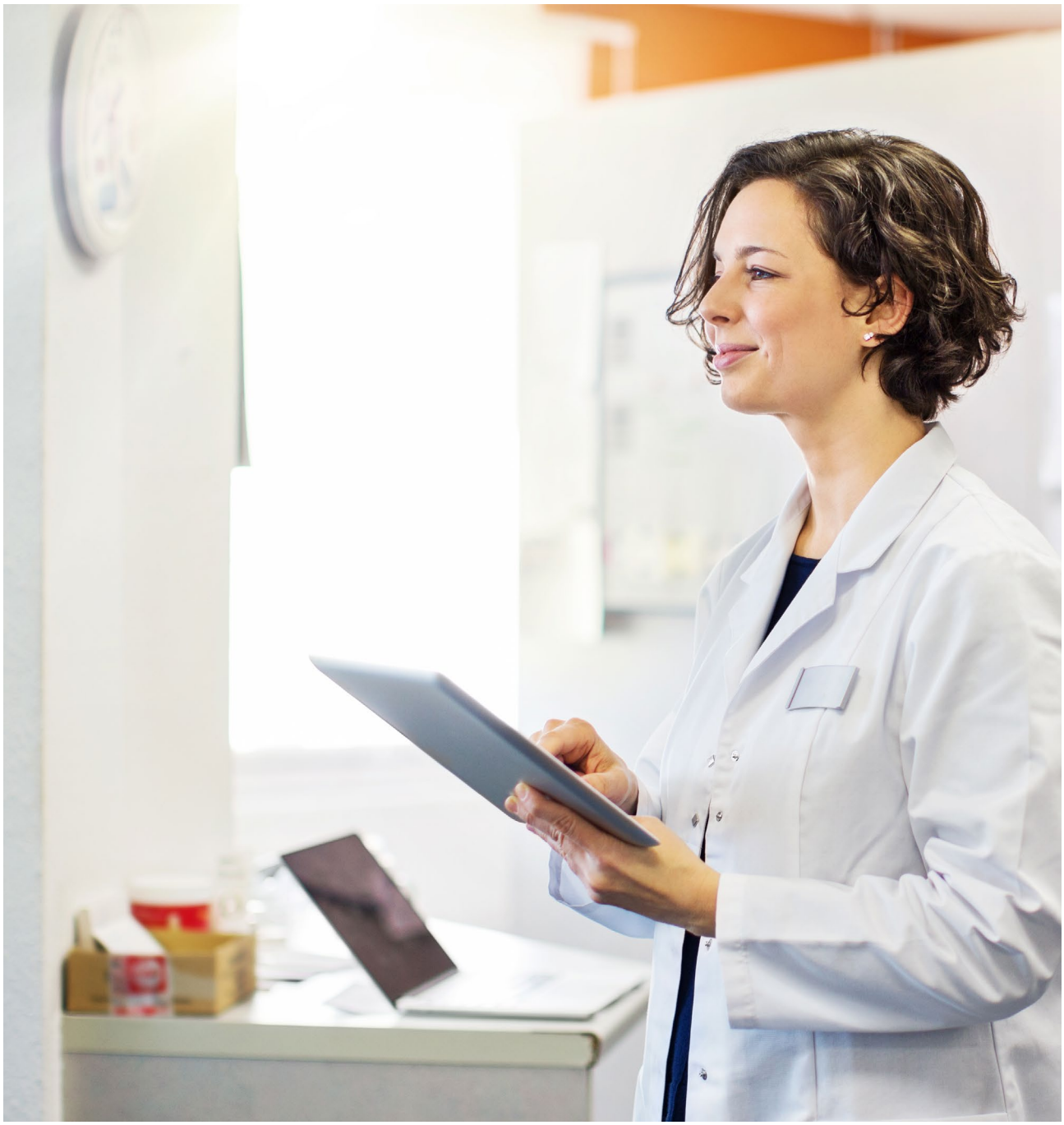
The 3Ds of Clinical Decision Support

Device, Data and Decisions



Orion Health White Paper
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Introduction

There is a transformation underway in healthcare, with the adoption of Clinical Decision Support (CDS). What does this mean for an individual, healthcare organisation and the population? CDS is a health information technology system that is designed to provide clinicians and other health professionals with clinical decision support[1]. CDS has three core components: Device, Data, and Decisions. Data is derived from the electronic device and subsequent clinical decisions are then formulated.

