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Review Article

A Literature Review of the Effectiveness of CDS Vaccine Reminders on the Vaccination Rates

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ABSTRACT: Some infectious and contagious diseases can spread like wildfire. Vaccinations can prevent this from happening. They can prevent two to three million deaths every year worldwide. Thirty-three percent of US children are incompletely protected against some vaccine-preventable diseases. The purpose of this paper is to investigate whether clinical decision support alerts or reminders appeared to clinicians can increase vaccination rates or not. To do so, PubMed, Google Scholar and Scopus were searched to find out what has been said about this topic. Among 82 articles, 14 articles were included in this paper based on the inclusion criteria. All the articles support the statement that CDS reminders or alerts can improve the vaccination rate.

INTRODUCTION

Immunization shots can prevent many diseases, some of which are even life-threatening. They can protect against diseases such as measles, mumps, rubella, polio, and influenza. Immunizations are essential for children as well as for adults ("Immunization," 2014). Some people might argue about the side effects of vaccinations; however, the benefits of vaccination outweighs risk of its side effects (Offit, 2013). The more people receive vaccines, the fewer infectious diseases spread among that community ("Key Facts about Seasonal Flu Vaccine", 2014).

The immune system helps the body to combat germs by generating substances to fight them. Once the immune system kills these germs, it remembers the germs and can combat them again. Vaccines contain dead or weak germs. When the vaccines are injected into a healthy person, they stimulate the immune system to respond and then build immunity against that infectious disease. In the past before vaccines, getting sick, which means having a disease and surviving it, was the only way people became immune. Immunizations are a much less risky method to become immune because getting sick is not a controlled method (Kaneshiro, 2014).

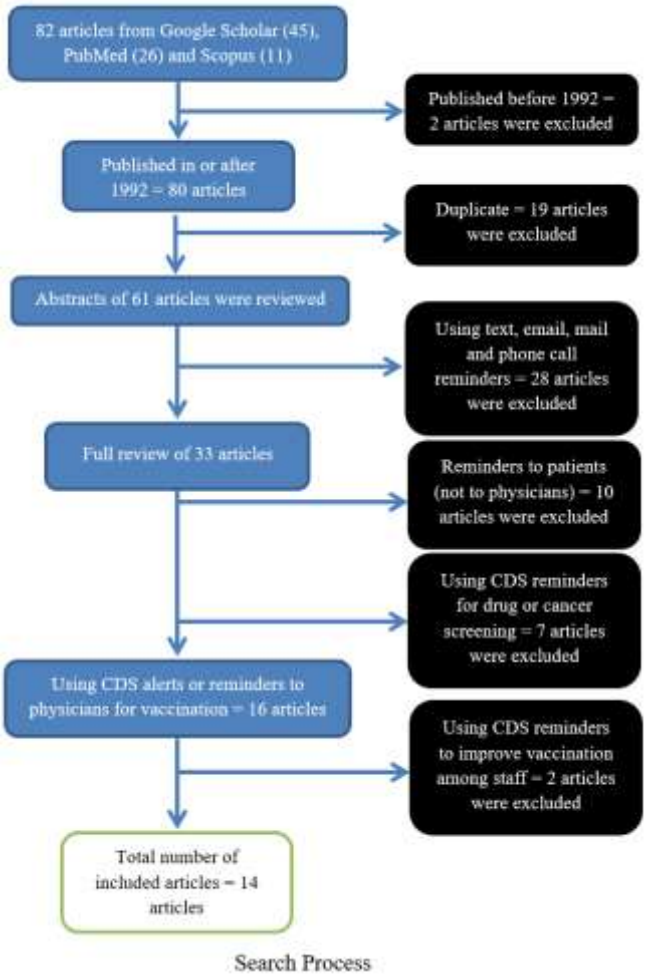
It is estimated that immunization can prevent two to three million deaths every year worldwide by preventing dangerous and life-threatening diseases ("Immunization," n.d.). Thirty three percent of children in the United States are incompletely protected against some vaccine-preventable diseases such as MMR, hepatitis B and varicella (Stockwell & Fiks, 2013). The recent outbreak of measles in the US and Brazil, for instance, suggests that vaccination rates in some regions have fallen below levels needed to eliminate the spread of the disease (Hayatee, 2015). It is estimated that if 95% of a community receives the measles vaccination, the other 5% of that community who either refuses to be vaccinated or cannot be vaccinated, e.g. too young to be vaccinated, will be protected from the measles virus because the virus cannot spread among that community (Grefenstette et al., 2013)

