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The introduction of a diagnostic decision support system (DXplain™) into the workflow of a teaching hospital service can decrease the cost of service for diagnostically challenging Diagnostic Related Groups (DRGs)

Peter L. Elkin[a,*], *Mark Liebow*[b], *Brent A. Bauer*[b], *Swarna Chaliki*[b], *Dietlind Wahner-Roedler*[b], *John Bundrick*[b], *Mark Lee*[b], *Steven H. Brown*[c,d], *David Froehling*[b], *Kent Bailey*[b], *Kathleen Famiglietti*[e], *Richard Kim*[e], *Ed Hoffer*[e], *Mitchell Feldman*[e], *G. Octo Barnett*[e]

[a] *Center for Biomedical Informatics, Mount Sinai School of Medicine, One Gustave L. Levy Place, Box 1023, New York, NY 10029, United States*
[b] *Mayo Clinic College of Medicine, Rochester, MN, United States*
[c] *Vanderbilt University, Nashville, TN, United States*
[d] *Veterans Administration, Nashville, TN, United States*
[e] *Harvard Medical School, Massachusetts General Hospital, Boston, MA, United States*

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ABSTRACT

Background: In an era of short inpatient stays, residents may overlook relevant elements of the differential diagnosis as they try to evaluate and treat patients. However, if a resident's first principal diagnosis is wrong, the patient's appropriate evaluation and treatment may take longer, cost more, and lead to worse outcomes. A diagnostic decision support system may lead to the generation of a broader differential diagnosis that more often includes the correct diagnosis, permitting a shorter, more effective, and less costly hospital stay.

Methods: We provided residents on General Medicine services access to DXplain, an established computer-based diagnostic decision support system, for 6 months. We compared charges and cost of service for diagnostically challenging cases seen during the fourth through sixth month of access to DXplain (intervention period) to control cases seen in the 6 months before the system was made available.

Results: 564 cases were identified as diagnostically challenging by our criteria during the intervention period along with 1173 cases during the control period. Total charges were \$1281 lower ($p = .006$), Medicare Part A charges \$1032 lower ($p = 0.006$) and cost of service \$990 lower ($p = 0.001$) per admission in the intervention cases than in control cases.

Conclusions: Using DXplain on all diagnostically challenging cases might save our medical center over \$2,000,000 a year on the General Medicine Services alone. Using clinical diagnostic decision support systems may improve quality and decrease cost substantially at teaching hospitals.

* Corresponding author. Tel.: +1 212 824 7657; fax: +1 212 824 2329.
E-mail address: peter.elkin@mssm.edu (P.L. Elkin).
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1. Introduction

Case-based payment systems for hospitals such as Medicare's Prospective Payment System create strong financial incentives for short stays and limited inpatient testing. Residents tell us they are aware of these incentives. Residents admitting patients are anxious to develop a working diagnosis, confirm the diagnosis as rapidly as possible, treat the patient until stable, and then discharge the patient for further care as an outpatient. However, a rapid pace can discourage the contemplation of the condition of newly admitted patients, even though admission is often the time when such contemplation can be most useful. Lack of time to consider a differential diagnosis, especially for the elderly, complex patients who make up an increasing percentage of our inpatient services, can lead to an incomplete differential diagnosis and, from there, premature closure on an incorrect diagnosis. An incorrect diagnosis can increase costs and length-of-stay while reducing quality of care, a doubly undesirable outcome.

An adequate differential diagnosis is a way to avoid premature diagnostic closure (PDC). Keeping several diagnoses in mind makes it easier to change a working diagnosis that is becoming less plausible as a patient's evaluation progresses. Having a differential diagnosis reduces the temptation to interpret the data to fit a single diagnosis to which the resident may have become attached.

