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Research Paper

Effectiveness of a clinical knowledge support system for reducing diagnostic errors in outpatient care in Japan: A retrospective study

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ABSTRACT

Clinical evidence has indicated the effectiveness of computer-based systems for preventing and reducing diagnostic errors. Our study aimed to evaluate the effectiveness of UpToDate, a computer-based clinical knowledge management system, for reducing diagnostic errors. We retrospectively identified 100 patients who visited an outpatient department in a community-based hospital from July 2014 to June 2015. Fifty patients (exposure group) were seen by UpToDate-equipped physicians and another 50 (control group) were seen by UpToDate-unequipped physicians. We extracted data on patient sex, age, primary diagnosis, and case difficulty that could potentially affect diagnostic outcomes. We compared the two groups regarding diagnostic error rate and performed logistic regression analysis to analyze the concurrent effects of various factors affecting diagnostic error. The diagnostic error rate was 2% in the exposure group, while the error rate was 24% in the control group. Multivariate logistic regression analysis showed that error rate reduction was significantly associated with exposure to UpToDate with an odds ratio of 15.21 (95% CI 1.86–124.36). Our results demonstrated the effectiveness of UpToDate for the prevention and reduction of diagnostic error.

1. Introduction

A recent major report from the Institute of Medicine (IOM) “Improving Diagnosis in Health Care," indicated that diagnostic error rates in the United States were unacceptably high, and made recommendations to address this problem [1]. The authors of the report also stated that while most people were likely to experience significant diagnostic errors in their lifetime, the importance of this problem remained under-appreciated, as noted in a past study [2]. Diagnostic errors are relatively common compared to other types of medical errors such as medication and surgical errors [3–10]. According to previous estimates, more than 5% of adults who seek outpatient medical care experience diagnostic errors [1,11,12]. The IOM report, based on research over many decades, also revealed that diagnostic errors contribute to approximately 10% of all deaths. In the outpatient care setting, diagnostic errors impose a significant burden on healthcare quality and safety and pose challenges for patients, physicians, other healthcare professionals, and policy makers [13,14].

1.1. Dual process theory

Dual process theory (DPT), popularized by Kahneman’s book ‘Thinking Fast and Slow’, has been widely discussed as a model for analyzing decision-making processes [15]. The fundamental theory underpinning DPT is that the brain has a fast and a slow decision-making process. The two processes are called system 1 (non-analytical) process and system 2 (analytical process): the former system is an intuitive but frequently error-prone system; the latter, a slower, energy-intensive but more thorough analytical system. The DPT model has been widely discussed outside and inside medicine.

1.2. Research question

In every clinical setting, cognitive errors made via the system 1 process can be mitigated by the system 2 process, which includes computer-aided clinical knowledge management systems [16]. While little research has been conducted on primary care computerized diagnostic decision support systems [17], nevertheless, the clinical effectiveness of computer-based systems in aiding diagnostic accuracy has been reported [18–20]. The diagnostic effectiveness of UpToDate,

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regarded as one of the foremost computer-aided clinical knowledge management systems, has not been specifically evaluated [21]. Consequently, we conducted a study comparing the diagnostic error rate between UpToDate-equipped physicians and non-equipped physicians, in order to evaluate clinical effectiveness with respect to diagnostic error reduction.

2. Methods

2.1. Study design

This study was a retrospective, single-center study. In this study, we randomly sampled and reviewed 50 patients (charts) seen by UpToDate-equipped physicians and 50 seen by UpToDate-non-equipped physicians. We included patients aged 15 years and older who presented with various acute, newly-developed symptoms and visited the outpatient department of the Tokyo Joto Hospital, Japan from July 2014 to June 2015. Cases without a final diagnosis were excluded.

2.2. Data collection

The hospital, Tokyo Joto hospital, is a major community-based acute care hospital and covers primary to secondary care in eastern Tokyo. The hospital represents the typical community-based acute care hospital in Japan with 129 beds and 327 outpatient/emergency room visits per day (as at January 19, 2017 http://hospia.jp/hosinfo/1130870071). The hospital also belongs to a group of 57 community-based hospitals of the Japan Community Hospital Organization as a flagship teaching hospital.