Computerized alerts or reminders are specific types of Clinical Decision Support (CDS) automation which are designed to notify physicians about specific information. Many studies suggest that CDS alerts or reminders can increase vaccination rates (Karsh, 2009). In his book, Greenes (2014) showed findings of a study which revealed that the CDS reminders increased physicians' immunization rate orders. Another study has shown that CDS alerts helped boost the performance of the physicians and enhanced patient care (Persell et al., 2011).

Many health care providers do not have CDS alerts or reminders in their electronic health records system because they might be uncertain regarding their success. Also, some of them believe that there is no strong evidence that CDS immunization reminders can improve vaccination rates among patients, and this area has not been fully explored (Pereira, 2012). The aim of this paper is to show the impact of the CDS immunization reminders on the vaccination rates.

METHOD

This paper is intended to answer the following question: Can CDS vaccination alerts and reminders improve vaccination rates among patients? To do so, PubMed, Google Scholar and Scopus were searched for articles that discussed this topic. The keywords used for searching were (EHR OR CDS OR Clinical Decision Support) AND ("reminder" OR "alert") AND ("vaccination" OR "immunization" OR "vaccine"). The search yielded 82 articles from these databases. Two articles were excluded because they were published before 1992. From the titles, 19 articles were duplicates, leaving 61 articles. Based on abstracts, 28 articles were excluded because they were discussing mail, text, email and phone call reminders. After a full review, 19 articles were excluded because they did not meet the inclusion criteria, leaving 14 articles. The figure below explains more about the search process.



Search Process

Significance of the paper

This paper aggregates some of the benefits of using Clinical Decision Support immunization reminders or alerts and how they can help improve vaccination rates. Moreover, in this paper, some of the barriers of adopting and utilizing CDS vaccination reminders or alerts are discussed and some solutions to overcome these barriers are suggested. This paper may lead to further research on how to make full use of CDS vaccination reminders or alerts and how to improve their utilization.

Results

A. *Background*

Despite the efforts to increase vaccination delivery to people, vaccination rate is still low. Only two thirds of children aged between 19 months to 3 years in the US have completed their primary vaccination series (Stockwell & Fiks, 2013). It is estimated that 36,000 deaths annually in the United States are caused by influenza; moreover, around 431,000 patients in the US are hospitalized every year due to influenza. Eighty five percent of the population in the US is considered at high risk and should be vaccinated against influenza; however, during the 2008 and 2009 influenza season, less than 40% of this population received immunization. Improving immunization rates among people will result in decreasing infectious diseases in that community (Venkat et al., 2010). Therefore, it is important to find a method to enhance the vaccination rate among people.

B. *CDS Vaccination Reminders*

Some people might have concerns about vaccinations and their side effects, which may lead to patient refusal to receive the vaccinations (Freed et al., 2010). It is found that the vaccination rate improves significantly when physicians explain to their patients about the complications from influenza and the benefits of having the influenza vaccination (Cooper and Walton-Moss, 2013). The easiest and most effective way to remind physicians to advise their eligible patients to receive the influenza vaccination is by CDS influenza immunization reminders. According to Fiks et al. (2013), CDS vaccination reminders that appear to physicians were the most effective method to initiate the HPV vaccine series. It has been proven that Using Clinical Decision Support vaccination reminders or alerts can improve the influenza immunization rate (Garg et al., 2005; Shojania et al., 2009; Williams et al., 2011; Aigboguna et al., 2015).

