Randomized Study of Online Vaccine Reminders in Adult Primary Care

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ABSTRACT

Online immunization reminders were implemented in an adult medicine setting in which all immunization history, vaccine ordering and charting were required online. Physicians were randomized to one of two arms in a cross-over design. Each arm was shown online recommendations for vaccines indicated by nationally accepted guidelines either during the first or during the second part of the study period. The main purpose of the study was to assess the impact of reminders on correct decisions related to prescribing vaccines. Online reminders had the following impact on physician behavior: 1)Physicians used the application almost 3 times as often when shown reminders. 2)Physicians in the reminder group were 27% less likely to order a vaccine in the reminder group (P- value 0.0005). 3)Compliance with guidelines was improved significantly for Tetanus and for Hepatitis B in several analyses. No such effects were found for Pneumoccocal, Measles, or Influenza vaccines.

INTRODUCTION

Vaccine-preventable diseases including influenza, pneumococcal pneumonia and hepatitis B cause an estimated 50,000 excess deaths per year in the United States[1]. Considerable data exists regarding the safety, efficacy and cost-effectiveness of these vaccines. However, the majority of adults for whom vaccination is recommended are not immunized. Certain clinical preventive services, including immunization and early detection of disease through screening and improved case-finding, have led to major reductions in morbidity and mortality[2]. Previous observations in our ambulatory care clinics had indicated that tetanus in particular was highly underutilized in preventive care[3].

Oxman and colleagues recently reviewed all published trials of educational interventions in the health care professions to determine the effectiveness of different types of interventions in improving health professional performance and health outcomes[4]. Dissemination-only strategies demonstrated little or no changes in health professional behavior or health outcome when used alone. However, more complex interventions were variably, albeit moderately, effective. Thus, there are a wide range of interventions available that, if used appropriately, could lead to important improvements in professional practice and patient outcomes[4].

There have been few well-designed clinical trials on the effect of feedback and reminders on preventive activities in ambulatory practice[5]. The interventions and procedures studied differ widely, and the reporting of the results is insufficiently precise. However, the literature demonstrates a positive effect of feedback on compliance with guidelines or standards. In this respect, the effect of reminders may be greater than that of feedback. There is an important need for research on the effect of feedback, reminders and other instruments of quality assurance on various aspects of medical performance in different clinical settings[5].

METHODS

The Immunization application is part of the UIHC online patient record, INFORMM Patient Record (IPR), a Windows-based application developed at the UIHC. The present version of IPR includes structured documentation of most of the summary components of the record (Allergies, Immunization History / Vaccine Orders / Vaccine Charting, Medications / Prescriptions) and most nursing documentation. All exam rooms, work rooms, and nursing stations have Windows devices (PCs or network workstations) for access to IPR as well as to a number of Web-based resources. Nearly all (>99%) of vaccine history, orders, and charting of administration are done online. The few written orders are back-loaded into the system.

The Immunization component captures the immunization history, vaccine orders, and vaccine administration, following the work flow of several disciplines. The components are: a clinical help file, a rules database, the historical information on a patient's vaccines, the process of ordering a new vaccine, charting the administration of a new vaccine, and reports on patients who need vaccines. These are all described in more detail in another report[3].

1091—8280/99/$5.00

Resources for the project included: Health Information for International Travel (Centers for Disease Control and Prevention), the Red Book (American Academy of Pediatrics), and Guide for Adult Immunization (American College of Physicians), and U.S. Preventive Services Task Force Guidelines. Using these sources, we compiled a set of documents describing 38 vaccines, serum products, skin tests and other substances for assessment of immunity.

The rules engine generated recommendations for vaccine orders. Pediatric and adult (>16 years of age) rules were abstracted from these sources. The entire set was described in detail[3]. The adult rules are summarized briefly:
Hepatitis B was flagged "consider" if the patient was a hospital employee or if less than 25 years of age.
Influenza was recommended during October-January and the patient was a hospital employee or was greater than 64.5 years of age
MMR: This was flagged "consider" if born after 1956 and fewer than 2 doses documented and more than 30 days since most recent dose.
Pneumococcal: This was recommended if age was greater than 64 years (flagged "consider" if more than 63.5 years) and more than 10 years since last received (flagged "consider" if more than 7 years since last received).
Td was recommended if no history of Tetanus vaccine in over 9 years and 6 months.

