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An effective computerized reminder for contact isolation of patients colonized or infected with resistant organisms

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ABSTRACT

Purpose: To improve contact isolation rates among patients admitted to the hospital with a known history of infection with Methicillin-resistant *Staphylococcus aureus* (MRSA) and Vancomycin-resistant Enterococci (VRE).

Methods: A before and after interventional study implementing computerized reminders for contact isolation between February 25, 2005 and February 28, 2006. We measured rates of appropriate contact isolation, and time to isolation for the 4 month pre-intervention period, and the 12 month intervention period. We conducted a survey of ordering physicians at the midpoint of the intervention period.

Results: Implementing a computerized reminder increased the rate of patients appropriately isolated from 33% to fully 89% ($P < 0.0001$). The median time to writing contact isolation orders decreased from 16.6 to 0.0 h ($P < 0.0001$). Physicians accepted the order 80% of the time on the first or second presentation. Ninety-five percent of physicians felt the reminder had no impact on workflow, or saved them time.

Conclusion: A human reviewed computerized reminder can achieve high rates of compliance with infection control recommendations for contact isolation, and dramatically reduce the time to orders being written upon admission.

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1. Introduction

The incidence of hospital acquired methicillin-resistant *Staphylococcus aureus* and Vancomycin-resistant Enterococci continues to rise [1]. Early contact isolation of patients colonized or infected with MRSA/VRE can limit their spread [2,3]. Consequently, most institutions try to identify and contact isolate these patients as early as possible during the admission process. Typically this effort uses manual methods for storing information about MRSA/VRE, and manual processes with many steps (e.g. match admission list to list of patients with MRSA/VRE, communication of findings to physician) to get from signal (presence of past MRSA/VRE) to action (order contact isolation). Processes that require continued human attention and effective communication of information are prone to failure [4]. Hence a majority of patients admitted with a history of MRSA/VRE are not isolated in a timely manner and some are not isolated at all.

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Computerized reminders increase compliance with prevention guidelines [5–8]. Computerized alerts notifying infection control of the MRSA status of admitted patients effectively reduced the average time to obtaining follow-up cultures from 25 to 3 days and increased the proportion of MRSA patients recognized at the time of admission from 13 to 40% [9]. This computer system printed paper alerts to the infection control providers, who could then follow-up with the treating clinicians. Our own institution has used manual methods for infection control and follow-up to achieve clinician compliance with isolation guidelines—with poor success. We hypothesized that a computerized reminder system directed to the treating clinicians, using centrally updated, expert-derived electronic data, will improve existing contact isolation compliance rates.

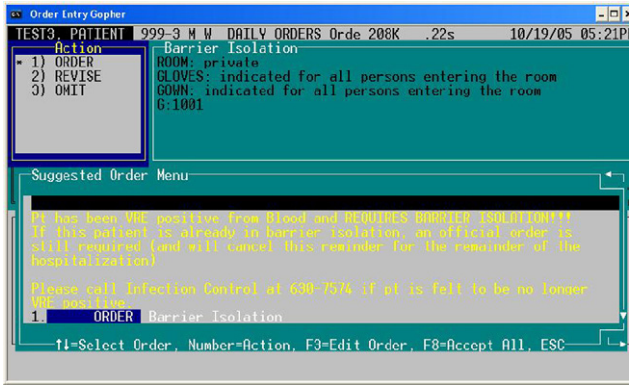

Fig. 1 – Screenshot of a computerized reminder for contact isolation.

2. Methods

2.1. *Setting and subjects*

We conducted a before and after interventional study. We obtained approval for this trial from the Institutional Review Board at the Indiana University Medical Center, Indianapolis. The study took place at Wishard Memorial Hospital, a 264-bed primary care hospital serving an urban population in Indianapolis. We collected baseline data on inpatient isolation orders for 4 months from November 1, 2004 until the start of the intervention on February 25, 2005. We implemented the computerized reminder from February 25, 2005 until February 28, 2006, for all admissions to Wishard hospital. Study subjects included all physician housestaff and faculty writing orders for hospitalized patients. Physicians routinely enter all hospital orders into the "Gopher" electronic physician order entry system.