Today, it is recognised that CDS has enormous benefits that optimise every aspect of healthcare (i.e. the individual patient, the acute care setting in a hospital and the health of the national population), but the challenge is (a) to make the CDS implementation easier to attain its full potential and (b) to provide rich CDS solutions embedded with the patient's electronic healthcare record (EHR).

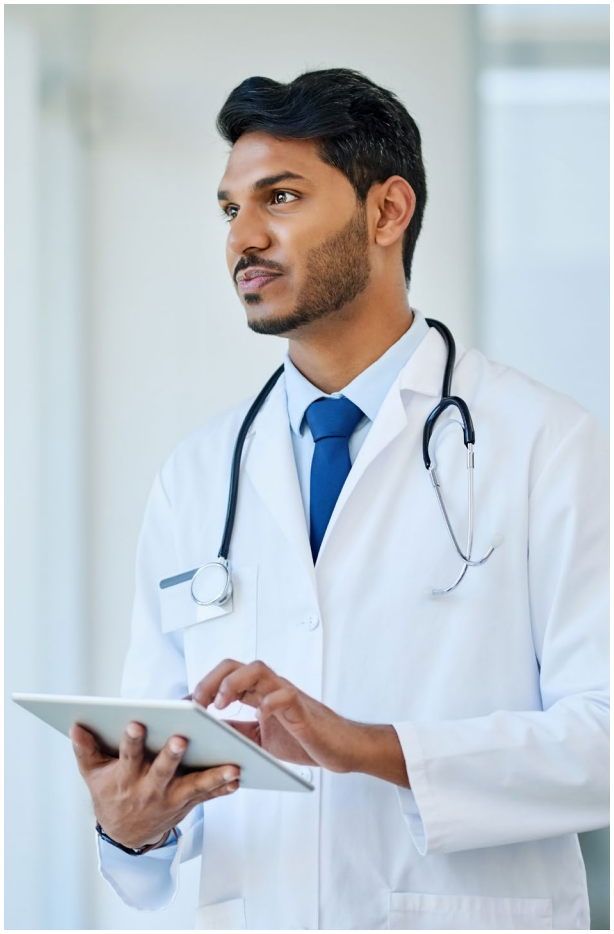
CDS is no longer a 'nice to have' option, globally, healthcare organisations are required to provide appropriate care, reduce medical errors and control healthcare costs. There is an ever growing list of international standards and regulations (such as HIMSS, JCI, MUs and HIPAA) established for improving healthcare outcomes across the healthcare delivery network, which requires clear CDS capabilities.

This paper explores aspects of the CDS system, including, market gaps, drivers and challenges. It will also highlight the importance of Electronic Medical Record (EMR) embedded CDS and the basic CDS functionality required to start making positive change in the healthcare ecosystem.

[1] https://en.wikipedia.org/wiki/Clinical_decision_support_system

Clinical Decision Support Systems (CDSS)

CDSS have proved their efficiency and quality of patient care by providing evidence-based tailored information to clinical professionals at the point-of-care. This enables informed and timely decision-making by clinicians, which in turn improves the timely diagnosis and ongoing care of individual patients. CDSS is a broad term which covers the clinical decisions that support improved clinical outcomes.



CDS has been defined by several organisations

Healthcare Information and Management Systems Society (HIMSS)

CDS is a process for enhancing health-related decisions and actions with pertinent, organised clinical knowledge and patient information to improve health and healthcare delivery. Information recipients can include patients, clinicians and others involved in patient care delivery; information delivered can include general clinical knowledge and guidance, intelligently processed patient data, or a mixture of both; and information delivery formats can be drawn from a rich palette of options that includes data and order entry facilitators, filtered data displays, reference information, alerts, and others[2].

Healthcare Information and Management Systems Society (HIMSS)

CDS provides clinicians, staff, patients or other individuals with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and healthcare. CDS encompasses a variety of tools to enhance decision-making in the clinical workflow. These tools include computerised alerts and reminders to care providers and patients; clinical guidelines; condition-specific order sets; focused patient data reports and summaries; documentation templates; diagnostic support, and contextually relevant reference information[3].