C. *Impact of Health Information Exchange on Vaccination Delivery*

One of the barriers of the implementation and use of CDS immunization reminders is the lack of health information sharing between multiple vaccination providers. Many patients visit more than one health care center and vaccination records of these patients are distributed among multiple hospitals, making it difficult to collect them. This will result in a lack of accuracy and completeness of patient vaccination records (Pereira, 2012). Linking an EHR that contains CDS vaccination reminders to a city immunization information system (IIS) will solve this issue. CDS vaccination reminders will be more efficient and accurate when they are linked to a city immunization information system. A study by Stockwell et al. (2015) investigated the effectiveness of a vaccination reminder in an EHR linked to a regional immunization information system on influenza vaccination rates. The study was conducted during the fall and winter of 2011 and 2012 at four academically affiliated hospitals in New York City that serve a low-income population. The findings of this study showed that influenza vaccination reminders increased vaccination rates during the fall and winter.

D. *A Good Design of CDS Vaccination Reminders*

A better designed CDS system can produce better results and enhancements of health care outcomes ("EHR Clinical Decision Support," 2014). During the implementation of the EHR system into Stroger Hospital, a public hospital in Chicago, Illinois, Gerard and colleagues tested the utilization of a CDS rule to improve the inpatient influenza immunization rate. They evaluated the impact of CDS on the influenza vaccination rate over the 2003, 2005, and 2006 influenza seasons. CDS reminders did not succeed in enhancing the influenza vaccination rates in 2003 and 2005. The reason why the influenza immunization rate did not improve was primarily because the EHR system had an incomplete maturation. The EHR system gradually developed as information was transferred from a paper-based to an electronic-based system. In the third year, 2006, the immunization rate was improved

significantly. More than half of the patients who were hospitalized were vaccinated during their stay in the third year of the study. The results of the study suggest that to successfully implement a CDS in an EHR system, it is important to work on the interaction between health care practitioners and the system, the move of most components to the electronic format, and most importantly, the integration of workflow (Gerard et al., 2008). Failure to integrate a CDS into an EHR might be related to not fully understanding the local workflow and culture of an organization. The implementation of a CDS system requires more attention to local workflow and culture. In addition, it requires deep understanding of what kind of changes in workflow will be necessary. For example, if an organization implements a CDS, workflow disruptions may occur. The time needed for the workers to learn how to use the CDS might slow down the work. Some workers might refuse to use the CDS. Therefore, success of CDS implementation may be realized after decision makers in an organization fully understand the local workflow and culture of their organization (Fenton et al., 2006; Gerard et al., 2008).

There are some important concepts to design an effective CDS immunization reminder system. These concepts include speedy delivery of the reminders to physicians when needed, reminders smoothly shown to clinicians so they do not interrupt the clinicians' workflow, and trust that the reminders are accurate and specific (Bell et al., 2010).

E. *Physician-Centered vs Patient-Centered Reminders*

Physician-based reminders, compared to patient-based reminders such as letters, can yield better results regarding vaccination rate. Fiks et al. (2013) investigated the impact of CDS reminders targeting families, physicians, or both on human papillomavirus (HPV) vaccination rates. A total of 22 primary care practices were cluster-randomized to receive a physician-centered intervention. These interventions were education, EHR-based alerts, and audit and feedback, or none. Patients were randomly assigned into four groups. Each group received one of the interventions which were family-centered, physician-centered, combined, or no intervention. The effectiveness of each intervention was measured by measuring the final vaccination rates. The results of the study revealed that physician-focused interventions, including EHR-based reminders, were more effective and significantly higher than family-focused interventions. Another study by Stockwell and Fiks (2013) showed the importance of some technology-based interventions that have been used to improve immunization rate. The technology-based interventions were either parent-centered, such as text message and email, or provider-centered, CDS reminders for instance. The CDS reminders and alerts appear on-screen to physicians and summarize the vaccines that are due to be given to the patient. The researchers stated that clinical decision support (CDS) reminders and alerts delivered through the EHR is a significantly effective intervention.