In the baseline (before) period, infection control maintained a standalone database of patients with a prior history of colonization or infection with MRSA or VRE and had not undergone decontamination. Infection control sent a paper printout of this list to bed control. Bed control personnel would match each admission against this list, and communicate this information to the ward nurse who would then ask the treating physician to write the order for contact isolation. Infection control did not conduct active surveillance during the time of this study.

2.2. *Physician reminders*

We performed a one-time batch electronic entry of the separately maintained infection control database into the Gopher Order entry system. Data elements captured in standardized vocabulary terms included patient medical record number, type of infection (MRSA and/or VRE), site of infection, and date of entry into system. We created electronic entry forms that infection control used to maintain their historical table of patients with MRSA/VRE directly within the Gopher physician order entry system. Infection control curated this list by adding and removing patients based on sources of information beyond routine cultures (e.g. a patient with a known history of infection from an outside institution). We created G-CARE [10] rules that suggested contact isolation orders for patients on the Gopher electronic MDRO list who did not yet have an order for contact isolation during the current hospitalization. When a physician began to write orders for a patient who satisfied these rules, the computer popped up a reminder about the need for such an order and presented a canned order for the same. The provider could initiate the order with one key stroke as shown in Fig. 1. This reminder appeared every time a physician initiated an order for that patient, until either the patient was discharged, or an order for contact isolation was written (Fig. 1). All physicians placing orders on hospitalized patients were included in the study.

2.3. *Definition of outcomes*

We captured detailed information on the reminders delivered during each order session. Data included provider name, patient name and medical record number, time and location of presentation, and result of reminder (accept or decline). We defined a patient as eligible for contact isolation if they had a history of colonization or infection with MRSA or VRE per the electronic list, prior to the admission date. We defined the time to isolation order as the difference in time between patient arrival at a ward bed and when a contact isolation order was written, as captured electronically from our patient registration system, and the Gopher electronic order entry system. For analysis, negative times to isolation order (indicating the order was written prior to arrival on the ward) were treated as zeros. Nosocomial infections were defined as positive culture results for MRSA or VRE occurring greater than 48 h after admission to the hospital.

2.4. *Cross-sectional survey*

We conducted a cross-sectional, anonymous, 10 item survey of a subset of the ordering physicians at the midpoint of the intervention period (N = 27). The convenience sample represented medicine housestaff (25 out of 27) and one infectious disease fellow and one medical student.

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2.5. *Statistical analysis*

We compared the proportions of patients isolated during the baseline pre-reminder period and the reminder period using the chi-square test. We used SAS software 8.2 (SAS Institute, Inc., Cary, NC). All tests were one tailed with a P value <0.05 considered significant. For comparison of compliance rates between staff and housestaff and medical versus surgical services, we used generalized estimation equations to account for clustering within patients with multiple visits, or physicians presented with multiple reminders.

3. Results

There were 5835 admissions during the 4 month baseline period, and 17,961 admissions during the 12 month intervention period for a total of 23,796 admissions.

Using manual methods during the baseline period, bed control identified 109 admissions (1.9%), (85 unique patients) with MRSA (92%) or VRE (8%) who were eligible for contact isolation and physicians wrote contact isolation orders on 33% of them. For patients with isolation orders, the median time between ward arrival and isolation order was 16.6 h. Contact isolation orders were written before arrival on the ward in only 8% of the eligible admissions.

During the 12 month intervention period, the computer system identified 520 admissions (296 unique patients) with past documented MRSA (93%) or VRE (7%) infection or colonization comprising 2.9% of all hospital admissions. Physicians complied with the reminder and wrote contact isolation orders on 89% of eligible admissions, and did so before the patient arrived on the ward 63% of the time (compared to 8% in the base line period, $P < 0.0001$). Median time between arrival on the ward and isolation order decreased from 16.6 to 0.00 h, at a significance of $P < 0.0001$ (Table 1).

