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RESEARCH ARTICLE

Evaluation of a pharmacist-led antimicrobial stewardship service in a pediatric emergency department

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Abstract

Background To improve antimicrobial use, incorporation of a pharmacist in antimicrobial stewardship initiatives in the emergency department has been recommended. Recognizing the potential value, a pharmacist-led antimicrobial stewardship (AMS) service which included review and follow up of microbiology results for patients discharged from the pediatric emergency department (PED) with suspected infections was implemented at our local institution. *Objective* The objective of this study was to evaluate the impact of pharmacists delivering this service compared to usual care. *Setting* Pediatric emergency department at the IWK Health Centre in Halifax, Canada. *Method* This study was completed as a retrospective chart review of pediatric patients discharged from the PED 6 months before and after implementation of the pharmacist-led AMS service. Data was extracted from electronic medical records. Data were reported descriptively and compared using a two-sided chi-square test and ordinal logistic regression. *Main outcome measures* The primary outcome measure was rate of return visits to the PED within 96 h of initial presentation. *Results* This study included 1070 patient encounters pre-implementation and 1040 patient encounters post-implementation. The rate of return visits to the PED within 96 h was 12.0% (129/1070) pre-implementation vs. 10.0% (100/1049) post-implementation ($p = 0.07$). The rate of return visits or hospitalization at 30 days was 22.1% (237/1070) pre-implementation compared to 19.9% (207/1040) in the post-implementation phase ($p = 0.21$). Inappropriate antimicrobial therapy was identified more often in the pre-implementation phase (7.0%, 68/975) vs. the post-implementation phase (5.0%, 46/952), $p = 0.047$. Time to notification within the first day after discharge occurred more frequently in the post-implementation phase (53.3%, 80/150) as compared to the pre-implementation phase (40.3%, 52/129, $p = 0.0298$). *Conclusion* Although this pharmacist-led AMS service did not significantly affect the rate of return visits or hospitalization, it may have led to more judicious use of antimicrobial agents and faster time to notification.

Keywords Antimicrobial stewardship · Clinical pharmacist · Emergency department · Microbiology

Impact of practice

- It would potentially be benificial to expand clinical pharmacy services to pediatric patients discharged from the emergency department.
- Incorporation of a pharmacist in the microbiology review and follow up process for patients discharged from the emergency department may benefit patients and healthcare systems.
- Pharmacists delivering this service may contribute to improved use of antimicrobial agents and a resulting decreasing in resistance.

Introduction

In response to concern of increasing rates of antimicrobial resistance (AMR) nationally and internationally, the Canadian federal government has developed a framework for action to mitigate the risks associated

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with AMR. Antimicrobial stewardship (AMS) is recommended as a core component of this framework [1]. AMS is defined as "coordinated interventions designed to improve and measure the appropriate use of antimicrobial agents by promoting the selection of the optimal antimicrobial drug regimen including dose, duration of therapy, and route of administration" [2]. Recognizing the importance of AMS, Accreditation Canada has listed AMS as a required organizational practice for accreditation of healthcare institutions in Canada [3]. Implementation of AMS initiatives has resulted in a reduction in length of hospital stay, improved use of antimicrobial agents, and a reduction in associated costs [4, 5].

Despite recognized benefits of AMS initiatives and programs, most evidence supports AMS in inpatient settings rather than in the emergency department (ED). A recent systematic review of AMS interventions in the ED highlighted a need for additional research in this area [6]. Identified barriers to implementing AMS in the ED include acuity, diagnostic uncertainty, and high patient volume [7]. Incorporation of an ED pharmacist as part of a multidisciplinary team in addressing antimicrobial use has been suggested [8]. Various roles of the ED pharmacist have been recommended including participation in review of microbiologic testing and follow-up [7, 8]. Although studies have evaluated pharmacist participation in review of microbiologic testing and follow up of patients discharged from the ED [9–15], no studies have evaluated pharmacists' independent microbiologic review and follow up in a pediatric emergency department (PED).

Recognizing the potential value of incorporating clinical pharmacists in the microbiologic review and follow up process, a collaborative practice agreement (CPA) was developed for a collaborative prescribing model in the PED at the IWK Health Centre in Halifax, Nova Scotia, Canada. Pharmacists' scope of practice, including ability of pharmacists to prescribe, is increasingly expanding in Canada and varies by jurisdiction. One province in Canada has independent prescribing of all prescription medications (schedule I drugs excluding those in the *Controlled Drugs and Substances Act*). Five additional provinces including our province of Nova Scotia allow pharmacists to initiate, manage or adapt a prescription under their own authority in collaborative practice settings or with collaborative agreements [16]. Provincial legislation in Nova Scotia specifies that pharmacists can independently prescribe when provided a diagnosis and in a suitably collaborative practice environment approved by Council. Examples of approved settings include a hospital, a home for special care, or a multidisciplinary environment where collaborative relationships or appropriate protocols are in place [17].