F. *CDS Vaccination Reminders to Improve Vaccination Rate among Children*

Children with chronic diseases such as children with asthma or rheumatic disease can be at a high risk of the complications from influenza. For instance, most children admitted to the hospital diagnosed with influenza have asthma ("Asthma & the Flu," n.d.). Influenza vaccination helps protect children with chronic diseases from the severe consequences of influenza which sometimes end in death (Fiks et al., 2009; Patwardhan et al., 2011). Thus, it is critical to protect such children from being infected by the flu virus. To do so, the influenza vaccination rate among children with chronic diseases needs to be improved. One effective way might be by integrating CDS influenza vaccination reminders in an EHR and make them appear to physicians at the time of the patient's visit (Tang et al., 1999).

A study was conducted at 20 primary care sites in Philadelphia, PA, to examine the effect of influenza vaccination alerts on influenza immunization rates among asthmatic children. The findings revealed that influenza vaccination alerts slightly enhanced the influenza immunization rates (Fiks et al., 2009). However, CDS influenza vaccination reminders can significantly, not just slightly, enhance the immunization rate among chronic children. A study by Patwardhan et al. (2011) proved that CDS influenza vaccination reminders integrated in an EHR system of a pediatric rheumatology clinic enhanced the influenza vaccination rate among children with a rheumatic disease. Children with a rheumatic disease are at a high risk of being infected by influenza, because children with a rheumatic disease, juvenile rheumatoid arthritis for example, need immunosuppressive therapy, which results in a decrease in immune system function. The study is a cohort study that lasted for three years; it started in 2007 and ended in 2009. The EHR reminder was implemented in the EHR system of the Nationwide Children's Hospital in central Ohio in September 2009. It was designed to appear to physicians during the patient's visit. These reminders do not disappear until the physicians respond to them. That made them fail-proof. Influenza immunization rates in 2009, after EHR reminders were implemented, were significantly improved compared to the Influenza immunization rates in 2007 and 2008, which was before the implementation of EHR reminders.

Besides influenza vaccination rates among children, CDS immunization reminders can improve the primary immunization series rate among children. A study was done which aimed to investigate the effectiveness of CDS vaccination reminders on the immunization rates among children aged two years old or younger. The study lasted for one year and was done in four primary care centers in Philadelphia, PA. During the year, physicians received CDS vaccination reminders and at the end of the year the vaccination rates were compared to the ones from one year earlier, which were before the intervention of CDS vaccination reminders. The findings of the study showed that CDS influenza immunization reminders increased vaccination rates among children two years old or younger from 81.7% to

90.1% (Fiks et al., 2007).

G. CDS Vaccination Reminders to Improve Vaccination Rate among Adults

Not only can the CDS influenza vaccination reminders improve the vaccination rates among children with chronic diseases, but they can also enhance the immunization rate among adult patients at high risk of pulmonary diseases. A study was conducted in Indiana at a general medicine hospital to evaluate computer-generated influenza vaccination reminders. Physicians at that hospital were randomly divided into two groups. The experiment group received influenza vaccination reminders whereas the control group did not. The results of the study revealed that the influenza vaccination rate of the experiment group's patients was double the influenza immunization rate of the control group's patients (McDonald, Hui, & Tierney, 1992).