During the intervention period reminders were presented 1437 times to 372 unique clinicians. Individual clinicians were presented with the reminder from 1 to 37 times over the course of the study. Of these reminders, 89% were delivered to housestaff and 11% to attending physicians. By service, the distribution was 80% medical and 20% surgical services. Using generalized estimating equations to account for clustering by physician or patients, there was no significant difference in compliance rates between housestaff and staff physicians or between surgical and medical services.

Sixty-three percent of the time, physicians accepted the reminder on the first presentation, increasing to 80% by the second presentation and to 89% including all presentations during an admission. In our mid-study survey, 95% of respondents (19/20) reported that the reminder either had no negative effect on workflow or saved them time (30%). Ninety-three percent (25/27) agreed with automatic contact isolation, and half of these (13/25) would simultaneously request surveillance swabs.

During the intervention period, the number of patients with known MRSA or VRE increased from 1047 to 1859, which reflected an increased ability of the infection control service to both identify patients and update the list. Echoing national trends, rates of nosocomial infections with MRSA/VRE increased from 5.7 versus 7.3 infections/1000 admissions over the 16 months of the study, but the difference between the 4 month baseline period and intervention period was not significant ($P = 0.2$).

4. Discussion

Computerized reminders had a dramatic and significant effect on both the writing of contact isolation orders, increasing the rate from 33 to 89%, and the timeliness of those that are written (from 8% before arrival on the ward to 57%). In this study the physician complied with an unprecedentedly high 89% of the reminders for contact isolation—principally because the reminder was based on specific and accurate data and was consistent with physician's intentions. In prior vaccination studies at the same institution [6,7], our compliance rate peaked at 56%, as a significant portion of the reminders triggered on ineligible patients, based on missing (e.g. prior vaccination) or inaccurate data in the medical record system. Studies at other institutions achieved compliance rates of 41% for reduction in ordering contraindicated medications [11] and 69% for reduction of redundant laboratory tests [12]. Other key factors contributed to the high compliance rate in this study: Physicians agreed with the need for contact isolation in this subset of patients and the reminder accurately flagged these patients to the physician's attention at the ideal point in the workflow. The Gopher order entry system is well meshed into clinician workflow and achieves sub second "screen flips" and saved the clinician, bed control, and infection control from having to check a patient's infection history at each step along the way. The expert group that made the determination, in this case infection control, was clearly stated in the reminder and provided with a simple electronic means to maintain this list. We harmonized this process with infection control's ongoing efforts to curate the data to ensure a sustainable, up to date, and reliable reminder.

Our study confirms the infection control literature that well designed medical record systems will improve the control of drug resistant infections [2]. In a prior study, Pittet et al., used computer generated paper reports to notify infection control of the MRSA status of admitted patients. Infection control then followed-up with the treating clinicians directly. This intervention reduced the average time to obtaining follow-

Table 1 – Ordering rates for contact isolation for eligible patients

	Pre-intervention (4 months)	Intervention (12 months)	P value (Chi-square)
Eligible patients isolated, n (%)	36/109 (33%)	463/520 (89%)	<0.0001
Ordered before arrival on ward, n (%)	9/36 (25%)	265/463 (57%)	<0.0001
Median time to isolation (h)	16.6	0.0	n/a

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up cultures from 25 to 3 days and increased the proportion of MRSA patients recognized at the time of admission from 13 to 40% [9]. Our study had a stronger effect we believe due to the fact that the computer delivered its information about MDRO cases directly to the physician—leaving out the middle step that required infection control to reach the physician manually. Further it did this during the physicians' normal work flow while they were entering orders into the computer, and required only a single key press to generate the order for contact isolation.

Our study had a number of limitations. It was conducted at an inner city hospital where physicians (mostly residents) entered all orders through the computer—so we cannot be certain that the results will be apply to other kinds of institutions. Baseline contact isolation rates were low, and the effect of this intervention would likely be less at an institution with a higher baseline isolation rate. It was a before and after study design and is subject to confounding by trends in clinical procedures, although there were no significant infection control policy changes during the course of the study. Our survey data were anonymous, and conducted at only one point in the study. It is unclear if survey results would have sustained by the end of the study, although our compliance rates suggest that physicians accepted this reminder into their daily workflow.