[2] http://www.himss.org/library/clinical-decision-support

[3] https://www.healthit.gov/policy-researchers-implementers/clinical-decision-support-cds

Agency for Health Research and Quality (AHRQ)

CDS provides timely information, usually at the point of care, to help inform decisions about a patient's care. CDS tools and systems help clinical teams by taking over some routine tasks, warning of potential problems, or providing suggestions for the clinical team and patient to consider[4].

A clinical decision support system is a health information technology system that is designed to provide clinicians and other health professionals with clinical decision support. A working definition has been proposed by Robert Hayward of the Centre for Health Evidence.

> Clinical Decision Support systems link health observations with health knowledge to influence health choices by clinicians for improved healthcare.
>
> **Robert Hayward**

CDSS constitute a major topic in artificial intelligence in medicine.

In the early days, CDSS were conceived of, and thought to be used to literally make decisions for the clinician. The clinician would input the information and wait for the CDSS to output the "right" choice and the clinician would simply act on that output. However, the present use of CDSS is to assist the clinician by utilising both, their own knowledge and the CDSS. This can lead to improved analysis of the patient's data, as both sources of knowledge are included. Computerising healthcare is expected to be one of the powerful levers necessary for significant transformation in the quality and cost of delivering healthcare. CDS has an important part to play in this healthcare transformation, by increasing the quality of care and improving health outcomes, avoiding errors and adverse events. In doing so, improving efficiency, cost-benefit, and provider and patient satisfaction.

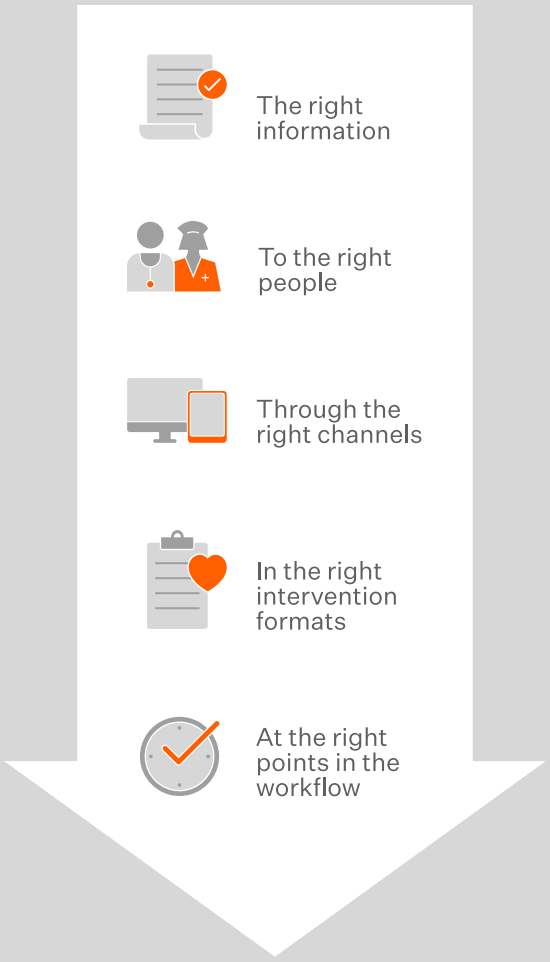
CDS requires computable medical knowledge, person-specific data, and a reasoning or inferencing mechanism that combines knowledge and data to generate and present helpful information to clinicians as care is being delivered. This information must be filtered, organised and presented in a way that supports the current workflow, allowing the user to make an informed decision quickly and take timely action. Health information technologies, designed to improve clinical decision making, are particularly attractive for their ability to address the growing information overload clinicians face, and to provide a platform for integrating evidence-based knowledge into care delivery. The majority of CDS applications do not operate as embedded components of comprehensive EHR systems.

[4] http://www.ahrq.gov/professionals/prevention-chronic care/decision/clinical/index.html

CDS Five Rights

Another critical point is the emphasis of the "CDS Five Rights" concept – which Osheroff helped develop[5]. The idea is that interventions must provide:

- The right information (evidence-based guidance, response to clinical need) to
- The right people (entire care team – including the patient) through
- The right channels (e.g., EHR, mobile device, patient portal) with
- The right intervention formats (e.g., order sets, flow-sheets, dashboards, patient lists) at
- The right points in workflow (for decision making or action).



