CONCISE COMMUNICATION

Web-Based Electronic Health Records Improve Data Completeness and Reduce Medical Discrepancies in Employee Vaccination Programs

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A Web-based electronic health record (EHR) system was compared with traditional paper-based documentation and vaccination tracking during the 2009 H1N1 influenza pandemic. In a cohort of 8,411 healthcare network employees, EHRs improved completeness of self-reported contraindication data and reduced medical discrepancies. Vaccination program quality and accuracy are enhanced by EHRs.

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Electronic health records (EHRs) can reduce clinical errors and streamline documentation.[1-4] However, few healthcare institutions use EHRs for employee vaccination programs; most instead rely on paper documentation of vaccine eligibility, declination, and administration. This often yields inconsistent, incomplete, or illegible records that must be manually entered into databases for purposes of tracking, reporting, and regulatory compliance.

The H1N1 pandemic of 2009 highlighted the need for improved efficiency in immunizing large numbers of healthcare workers and providing documentation that each employee had received or declined vaccination.[5,6] Although research suggests that the use of declination forms improves vaccination rates among healthcare workers, the usefulness of declination forms in an electronic format has been little explored.[7,8] Additionally, little is known about the impact of EHRs on vaccination errors or data quality. We compared Web-based EHRs with traditional paper-based records to determine the impact of EHRs on the completeness of self-reported contraindications and clinical documentation and on the frequency of medical discrepancies during the 2009 pandemic.

METHODS

A Colorado Multiple Institutional Review Board (COMIRB) exemption was received to obtain deidentified clinical survey data from November and December 2011 for 8,411 employees of a California-based healthcare network of acute care hospitals and outpatient facilities. Data were provided by the healthcare network to Axion Health. The healthcare network provided permission to use deidentified clinical data for research. Axion Health combined paper and electronic records into a single deidentified data set in compliance with COMIRB requirements, to ensure confidentiality. The senior investigator (L.S.N.) remained blinded to the identity and the status (paper form vs electronic form) of participants. Principal analyses were performed in SAS by 3 investigators (M.S., K.E.S., and S.H.S.) at the Colorado School of Public Health (CSPH). All authors contributed to the interpretation of results and manuscript preparation.

Employees were required to receive the H1N1 2009 influenza vaccine or document that they had declined vaccination. Employees chose to complete a vaccination survey using either a Web-based EHR (ReadySet for Healthcare; Axion Health) or a traditional paper form. Electronic forms were accessible through a secure, password-protected Web site on any computer with Internet access, including computer stations at vaccination events. Two electronic forms were available to employees: one to consent to vaccination and indicate vaccine contraindications and one for declination. In contrast, there were 6 vaccination and 3 declination paper forms in circulation during the program, each differing from the others in wording and content. Both electronic and paper systems allowed users to skip survey questions. Vaccinators had the ability to review self-reported survey answers both on paper and in electronic form, to request additional information from employees concerning contraindications, and to provide additional documentation in writing or in text fields. Of the 14 contraindication questions solicited on ReadySet in accordance with the manufacturers' 2009 package inserts, only 3 appeared consistently across all paper forms. These were the only questions that we used to assess data completeness, and they included whether the employee had an egg allergy, was pregnant, or was feeling ill on the day on which the questionnaire was completed. We used χ^2 analysis to compare the frequency of missing data for these 3 questions.

Vaccinators completed clinical documentation either in the EHR or on paper, depending on which form the employee used. Documentation included the route (nasal spray or injection), manufacturer, lot number, dose, and injection site. If a medical contraindication was indicated on the electronic survey, the EHR flagged that answer and provided clinical decision support to the provider (eg, "age >49: live attenuated vaccine contraindicated; consider use of IM vaccine"). Paper forms provided no clinical decision support. The completeness of clinical documentation was compared using χ^2 analysis, based on whether the route of administration was recorded.

We examined the number of employees who may have inappropriately been given vaccine. A "medical discrepancy" was counted when an employee was vaccinated despite reporting an egg allergy, a current febrile illness, a severe adverse reaction to previous influenza vaccination, or a history of Guillain-Barré syndrome after previous influenza vaccination. A medical discrepancy was also counted when live attenuated

TABLE 1. Completeness of Self-Reported Data in Electronic and Paper Form Groups

Group	No. (%) of complete forms[a]	No. (%) of forms with blank responses, by no. of responses left blank			No. (%) of employees with blank responses (n = 4,780)	No. (%) of blank responses (n = 6,278)	Mean no. of blank responses per employee
		1	2	3			
Electronic	1,711/2,389 (71.6)	66/2,389 (2.7)	9/2,389 (0.4)	603/2,389 (25.2)	678 (14.2)	1,893 (30.2)	0.79
Paper	1/4,103 (0.02)	3,827/4,103 (93.3)	273/4,103 (6.7)	2/4,103 (0.05)	4,102 (85.8)	4,385 (69.8)	1.07

NOTE. The 3 self-reported contraindications included in analysis were egg allergy, pregnancy, and feeling ill on the day that the questionnaire was completed.

[a] A complete form was defined as one with no blank responses; $P < .0001$.

vaccine was administered to an employee who had indicated chronic illness, pregnancy, immunodeficiency, or a reported age of 50 years or greater. Frequency distributions and χ^2 analysis were used to compare discrepancies across groups.