By reviewing medical records, we collected data on presenting symptoms at the index visit, correct diagnosis, erroneous diagnosis, and potential contributory factors. Diagnostic errors were confirmed through a chart review and defined as ‘detection of unusual patterns of return visits after an initial primary care visit or lack of follow-up of abnormal clinical findings related to the primary diagnosis’ based on the method described by Singh et al. [11]. The study protocol was approved by the institutional review board. The need for patient consent was waived because of the anonymous nature of the data.

2.3. Measurement

Collected data were classified as binary variables, assigning 0 or 1, to sex (man = 1; woman = 0), difficulty of cases (difficult = 1; easy = 0), exposure (seen by physician with UpToDate = 1; seen by physician without UpToDate = 0), and diagnostic error (correct diagnosis = 1; diagnostic error = 0). The difficulty of cases was determined based on the consensus of the two participating researchers (TS and TN), who were general physicians. If they had contradictory verdicts about one case, they discussed the difficulty of the case and determined the final decision of the difficulty. The access to UTD was allowed both in and out of clinic. And the exposure group were found to be newly provided access to UTD at the beginning of study. The access were on cell phone mobile, tablets and computer desktop.

2.4. Data analysis

We initially calculated the averages of age, sex, and difficulty of cases with respect to the exposure and control group. Moreover, we used the two-sample Wilcoxon rank-sum (Mann-Whitney) test to compare the averages of age and Pearson’s chi-square test to compare the proportions of sex and difficulty between the exposure and the control group. Next, we compared the proportion of diagnostic error between the control and exposure group, and tested our hypothesis to ascertain any significant association between error and other factors by using a logistic regression model including the binary variables. Potential confounders such as age, sex, and difficulty of cases were included as covariates. There were no missing data in the collected cases. A two-tailed $p < 0.05$ was considered statistically significant. Statistical analyses were conducted using STATA version 13 (StataCorp LP, College Station, TX, USA).

3. Results

3.1. Demographic profile

Each participated physician practiced general practice on daily basis. Prior use and familiarity with UpToDate were comparable in the two groups. One hundred cases were enrolled and evaluated. The average patient age was 70 years (standard deviation [SD], 20.9; range, 16–100) in both groups, 66.1 years (SD, 22.6) in the exposure group, and 75.7 years (SD, 17.9) in the control group. In total, 57% of patients were females in both groups, 56% in the exposure group, and 58% in the control group. Difficult cases were 49% overall, 50% in the exposure group, and 48% in the control group. While a significant difference regarding average age ($p = 0.03$) was observed, no significant difference in sex ($p = 0.84$) and case difficulty ($p = 0.84$) between the exposure and control group. Major symptoms included fever (31%), dyspnea (25%), abdominal pain (6%), fatigue (6%), altered mental status (5%), and weakness (3%).

In the exposure group, the diagnostic error rate was 2% (95% confidence interval [CI], 0.51–10.65%), while in the control group, it was 24% (95% CI, 13.06–38.17%).

3.2. Multivariate logistic regression

The results showed that error rate reduction was significantly associated with UpToDate exposure with an odds ratio [OR] of 15.21 (95% CI 1.86–124.36) (Table 1).

4. Discussion

This retrospective single-center study investigated the difference in diagnostic error rate between UpToDate-equipped and non-equipped physicians and also tested our hypothesis regarding the existence of an association between diagnostic outcome and other factors, using logistic regression. The results showed that the diagnostic error rate by physicians with UpToDate was lower than that by physicians without UpToDate. Furthermore, the logistic regression model revealed that diagnostic reduction was significantly associated (OR: 15.21) with UpToDate use. The confidence interval for the obtained OR seemed wide and this was possibly due to the small sample size.

Clinicians desire to make clinical decisions as fast and as precisely as possible. From the DPT standpoint, it seems preferable that clinicians make these decisions with system 1, the intuitive approach. However, because of the complexity of the clinical setting and the background and nature of medical conditions, clinicians occasionally confront difficulties in decision making with the intuitive approach. In these situations, the system 2 decision-making process can help answer questions facing clinicians. Moreover, better use of diagnostic coding vocabulary in clinical decision support system and integrating these with the electronic health record has been reported to have the

Table 1
The result of the multivariate Logistic regression to distinguish subjects in the diagnostic error reduction.

Variable	Odds Ratio	Standard Error	p-value	95% Confidence interval	
Age	0.97	0.02	0.23	0.93	1.02
Sex	0.97	0.63	0.96	0.27	3.49
Difficulty	0.47	0.31	0.25	0.13	1.71
Exposure	15.2	16.3	0.01	1.86	124.4

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