Computerized decision support systems may help residents generate a more thorough differential diagnosis. DXplain is one of these systems. It is a computer-based medical education, reference, and decision support system ("expert system") that has continued to evolve since its initial development in the mid-1980s by the Laboratory of Computer Science at Massachusetts General Hospital [1,2]. DXplain has characteristics of a decision support tool, a medical reference system, and an electronic medical textbook. As a decision support tool, it uses an interactive format to collect clinical information and then uses data on the crude probabilities of about 5000 clinical manifestations (history, examination findings, laboratory and imaging data) to generate from the manifestations present in a patient a differential diagnosis ranked by probability of the diagnosis. The data base is continuously updated and the system uses a modified form of Bayesian logic along with numerous heuristics to produce its differential diagnosis. DXplain also lists other findings that would support a diagnosis if present and those entered by a user not usually found in a disease. As a medical textbook and reference, DXplain provides a comprehensive description and selected references for more than 2200 different diseases, emphasizing the signs and symptoms present in each disease, the etiology, the pathology and the prognosis [3,4]. DXplain has been used by thousands of physicians and medical students for clinical assistance over the last twenty years. Ten years ago, the Laboratory of Computer Science began to make DXplain available over the Internet to hospitals, medical schools, and other medical organizations [5].

How can an expert system help? A first-year medical resident, not yet an experienced clinician, may admit 5 patients, some of whom are diagnostically challenging, in 24 h while being responsible for up to 30 inpatients at night. The resident may have little time to read about or consider the differential diagnoses for the newly admitted patients. Using an expert system may help a resident generate an adequate differential diagnosis quickly and easily while also teaching medical knowledge and diagnostic strategies that may be useful for future patients. Faculty can also glean teaching points from the differential diagnoses generated by the expert system.

We undertook this exploratory study to see if the use of DXplain as a clinical decision support system has the potential to decrease the cost of care for diagnostically challenging cases as compared with usual practice on General Medicine services in a teaching hospital as compared with usual practice.

1.1. *Computer-based Diagnostic Decision Support Systems*

As early as 1959, Ledley and Lusted suggested that computers could help doctors in the diagnostic process [6]. Many papers appeared showing the accuracy of medical diagnosis by computer, generally in a very limited field such as thyroid disease or congenital heart disease. Few of these early systems were used outside the environment of their developers due to their limited knowledge bases, poor user interfaces and the many obstacles to sharing computer systems in the time period of the early 1960's. In the current environment of the Internet and widespread availability of personal computers, the potential for routine use of decision-support systems to assist health professionals in the diagnostic process has become reality.

Tim de Dombal at the University of Leeds created the first abdominal pain diagnosis program based on Bayesian probability theory. The system differentiated between appendicitis, diverticulitis, perforated ulcers, cholecystitis small-bowel obstruction, pancreatitis and non-specific abdominal pain using data acquired from thousands of patient presentations [7]. Ted Shortliffe while at Stanford University developed a program named MYCIN which provided consultation regarding the empiric antibiotic management of infectious diseases [8]. MYCIN used production rules consisting of conditional statements that took the form of If/Then statements (e.g. **If** the location of the infection is the meninges and the patient is of an age range 15–55 **Then** the likely organisms causing the infection are Streptococcus Pneumoniae, etc) [9]. This methodology falls under the general computer science category of artificial intelligence [10].

Homer R. Warner at the University of Utah created the HELP system which was an integrated hospital information system with associated decision support [11,12]. The HELP system incorporated a complete electronic medical record with a hospital information system. The rules in the HELP system were written in a preprescribed fashion and this syntax eventually became standardized as the Arden Syntax [13]. Each complete rule set is named a medical logic module and each such module has its own conclusions [14].

Randy Miller and Jack Myers created the quick medical reference (QMR) which was developed as a diagnostic decision support system for general medicine [15]. QMR was employed at the University of Pittsburg as a consult service which functioned under the model that a physician with a computerized clinical diagnostic decision support system was more effective at making diagnoses than the physician alone [16]. In QMR