> If you want to improve care delivery and processes, to make all these good things happen in healthcare, a best practice for approaching that is the CDS Five Rights.
>
> **Jerome Osheroff,**
> MD, a former CIO[5]

Clinical decision support, properly deployed, has a huge role to play in driving care improvement[5]. He highlights clinical decision support as a central requirement for meaningful use and for improving care.

> Organisations often struggle to deploy CDS successfully; nonetheless, there's convincing evidence when executed well, significant performance benefits can be realised.
>
> **Jerome Osheroff,**
> MD, a former CIO[5]

CDS provides timely information, usually at the point of care, to help inform decisions about a patient's care. CDS tools and systems help clinical teams by taking over some routine tasks, warning of potential problems, or providing suggestions for the clinical team and patient to consider.

[5] http://www.healthcareitnews.com/news/clinical-decision-support-its-about-more-technology

Examples of CDS

CDS tools include order sets created for particular conditions or types of patients, recommendations, and databases that can provide information relevant to particular patients, reminders for preventive care, and alerts about potentially dangerous situations. CDS can potentially lower costs, improve efficiency, and reduce patient inconvenience. In fact, CDS can sometimes address all three of these areas at the same time – for example, by alerting clinicians about possible duplicate tests a patient may be about to receive.

CDS has three core components – Device, Data and Decisions

With the 'Internet of Things' growing rapidly, it is estimated that the 'Internet of Things (IoT)' healthcare market is poised to hit $117 billion USD by 2020[6]. Today, internet-connected devices in healthcare are emerging as useful monitoring tools. IoT devices are available to users as their personal devices, such as a watch or band, or consumer devices such as a pulse oximeter, blood pressure monitor (includes all vital signs monitors) and hospital grade devices.

Clinical knowledge is also growing at a rapid pace. It is estimated that clinical knowledge currently doubles every 18 months and on average, human knowledge is doubling every 13 months[7]. Now, it is beyond the human's capability to know all the clinical information in order to provide timely and appropriate patient care. Moreover, the enormous amount of data being generated from each source, which in the near future will be linked to the EMR, will enable informed clinical investigations to be processed using standard machine learning process for precise interventions and individualised care.

There are several drivers influencing healthcare IT. Major themes include the critical nature of security and the impact of breaches in healthcare, the availability of 3rd Platform technology and innovation accelerators to enable digital transformation, access to mobile technology, the movement

toward personalised medicine, and the need for new data sources and advanced analytics including cognitive computing.

IDC Health Insights show that digital transformation is beyond technology and impacts data, people, processes, and strategy. The predictions cover organisational changes, staffing requirements, and consumer-facing initiatives[8].

It is predicted by 2018 that 30% of worldwide healthcare systems will have real-time cognitive analysis to provide personalised care leveraging a patient's clinical data[8] and big data analytics, and the IoT are expected to save $450 billion USD from 2015 to 20209. CDSS incorporate a wide range of intelligent tools that assist healthcare professionals in providing timely and precise care to patients. Some of the basic CDS tools are clinical documentation

(forms), including risk scores, assessments, pathways, clinical workflows, Computerised Physician Order Entry (CPOE), alerts, notifications, error checks and interactions including, drug-drug, drug-dose, drug-food, etc.

[6] http://www.forbes.com/sites/tjmccue/2015/04/22/117-billion-market-for-internet-of-things-in-healthcare-by-2020/#2265a2132471