Discussion

From the studies that were reviewed, CDS vaccination reminders appear to have a significant impact on the immunization rate. The only study that does not support this statement is the study of Fiks et al. (2009). However, this study does not really reflect the impact of the CDS influenza vaccination alerts on the immunization rate, because the researchers did not study the number of orders made by physicians who were exposed to the CDS alerts. Instead, they just studied the number of children who received vaccines. CDS influenza vaccination alerts might have increased the influenza vaccine orders made by physicians. In this study, there was no specific information about the impact of CDS alerts on vaccination orders and why the flu shots were not given; for instance, parents refused the vaccine be given to their children or physicians ignored them.

***Alert Fatigue*:** Excessive numbers of warnings and reminders that appear on the screen can cause alert fatigue to physicians (Kesselheim et al., 2011). Alert fatigue can cause physicians to override the CDS reminders or alerts. CDS reminders and alerts are not always taken seriously by physicians. For example, in a study by Phansalkar et al. (2013), the researchers stated that due to alert fatigue, 90% of the time the drug–drug interaction (DDI) alerts are overridden by physicians. According to Karsh (2009), CDS reminders are overridden 49% to 96% of the time. They can be found to be impeded and useless because physicians may get alert fatigue. It was found that CDS reminders that appear during a patient's visit can add to clinician overload and cause some physicians to ignore them (Pereira, 2012). Part of the problem might be because health care providers may not have been educated about the CDS reminders or alerts ("Study: Alerts for acute," 2015). Therefore, it is essential to educate physicians about CDS vaccination reminders.

Barriers to CDS Vaccination Reminders Implementation: There are some barriers to the implementation and use of CDS immunization reminders. Some of which involve (Pereira et al., 2012):

1. Financial and resources barriers. CDS system can reduce costs, but the initial implementation of a CDS system can be costly.

2. Lack of reliable and accurate immunization data on which to base alerts. This problem can be solved by linking an EHR system to a state immunization registry.

3. Increased overload and workflow change barriers.

4. Uncertainty about CDS system success.

Solutions to Some Barriers of CDS Vaccination Reminders Implementation: The following are some suggestions for designing a good CDS vaccination reminder or alert to overcome these barriers and to reduce alert fatigue and decrease the override rate (Birmingham et al, 2011).

1. The CDS vaccination reminders within an EHR system should be reliable and accurate.

2. It should involve the immunization data of the patient, and not just notify the physician that the patient needs vaccination. Therefore, the physician does not need to search for the required vaccination.

3. It should not require multiple actions and many responses.

4. It should not interrupt the workflow of the physician. It should appear on the screen in a place that does not disturb the clinician; however, it should be noticeable.

5. It should not require an immediate action and it should not force the physician to respond before he or she continues his or her work.

6. It should stay on the screen (without interrupting the workflow, in the left upper corner for example) until the physician is ready to act on it.

7. It should not strain busy health care practitioners.

8. To solve patient refusal, the CDS immunization reminder should be shown early in the course of the visit so that the physician can introduce the topic to the patient in a timely manner.

9. The CDS vaccination reminder should contain allergy information and the medical history of the patient, and it should allow the physician to directly order the vaccination from it to save his or her effort and time.

10. It should allow the physician to report why the vaccine was not given to the patient and save the information into the EHR.

An Ethical Issue: The purpose of the CDS vaccination reminder or alert is to increase vaccination rate; it should not be used for commercial aims. Physicians are concerned about sponsored alerts, for which industry groups such as drug companies pay. These sponsored alerts will appear on an EHR of a patient when he or she is due for vaccination and will recommend that payer ("Industry Divided Over Use," 2015). Sponsored alerts should not be used in the health care because it is not appropriate to treat health care as a commodity like

other goods and services.

Conclusion

The motivation behind the adoption of CDS systems, which includes CDS vaccination reminders, is to provide better and safer health care (Mitchell, 2011). From the articles included in this paper, it can be said that CDS vaccination reminders or alerts can improve the vaccination rate among child or adult populations. Designing good CDS systems will yield better health care quality and outcomes. Further research needs to be done to find out the barriers to implementing and effectively using CDS vaccination reminders.

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