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Preface: Enhancing the Value of the Laboratory with Clinical Decision Support ix

Anand S. Dighe

Decision Support Tools within the Electronic Health Record 197

Joseph W. Rudolf and Anand S. Dighe

Laboratory tests are an integral part of the electronic health record (EHR). Providing clinical decision support (CDS) for the ordering, collection, reporting, viewing, and interpretation of laboratory testing is a fundamental function of the EHR. The implementation of a sustainable, effective laboratory CDS program requires a commitment to standardization and harmonization of the laboratory dictionaries that are the foundation of laboratory-based CDS. In this review, the authors provide an overview of the tools available within the EHR to improve decision making throughout the entire laboratory testing process, from test order to clinical action.

Operational Aspects of a Clinical Decision Support Program 215

Gary W. Procop, Allison L. Weathers, and Anita J. Reddy

Clinical decision support tools that involve improving test utilization should be jointly overseen by a laboratory stewardship committee and the hospital informatics team. The roles of these groups vary by institution and may overlap. This is a team effort and collaboration is a must. The effectiveness of these efforts in an institution depends on the receptiveness of leadership and providers, as well as the effectiveness of the associated committees. Examples of the challenges and successes of laboratory stewardship interventions that have been operationalized at the Cleveland Clinic that use clinical decision support tools, as well as associated literature, are reviewed.

Decision Support and Patient Safety 231

Mario Plebani, Ada Aita, Andrea Padoan, and Laura Sciacovelli

In recent years, clinical decision support (CDS) systems have become recognized as increasingly important in assuring patient safety and supporting all phases of the clinical decision-making process. In Laboratory Medicine, CDS systems are usually used to drive test ordering and diagnostic prediction while combining IT components and staff skills. However, educational initiatives, user and provider feedback, and expert consultations should also be considered integral to CDS. The aim of this paper is to provide an overview of some important developments in CDS in supporting the clinical decision-making process and guaranteeing patient safety by reducing medical errors.

Integrating Decision Support into a Laboratory Utilization Management Program 245

Kent Lewandrowski

Overuse of clinical laboratory testing increases costs, contributes to iatrogenic anemia, and results in downstream costs, including unnecessary

work-ups and treatments. Physicians order unnecessary laboratory tests because of lack of knowledge, the practice of defensive medicine and adherence to historical test ordering. Utilization management is increasingly important to control costs and ensure patients receive appropriate tests for diagnosis and management. Clinical decision support is essential for a successful utilization management program. Successful programs rely on clinical informatics to identify misutilization, implement interventions, and track effectiveness. We describe the role of clinical decision support in a laboratory utilization management program.

Decision Support to Enhance Automated Laboratory Testing by Leveraging Analytical Capabilities **259**

J. Mark Tuthill

To achieve effective laboratory automation, analytical capabilities must be developed to support data analysis. This allows for effective development and deployment of decision support strategies within the automated laboratory. Practically, these take the form of dashboards, static and real time; workflow processes, such as autoverification; reflex protocols; and testing cascades, which reduce errors of omission and commission. This requires data from the LIS and middleware that enable sophisticated laboratory automation lines. This article addresses the historical, current, and future state of laboratory analytics using examples and offering a framework to organize thinking around analytical capabilities.

Decision Support in Transfusion Medicine and Blood Banking **269**

Neil K. Shah

Clinical decision support (CDS) can greatly enhance patient blood management through optimizing ordering and providing patient-specific information. At present, modeling and prediction have small roles in inventory management; they will likely have increasing applications to help guide donor center collections based on real-time demand to meet more dispersed needs. Transfusion side-effects management for both donor and recipients is an area ripe for intervention by CDS to enable proactive actions. Last, CDS and broader prediction will 1 day function alongside and seamlessly along many of our major processes to create a human-computer symbiosis.

Technical, Biological, and Systems Barriers for Molecular Clinical Decision Support **281**

Niklas Krumm and Brian H. Shirts

Genome-enabled or molecular clinical decision support (CDS) systems provide unique advantages for the clinical use of genomic data; however, their implementation is complicated by technical, biological, and systemic barriers. This article reviews the substantial technical progress that has been made in the past decade and finds that the underlying biological limitations of genomics as well as systemic barriers to adoption of molecular CDS have been comparatively underestimated. A hybrid consultative CDS system, which integrates a genomics consultant into an active CDS system, may provide an interim path forward.

Decision Support from a Reference Laboratory Perspective 295

Brian R. Jackson

Esoteric testing presents a broad range of opportunities to improve clinical decision making. To be effective, the knowledge support needs to be seamlessly embedded into clinical workflows. Reference laboratories are uniquely positioned to play an outsized role in laboratory decision support, in part because they are large repositories of esoteric testing knowledge and in part because of their resources and client relationships. To accomplish this, however, reference laboratories must develop strong capabilities to integrate content and logic into clinical software platforms, including but not limited to electronic health records.

Training Aspects of Laboratory-Based Decision Support 303

Bruce P. Levy

Pathology has a large role to play in the proper development, implementation, and optimization of clinical decision support (CDS). CDS training must be supported by an educational foundation in clinical and pathology informatics. Educational opportunities are currently limited, but expanding, in the pathology residency space with Pathology Informatics Essentials for Residents. The use of an educational version of electronic clinical systems is an important educational tool to support the needed outcomes-driven and exercise-based informatics and CDS training. With the multidisciplinary nature of informatics, it is advantageous to include laboratory professionals in the training exercises as appropriate.

Machine Learning and Other Emerging Decision Support Tools 319

Jason M. Baron, Danielle E. Kurant, and Anand S. Dighe

Emerging applications of machine learning and artificial intelligence offer the opportunity to discover new clinical knowledge through secondary exploration of existing patient medical records. This new knowledge may in turn offer a foundation to build new types of clinical decision support (CDS) that provide patient-specific insights and guidance across a wide range of clinical questions and settings. This article will provide an overview of these emerging approaches to CDS, discussing both existing technologies as well as challenges that health systems and informaticists will need to address to allow these emerging approaches to reach their full potential.