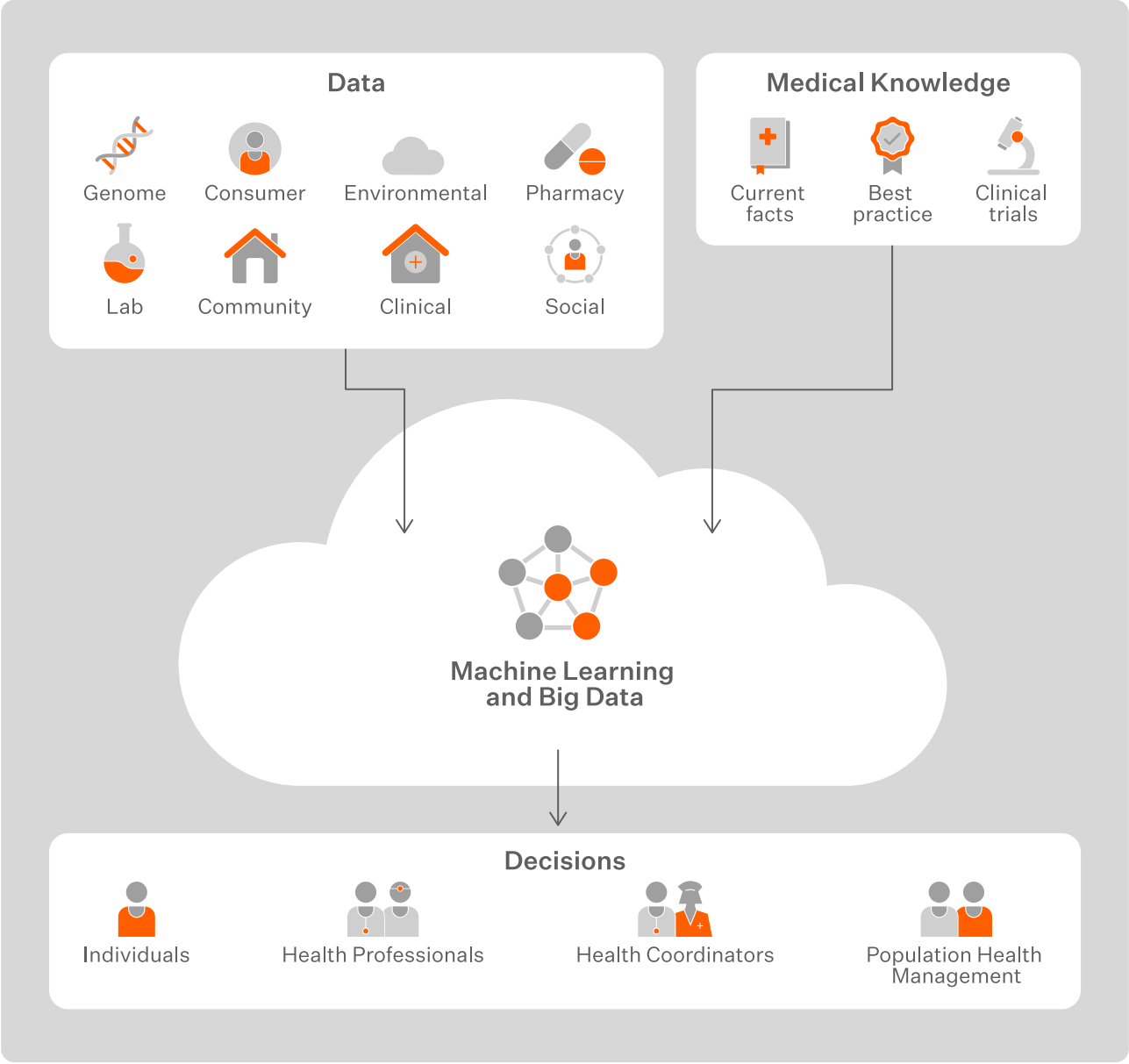
[7] http://www.industrytap.com/knowledge-doubling-every-12-months-soon-to-be-every-12-hours/3950

[8] https://www.idc.com/research/viewtoc.jsp?containerId=259908

[9] The Value of Big Data and the Internet of Things to the UK Economy, http://www.sas.com/en_gb/offers/16q1/cebr-big-data-internet-of-things.html

Today, research shows, in order to attain the full potential of a CDSS, the system should also have an element of social, cultural and contextual factors, together with clinicians' perceptions and understandings of information technologies. Moreover, the CDSS should be broad in capturing the data and distinct in its suggestions and decisions – Machine Learning is key to this enablement[10].