These rules were expressed as algorithms and evaluated based upon the patient's age and history of previous vaccination. The accuracy of recommendations depends on an accurate patient vaccine history. Historical information was loaded into the system from UIHC pharmacy billing records. The nurse interview during the clinical visit supplemented the online history information.

The physician reviewed vaccine history. An indicator showed whether the vaccine was recommended based on the history and the rules. Also shown were any warnings generated from the rules engine regarding any of the vaccines

The physician could choose to override the recommendation, to order the recommended vaccine, or to order other vaccines. Pending orders were reviewed by the person administering the vaccines who then charted administration. This caused the vaccine history to be automatically updated.

Study design:. All providers working in the General Medicine Services of the UIHC were randomly assigned to one of two arms after being stratified by level of experience prior to randomization. A cross-over design allowed those in one arm to see the recommendations only during the first half of the study and those in the second group to see recommendations only during the second half of the study.

An automated log of each session in which a provider accessed the Immunization application recorded the status of vaccine recommendations at the beginning and the end of the session and whether or not the physician generated an order for the vaccine during the session.

The Immunization application was introduced to all providers in the General Medicine Services, including 24 nursing staff, 120 staff physicians, and 113 resident physicians. The nursing staff were given 2 hours training in a computer laboratory as well as on-the-job training during the first month of use. Staff and resident physicians were given 1 hour of training in a tutorial set up in the clinic in which they worked. In addition, assistance was provided during the first month of use. Physicians were instructed to review the online immunization history during the patient visit.

One month after the Immunization application was introduced into clinic, those in the reminder arm were first shown recommendations. Providers in both arms were informed about the availability of an online educational resource on vaccines and that some of them were being given computer generated reminders while others were not. After five months, providers in the reminder and control arms were crossed-over to the alternate group for the remaining four months of the study . The cross over date was chosen to be the midpoint of the influenza vaccination season.

Statistical analysis: For analysis of sessions, 2 x 2 contingency table analysis was performed with Chi-square analysis, using Fishers exact text where appropriate to compute two-tailed P-values.

Since ordering behavior was not expected to be independent at the physician level, in some analyses the data were collated by physician. Specifically, the proportion of physicians who ordered a vaccine at least once was calculated. Also, the proportion of sessions in which a vaccine was ordered (the median usage rate) was calculated for each physician.

Because of clinical schedule rotations throughout the year, only twenty-eight of the physicians participated in both study groups, i.e., crossed over, while 61 physicians were in one group only. For those that

crossed over, paired analyses were performed. For example, to determine whether the proportion of physicians who ordered the vaccine at least once varied across groups, an exact McNemar's test was used. A Wilcoxon signed rank test was used to compare the proportion of opportunities when a vaccine was ordered. For the physicians who did not cross over, unpaired analyses were performed. Fisher's exact test was used instead of the McNemar's test, and the Wilcoxon Rank-sum test was used instead of the signed rank test. A normal approximation combined the test results to obtain an omnibus test for all 89 physicians.

RESULTS

There were 1,985 Immunization application sessions involving non-physicians and 980 sessions involving-physicians. Non-physicians used the application at least once for each of 1,678 visits involving 1,548 patients. These sessions were used for updating the immunization history in the application so that automated reminders to the physician would reflect a current immunization history. Physicians used the application for 886 visits (53% of the total) involving 817 patients.

One-fourth(30) of the 120 staff physicians used the application at least once during the study. Nearly half (55, 49%) of the 113 resident physicians used the application at least once. Among 980 physician uses, there were 103 sessions in which there were no rule-generated vaccine indications. In the remaining sessions the application rules found at least one vaccine indicated. These recommendations were shown to physicians in the reminder arm.