RESULTS

The mean age among the 8,411 employees was 44 years (range, 19–89 years). Women, who represented 76.5% of the population (6,441 of 8,411 employees), were more likely to choose the EHRs ($P \leq .0001$). Overall, there were slightly more employees who used paper forms (n = 4,482) than used EHRs (n = 3,929). Seventy-seven percent of the healthcare workers received vaccine (n = 6,492), and 23% (n = 1,919) declined vaccination. The majority of employees who declined vaccination (1,540 [80%] of those who declined) did so electronically, probably because it was more convenient to decline electronically than to do so by filling out a paper form.

Those employees who used a paper form were much more likely to leave one or more medical contraindication questions blank, compared with employees who used an EHR (86% vs 14%; Table 1). Accordingly, 70% of the total number of blank responses came from the paper form group, whereas only 30% of such responses came from the electronic form group. On average, EHR users left 25.8% fewer questions blank (95% confidence interval [CI], 20.8%–30.7%; $P \leq .0001$). The probability of an employee leaving a blank response decreased by 35.0% when EHR was used (95% CI, 30.1%–39.6%; $P \leq .0001$). Of those employees who answered every question (ie, who left no blank responses), 1,711 came from the electronic form group, whereas only 1 came from the paper form group. Clinical documentation completed in the EHR resulted in 29.3% less missing information (95% CI, 14.7%–44.4%), compared with documentation completed on paper ($P \leq .001$).

In the electronic form group, we identified 37 medical discrepancies (1.6%) among the 2,389 employees who were vaccinated. In the paper form group, there were 97 discrepancies (2.4%) among the 4,103 employees who were vaccinated. No employees reported more than one contraindication. The use of EHR was associated with 35.1% fewer medical discrepancies (95% CI, 18.9%–63.6%; $P < .05$). The probability of medical discrepancy was reduced by 35.3% (95% CI, 24.6%–44.4%) when an EHR was used ($P \leq .0001$).

DISCUSSION

In this study, healthcare workers provided more complete information regarding their eligibility to receive influenza vaccine when they used a self-administered, Web-based EHR, compared with a conventional paper form. Clinical documentation was more complete when done electronically. EHRs significantly reduced the frequency of vaccine-related medical discrepancies by alerting providers to contraindications and providing clinical decision support, which promoted compliance with manufacturer and government guidelines.

Despite initial concerns that the convenience of an EHR would lead to a high rate of declinations, we observed a voluntary vaccination rate of 77%, which far exceeded national and state averages for healthcare worker vaccination during the 2009 H1N1 influenza pandemic.[6,7] Although causality cannot be proven, the high voluntary vaccination rate may be related to the design and order of the electronic declination form, which prompted users through a series of questions regarding their reasons for declination, educated them on the importance of healthcare worker vaccination, and allowed them to change their minds before submitting the declination form.

Consistent with other studies, we observed that EHR interfaces that allow patients to self-report personal health information result in more complete information.[9] By prompting patients to answer a series of questions with preestablished response options, administrative errors were reduced and data collection was improved, even when responses were not mandatory.

The observed improvement in clinical documentation associated with EHR is noteworthy and consistent with the literature.[2] Qualitatively, we observed that, by linking the

EHRs to pharmacy lot numbers, expiration dates, vaccine names, and manufacturers, we were able to eliminate illegible documentation and erroneously recorded alphanumeric lot numbers.

The observed reduction in medical discrepancies among EHR users may be attributed to the built-in alerts and clinical decision support features of the system. These alerts called attention to contraindications and displayed information regarding the best vaccination choices for each individual based on rapidly evolving recommendations from government agencies.

Our results bolster existing evidence that EHRs facilitate efficient tracking of participation, program performance, and vaccination outcomes.[4,10] We noted that trend analysis and completion of state-mandated reporting were greatly expedited by real-time electronic data capture. By virtue of the success of this program, the participating healthcare system adopted this EHR for its 2010 seasonal influenza vaccination campaign, during which the EHR was used by more than 99% of employees, virtually eliminating paper usage and post hoc data entry. In 2010, the prevalence of voluntary vaccinations increased to 84% of all employees (data not shown).

Because paper forms contained inconsistent questions, this analysis does not account for all potential medical discrepancies that occurred when providers received incomplete contraindication information. The actual reduction in discrepancies associated with EHRs is likely underestimated. Although sample sizes were approximately equal for the EHR and paper form groups, employees were not formally randomized into these categories, which left some potential for selection bias.

CONCLUSION

Management of influenza is perhaps the best example of a well-defined public health problem that lacks an effective solution.[9] Although surveillance and prevention guidelines exist, overall compliance with these recommendations is low.[6,9] EHRs that improve the quality, accuracy, and tracking of vaccination data can bridge the gap between public health recommendations and tangible improvements in health outcomes.

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Potential conflicts of interest. L.S.N. is the founding Chief Executive Officer and a part-time employee of Axion Health, the vendor that provided deidentified data to the Colorado School of Public Health (CSPH). L.G. is an employee of the healthcare organization that provided the clinical data for this study. All other authors report no conflicts of interest relevant to this article. Axion Health provided no financial support to CSPH or to the healthcare network. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

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