> Machine learning is becoming increasingly important in the delivery of software that enables the practice of precision medicine or personalised healthcare.
>
> **Ian McCrae,**
> CEO, Orion Health[11]



[10] https://www.healthit.gov/policy-researchers-implementers/clinical-decision-support-cds

[11] https://www.pulseitmagazine.com.au/news/movers-and-shakers/3363-orion-health-to-build-auckland-analytics-team-for-big-data-push

Market/Research Analysis and Gaps

The CDSS worth is estimated to be $558 million USD by 2018[12]. The global CDSS market crossed $350 million USD in 2013 and continues to grow.

The market is segmented based on products, models, applications, delivery modes, components, and provider entity capacity. Based on products, the CDSS market is further segmented into integrated and standalone CDSS solutions. Of all the integrated solutions (EHR-CDSS, EHR-CDSS-CPOE, and CDSS-CPOE), EHR-CDSS-CPOE will be the fastest-growing market in the next five years. Factors accelerating the growth of this market are the presence of government initiatives to promote clinical IT solutions such as EHR, CDSS, and CPOE; growing pressure to curtail healthcare costs; and rising demand for quality care. Integrated CDSS solutions also help in reducing the incidences of medication errors and facilitate the easier integration of clinical data repositories with workflow systems.

Based on applications, the CDSS market is segmented into drug allergy alerts, drug reminders, drug-drug interactions, clinical guidelines, clinical reminders, drug dosing support, and others. Drug allergy alerts accounted for the largest share of the global CDSS market in 2013. On the other hand, clinical reminders are expected to experience the highest growth. Various benefits while implementing this system, such as just-in-time alerts, prompt recommendation at the point-of-care, and improvements in quality care at low costs, will spur the market growth.

The three most important delivery modes highlighted are web-based, on-premises, and cloud computing. Owing to the growing need to meet the requirement of enhanced security and accessibility, the cloud computing mode of delivery is expected to grow. Cloud computing also reduces the burden on healthcare systems, as there is a reduced requirement for IT employees.

North America was the largest contributor to the global clinical decision support system market in 2013 and will also be the fastest growing region for CDSS till 2018. Factors driving the North American market are the growing demands for integrated CDSS solutions with EHR and CPOE, growth in the aging population, growing healthcare costs, and growth in patient consumerism for quality care.

Globally, the CDSS market will be driven by the growing pressure to reduce healthcare costs, growing patient consumerism for quality care, rising demand for analytical solutions, and national initiatives that promote the adoption of CDSS. The major bottlenecks for this market are the growing concerns over security, interoperability, integration challenges, costs incurred while integrating, and problems in implementing CDSS solutions. Alert fatigue, incomplete or poor quality of data entry, poor IT skills among staff, and poor financial support from governments in certain countries also contribute.

[12] http://www.marketsandmarkets.com/PressReleases/clinical-decision-support-systems.asp

Among all the integrated healthcare solutions, EMR embedded CDSS for Computerised Physician Order Entry (CPOE) and Medicines will be the fastest-growing market in the next five years, according to marketsandmarkets[12]. Key factors contributing to the growth are the national/ local initiatives; regulations and standards; growing pressure to reduce healthcare costs; and rising capabilities for population health management (preventive and long-term/ chronic care)[13]. It is expected that CDSS (integrated healthcare solutions) will grow during 2016-2022[14].

From the literature, two key limitations have been identified which limit CDSS adoption. Firstly, the majority of CDSS focus on the technical of CDSS focused on the technical and usability issues, ignoring or avoiding the social, cultural and contextual factors. Second, most studies evaluate the perceptions of frontline clinicians, but did not address the perceptions of different organisational roles (e.g., hospital administrators or care coordinators). One study shows that only 1.5% of 2952 United States hospitals surveyed fulfilled the criteria for a 'comprehensive' EHR-CDS system. Criteria includes, alerts, reminders, notifications and interactions[15].

Key CDS Drivers

Some of the key drivers responsible for CDS growth include: multiple-chronic disease management, an aging population, the requirement for shorter stays in hospitals, and growing system measures for quality. In addition, the need for an integrated healthcare IT system, improved quality of care and clinical outcomes plus the rising incidence of various fatal diseases and medication errors are also expected to increase the demand of CDSS. However, lack of experienced professionals, privacy and security issues, interoperability issues and high maintenance and service expenses are some of the factors inhibiting the growth of clinical decision support systems[16].