Impact of Reminders: Nearly three-quarters (726, 74%) of the 980 physician sessions were by physicians in the reminder arm (Table 1). The high fraction of use by physicians in the reminder arm remained consistent before and after the cross-over, both for all physician sessions and for the subset of sessions restricted to physicians who participated in both arms. In both cases the data showed that physicians used the application much more often when in the reminder arm.

There was no order for any vaccine in 420 (43%) of physician sessions , there were orders for at least one vaccine in 560 (57%) sessions. There were orders for at least 2 vaccines in 153 (16%) sessions. Those sessions involving physicians in the reminder arm were less likely to involve an order for a vaccine (P value < 0.0005, RR 0.73, CI_{95} 0.60 to 0.88).

Reminders were provided only if the physician chose to use the Immunization application. As such, an impact on second-vaccine ordering by physicians who've already decided to order one vaccine was considered. Among sessions with at least one order, those sessions with physicians in the reminder arm were not more likely to involve orders of two or more

Table 1: Effect of reminders on the number of orders overall

Sessions by Physicians Who Crossed-over		
	Number of Orders	
	None	At least 1
Non-reminder	67	127
Reminder	243	248
Significance	P < 0.0005, RR 0.70 (CI_{95} 0.56 – 0.86)	
Sessions byAll Physicians		
	Number of Orders	
	None	At Least 1
Non-reminder	85	169
Reminder	335	391
Significance	P < 0.0005, RR 0.73 (CI_{95} 0.60 – 0.87)	
Sessions byAll Physicians		
	Number of Orders	
	One	At least 2
Non-reminder	127	42
Reminder	280	111
Significance	Not significant	

vaccines overall (Table 1). However, there were significant effects of reminders on the distribution of specific vaccine orders (Table 2). The table shows the number of sessions (Total) and the number of sessions in which the indicated vaccines were ordered. The proportion of sessions involving specific vaccine ordering increased for tetanus and decreased for pneumococcal vaccines with reminders.

Table 2 Analysis of Sessions in which One or More Vaccines were Ordered.

	Reminder		
	No	Yes	P-value
Tetanus	88	244	0.025
Hepatitis	17	53	0.27
Influenza	42	92	0.75
Pneumo.-coccal	60	104	0.043
Measles	4	10	1.0
Total	169	391	

Orders for vaccines were classified "correct" if the vaccine was indicated by the rules and not ordering a

vaccine as "correct" if the vaccine was not indicated by the rules. Among all sessions, analysis of the proportion of correct decisions (Table 3) demonstrated no significant effect of reminders. However, subset analysis of sessions in which one or more vaccine was ordered did detect a significant effect of reminders on correct vaccine decisions for Tetanus (Table 4). The analyses of data from sessions in which at least one vaccine order and for those involving at least two vaccine orders indicated a significant effect of reminders on correct decisions involving tetanus. The analysis of the no-order sessions showed no effect of reminders on the proportion of correct decisions. Given the large number of no-order sessions is, no doubt, the reason why no significant effect was observed on correct ordering for sessions overall.

Table 3. Analysis of correct vaccine decisions for all sessions.

	Reminder		
	No	Yes	P-value
Tetanus	118	346	0.771
Hepatitis	206	555	0.137
Influenza	218	630	0.749
Pneumo.	196	593	0.119
Measles	188	503	0.174
Total	254	726	

Table 4. Analysis of Tetanus Decisions

	Reminder			
	No	Yes		
	Correct/Incorrect		Total	P-value
All sessions	118/136	346/380	980	0.771
No Order Sessions	14/71	75/260	420	0.298
At Least 1	104/65	271/120	560	0.079
At least 2	26/16	88/23	153	0.037

Because the physician was the unit of randomization, the data were analyzed for impact on individual physician behavior with respect to ordering specific vaccines. Two measures of behavior were considered: 1) the proportion of physicians who ordered at least once and 2) the median usage rate by individual physicians. There were no significant effects on the latter outcome. The data (Table 5) demonstrated the proportion ordering a given vaccine at least once when in the reminder or in the control arm. Among all physicians, there was a significant effect on ordering for Hepatitis B ($P < 0.004$) and a borderline non-significant effect ($P < 0.089$) on ordering for Tetanus. Among physicians who were in both arms of the study, the effect on both vaccines achieved significance ($P < 0.016$).