In addition, the benefits of contact isolation must be balanced against the additional cost [13], and evidence that patients in contact isolation may express less satisfaction with their treatment and receive less documented care [14]. During our study, annual isolation gown expenditures increased 23% from the same time period a year earlier (from US$ 167,000 to US$ 205,000). This increase is consistent with reports at other institutions, although evidence overwhelmingly favors strict contact isolation when factoring in the cost savings in prevented nosocomial infections [15–17].

Despite improved compliance with contact isolation rates, we saw no significant improvement in the rates of nosocomial infections. In fact, the trend was toward more nosocomial infections in the intervention period. However, some of this increase may have been due to improved reporting. For the purpose of this study we developed computer tools to help the infection control team capture and manage their list of patients harboring MRSA/VRE. These tools freed up the infection control providers to engage in more active reporting and investigation. Indeed, the absolute number of patients on the MRSA/VRE list maintained by infection control increased by 78%, but nosocomial rates increased by only 28% (32 additional cases) which was not statistically significant. Our intervention was in response to steadily increasing nosocomial infection rates over the previous few years and our rates may have increased more dramatically without this intervention. This increase is also consistent with national trends toward greater numbers of MRSA and VRE infections—including the recent emergence of a new strain of community-acquired MRSA [18].

So we must do more to contain the spread of these infections. Preliminary work from our institution, suggests that a significant portion of MRSA and VRE patients travel from institutions where their MRSA/VRE status is known to institutions where it is not. The sharing of MRSA/VRE lists between institutions can reveal this reservoir of MRSA/VRE and eliminate their contribution to the overall MRSA/VRE rate. To identify the patient population traveling between institutions within our community, we are expanding our electronic patient registry throughout our regional health information organization [19] to enable comprehensive community-wide tracking of infectious patients.

Active surveillance cultures can identify other hidden reservoirs of MRSA and by immediately isolating these patients—further reduce nosocomial spread [20]. Because of the high expense of active surveillance, use is typically limited to certain high-risk units. However prediction rules based on data easily collected from electronic medical records can help target active surveillance to high-risk patients [21]. We will explore the use of prediction rules to target active surveillence at high-risk patients with the goal of further reducing the pool of unrecognized MDRO patients and the chance of nosocomial spread. Computerized reminder systems could execute these prediction rules and generate reminders for testing high-risk patients and initiating decontamination procedures among those who test positive.

Summary points

What was known before the study?

- Computerized reminders are effective to improve compliance with prevention guidelines for both inpatients and outpatients.
- Low compliance rates due to reminder fatigue and inaccurate data compromise the efficacy of computerized reminders.
- Computerized reminders may be poorly adopted, and in fact, may be a source of medical errors.
- Contact isolation can reduce the spread of nosocomial infections.

What this study adds?

- Computerized reminders can be designed to be well accepted by clinicians resulting in high compliance rates.
- Human review may be a key component to achieving accurate data to power computerized reminders.
- Contact isolation, by itself at a single institution does not necessarily reduce rates of nosocomial infections.

5. Conclusions

Thirty years ago McDonald noted in the title of the first randomized trial of computer reminders that "man" (including the individual physician) is not perfectible [4]. Since then, we have proven that computerized reminders dramatically improve the physician's delivery of preventive care [6,7,22] among eligible patients, but given that computer reminders do not produce 100% acceptance a corollary is also true: com-

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puterized reminders based on human determined protocols are also imperfectable.

In this study, we demonstrated the greatest compliance rate for a protocol-based computerized reminder. We achieved this through a hybrid model, whereby the computer delivered a recommendation based on data derived and maintained by local experts (infection control). Such timely delivery of human endorsed recommendations may help address concerns about the application of rigid computer system designs to complicated clinical systems [23,24].

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