The HITECH Act (Health Information Technology for Economic and Clinical Health) is an example which focuses on increasing the usage of IT solutions in healthcare to improve the quality of care and enhance the performance of healthcare systems. Through this act, $36 billion USD was allocated to provide incentives (Meaningful Use 1, 2 and 3) to Medicare and Medicaid providers that have achieved the objectives of the act[17].

CDS Market Regulations and Maturity Models

HIMSS EMRAM	Hospital digital maturity (Three levels of CDS)
JCI	International standards in quality and patient safety
NSQHS (The National Safety and Quality Health Service)	The 10 NSQHS Standards provide a nationally consistent statement about the level of care consumers can expect from health service organisations
Harnessing the information revolution, NHS Paperless 2020 initiative	Harnessing the information revolution is to make the NHS Paperless by 2020 (e.g. Capabilities - Decision support)

[13] http://www.marketsandmarkets.com/PressReleases/clinical-decision-support-systems.asp

[14] Global Clinical Decision Support System (CDSS) Market Size, Share, Development, Growth and Demand Forecast to 2022, www.researchandmarkets.com

[15] Jha AK, Desroches CM, Campbell EG, Donelan K, Rao SR, Ferris TG, et al. Use of electronic health records in U.S. hospitals. N Engl J Med. 2009;360(16):1628–38.(15)

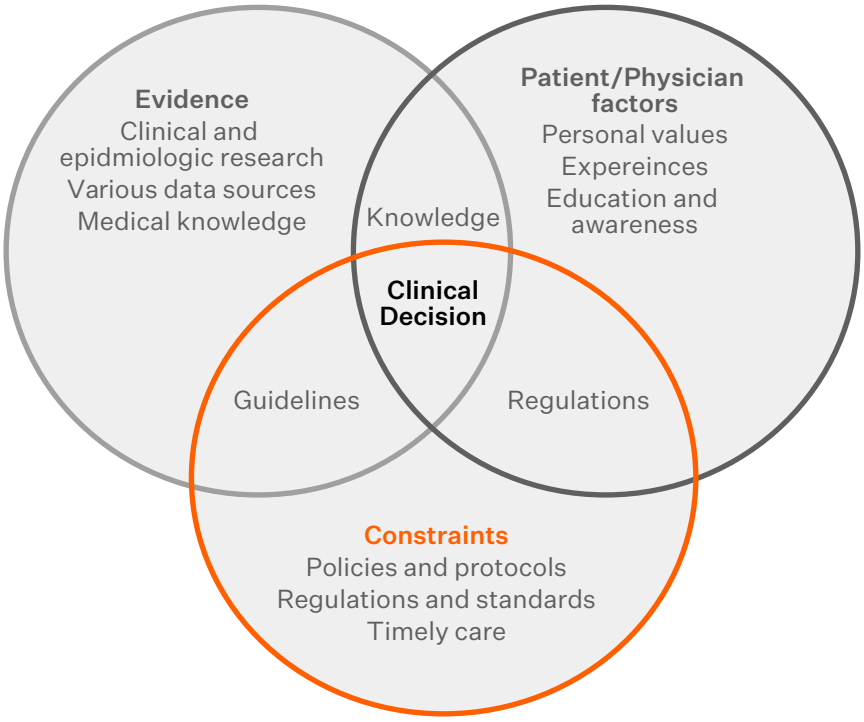
[16] Clinical Decision Support Systems Market - Global Industry Analysis and Forecast to 2020, http://www. persistencemarket-research.com/market-research/clinical-decision-support-systems-market.asp

Regulations and Standards related to the CDS

Arden Syntax	Arden Syntax originated in 1989 at the Arden Homestead. In 1992, version 1.0 became an ASTM standard. It transitioned to HL7 and version 2.0 became an ANSI and HL7 standard in 1999.
HL7® Continuity of Care Document	Continuity of Care Document or CCD comprises templates that can can be extremely powerful. Having defined a few dozen templates in the CCD, we now find those same templates appearing in numerous other standards and implementation guides from HL7, IHE, Continua and CDA for Common Document Types projects. The benefit for clinical decision support to this proliferation of the CCD templates is that we are finding the same templates being reused over and over again to record the same kinds of information.
HL7 Decision Support Service FHIR®	Decision Support Service takes in patient data as the input and provides back patient-specific assessments and recommendations. A Decision Support Service facilitates the implementation of clinical decision support capabilities in a scalable manner. The service payloads used by a Decision Support Service (e.g., Consolidated CDA or Virtual Medical Record representations of patient data) are defined through other projects within HL7.