Table 5 Analysis of the effect of reminders on the proportion of physicians who ordered at least once: data for all physicians

	Reminder		
	Yes	No	P-value
Tetanus	48/70=.696	29/47=.617	.089
Hepatitis	17/70=.243	3/47=.064	.004
Influenza	32/70=.457	18/47=.383	.320
Pneumo-coccal	43/70=.614	30/47=.638	1.000
Measles	10/70=.143	3/47=.064	.385

Table 6. Analysis of the effect of reminders on the proportion of physicians who ordered at least once: data restricted to physicians that crossed over.

	Reminder		
	Yes	No	P-value
Tetanus	25/28=.893	18/28=.643	.016
Hepatitis B	10/28=.357	3/28=.107	.016
Influenza	15/28=.536	14/28=.500	1.000
Pneumo-coccal	20/28=.714	19/28=.679	1.000
Measles	5/28=.179	1/28=.036	.219

DISCUSSION

In the environment in which the study was performed, narratives, prescriptions, allergies, nursing notes, and all test results were available online. On the whole, the computer was viewed as an essential tool in the patient care process. For instance, physicians were encouraged to write prescriptions online and over 90% of prescriptions were written using the computer. Immunization application was the first computer application used in this setting that was required in order to accomplish a specific task: the application was required in order to get any patient vaccinated. Physicians in the reminders arm saw vaccine reminders every time they chose to use the Immunization application to write any vaccine order. All physicians were trained and able use an online help file to see the vaccine recommendations on which rules were based.

Interestingly, inclusion in the reminder group increased the utilization of the application and, therefore, the frequency that the reminders were viewed. The effectiveness of online reminders was dependent on being viewed by a physician, but the reminders themselves seem to be an inducement to use the system.

Disappointingly, we did not find an effect on correct ordering for any vaccine in analysis of the data overall. Certainly this was not because of high proportions of correct decisions in the absence of reminders. Since there were a number of impacts of reminders, it seems clear that physicians saw the reminders. The fact that recommendations were often not followed may reflect disagreement with the guidelines represented in the rules. Alternatively, information available to the physician, such as patient history, but not entered into the application would have led to recommendations that the physician would not have followed.

Insufficient patient history is a common problem faced by this kind of application. We had made every attempt to ensure an accurate online history, including review of billing records and of the page in the paper record that was supposed to contain the summary of immunization history. In a companion report, we reported that it was difficult to demonstrate vaccine compliance based upon data that were easily found in the record[3]. The application described in that report is expected to alleviate that problem over time through increased reliance on Immunization application fore all aspects of vaccine-related health care.

One impact of reminders was the reduction in the proportion of sessions that resulted in an online order. One interpretation is that the physicians in the reminders group more often used the sessions purely to gain information, in this case the computer-generated recommendations. The other interpretation is that the online recommendations frequently dissuaded the physician from generating an order. This interpretation is the justification for our having analyzed the no-order subset of sessions for evidence of vaccine-specific effects on "correct" decisions.

Another subset analysis, the proportion of sessions in which a second vaccine was ordered among sessions in which at least one was ordered, was justified by the fact that a physician would see the reminders only if that physician chose to use the Immunization application with the intent of entering a vaccine order. While subset analyses can result in finding spurious associations, both of those presented here had good justifications. The resulting associations were highly significant statistically and the magnitudes were clinically significant.

The main outcome planned for the study was to assess the impact of reminders on correct decisions related to prescribing vaccines. The results of several analyses showed that there was a statistically and clinically significant impact on ordering for Tetanus and Hepatitis B vaccines. This is especially interesting in view of the fact that baseline compliance with Tetanus recommendations was found to be by far the lowest among all vaccines studied[3]. This may in turn reflect the fact that tetanus and diphtheria are disease rarely seen by the primary care physician in this country. This randomized controlled study demonstrates that providing reminders actually increases the review of vaccination history and, in selected cases, had a significant impact on improving compliance with national guidelines.

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