Common CDS applications

Clinical Documentation	Electronic documentation with embedded decision support
Event driven alerts and reminders	Active and event driven alerts and notifications for timely actions
Data summaries	Presentation of data as smart and meaningful
Clinical Information and Knowledge Resources	Point-of-Care information available to the clinician for rapid decisions
Warnings and Notifications	Tailored and precise notifications for clinicians with increased opportunities
Standards and Guidelines	National/ Local best practice adoption
Protocols and Planning	Computerised ordering, interactions (adverse drug reaction), structured problem list and care pathways



Importance of embedded CDS

The ability for clinical decision support systems to be 'populated' with an individual's background/ existing healthcare information, real-time data from devices and to consider genome data (future healthcare prediction) and to present a precise workflow based on this information, is technically possible today[18].

One of the most important success factors for CDSS is to make the personalised health information embed smoothly into the clinical workflow for timely clinical decisions. EMR, nursing communication tools and personal health records are required to be automated and integrated with the wider healthcare delivery ecosystems for efficient clinical outcomes.

From the literature, it is evident that the alerts and notifications often lack or did not accommodate contextual information. Due to the lack of coordinating from various data domains, the CDSS generated alerts and notifications may also make inappropriate assumptions about provider knowledge of the current domain and often needed to be interpreted for similar and repeated information (which most likely is documented in the patient health record)[19].

Lack of EMR integrated CDS systems

Clinical, technical and scientific knowledge bases are spread worldwide in a huge amount of storage ('information silos'). This vast amount of information needs to be connected and embedded into the EMR in an easy and meaningful way so clinical professionals can view and make timely clinical decisions. CDS systems should adopt the standard mechanism using machine learning to connect all the missing pieces of the information available in 'information silos' to help the clinician make informed decisions.

This is a key enabler for the 'future of healthcare' to overcome the 'big data' issue by using machine learning to enable the prominent goal of 'precision' health (Precision Driven Health research partnership)[20].

Conclusion

Transformation is underway in healthcare, with the adoption of Clinical Decision Support. CDS has three core components: Device, Data and Decisions. Data is derived from the electronic device and subsequent clinical decisions are then formulated.

CDS will have enormous benefit for the improvement of healthcare for individual patients, hospitals, and the health of the national population. Challenges remain for CDS implementation and how to provide rich CDS solutions embedded with the patient's electronic healthcare record.

CDS is required to provide appropriate care, reduce medical errors and control healthcare costs.

This paper has explored various aspects of the CDS system including market gaps, drivers and challenges. It has also highlighted the importance of electronic medical record embedded CDS and the basic CDS functionality required to start making positive change in the healthcare ecosystem. This combined knowledge of device, data and decisions, will enhance healthcare globally now and into the future.

Dr. Mirza Baig, PhD — Biography

Mirza is a Senior Solutions Specialist for Orion Health. He is also an active researcher in the biomedical and healthcare informatics area. Mirza holds a PhD in Biomedical and Medical Informatics from Auckland University of Technology, Auckland, New Zealand.

Mirza is a specialist in clinical informatics and clinical decision support. He worked on various commercial and research projects related to clinical decision support, patient monitoring and medical device integration. He has received several awards and research funding for his research on the patient monitoring and decision support system. He has published over 30 peer-reviewed book chapters, journals and conference papers in the biomedical and medical informatics domain.

He currently serves on the Institute of Electrical and Electronics Engineers (IEEE) NZ North Section committee, which provides technical advice to students and early career researchers, including the distinguished lecture series. He is an advisory board member of the Centre for Research and Innovation (CRI), guiding on the industrial and applied research initiatives. He is also a reviewer for several medical and healthcare informatics journals, including journal of medical systems, Springer; and Journal of Biomedical Informatics, Elsevier.

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