Aim of study

The aim of this study was to evaluate the impact of a pharmacist-led microbiologic review and follow up program for patients discharged from a PED.

Ethics approval

This study received ethics approval from the IWK Health Center Research Ethics Board (Project #1021512).

Method

Study design and setting

This study was completed as a retrospective chart review prior to and post-implementation of a pharmacist-led microbiologic review and follow up service. The study was conducted in the PED at the IWK Health Centre in Halifax, Canada. The IWK Health Centre is a tertiary hospital that provides care to women, children, and families in the Maritime region of Canada. The PED is the only tertiary PED in the Maritime Provinces of Nova Scotia, New Brunswick, and Prince Edward Island and has approximately 33,000 visits annually [18].

Population

Pediatric patients (≤ 18 years of age) who were assessed by a physician, had microbiologic testing that was part of the CPA completed during their PED visit, and were discharged from the PED were included in this study. Microbiologic testing that is part of the CPA includes: urine cultures, skin or wound swabs, throat swabs, stool cultures, gonorrhea and chlamydia cultures, nasopharyngeal swabs, sputum cultures, methicillin resistant *Staphylococcus aureus* screens, and herpes simplex virus swabs. Blood, cerebrospinal fluid, or synovial fluid cultures are excluded from the CPA; as well, any repeat microbiologic tests or follow up tests were not included in this study. We excluded patients < 3 months of age, patients who had left the PED before being assessed

by a physician, patients who had been admitted to hospital from the PED, and those who were prescribed intravenous antimicrobial agents as they were not part of the CPA.

Intervention and comparator

Prior to implementation of the CPA, the microbiologic review and follow up process involved manual broadcasting of a lab result by the microbiology technician to the PED printer. Support staff affixed the result to the patient's treatment record. A physician working in the department was assigned to review the results, take action and document on the patient's treatment record. This physician was also seeing patients in the ED while reviewing results and was subject to multiple distractions.

Incorporation of nurses, nurse practitioners, or other healthcare providers in the microbiologic review and follow up process had been explored. Financial constraints limited the ability of nurse practitioners to work in this capacity. Lack of prescribing privileges for nurses limits their ability to take action on lab results for discharged patients. Addition of a clinical pharmacist to the PED with an expanded scope to prescribe under a CPA presented an opportunity to consider how a clinical pharmacist's specific scope of practice and skills could best be used to enhance patient care. To improve workflow in the PED, pharmacists began to independently review and follow up with patients in January 2017 within the scope of a CPA. Clinical pharmacists initiate, modify, or discontinue drug therapy as required for patients with suspected infections discharged from the PED based on results from specific microbiologic laboratory tests and review of patients' presenting illness as documented in patient charts. Pharmacists review microbiologic test results during regular business hours (Monday to Friday), assess for drug therapy problems, revise pharmacotherapy as required, provide follow up and education to the patient and/or their caregivers when modifications of therapy are indicated, and document interventions. While delivering this service, pharmacists are physically located in the PED where they have access to patient charts and can communicate and interact with other members of the healthcare team including emergency physicians should questions arise. Pharmacists also communicate with external healthcare providers and/or patients and caregivers as required. Physicians in the PED continue to provide this service delivered in the same manner outside regular business hours and on weekends and holidays.

Data collection

The microbiology department electronically generated a list of all patient encounters with microbiologic testing, meeting inclusion criteria, ordered by a healthcare provider in the PED during our study period. Electronic medical records of identified patient encounters were retrospectively reviewed in Meditech® for a 6 month period prior to implementation (January 1st to June 30th, 2016) and a 6 month period post-implementation (February 1st to July 31st, 2017) of the CPA.

An undergraduate pharmacy student (KMM) collected data from electronic charts using a standardized data collection form. The student received training on data extraction by a member of the research team (MM). Data elements included: patient demographics, current or previous antimicrobial use, diagnosis (classified according to ICD-10 codes) at initial PED presentation as documented by the most responsible physician, culture and sensitivity results, empiric antimicrobial selection (including dose, route of administration, and planned duration of use), type of follow up after discharge and time to notification of culture results (if applicable), modifications to antimicrobial agents following discharge (if applicable), and return visits (with reason) to the PED or subsequent hospitalization within 30 days of initial presentation. Data were entered into an Excel database.

Outcome measures

The primary outcome measure of interest was rate of return visits to the PED, for any reason, within 96 h of discharge. This outcome measure was chosen to demonstrate the potential impact pharmacists may have on improving delivery of care to patients discharged from the PED at the patient and institutional level. Secondary outcome measures included: unplanned return visits to the PED for worsening of the initial presenting illness at 96 h, combined return visits to the PED or hospitalization within 30 days, time to patient and/or caregiver notification, and appropriateness of antimicrobial therapy. Time from initial presentation to patient and/or caregiver notification was categorized as < 1 day, 1 to < 2 days, 2 to < 3 days, 3 to < 4 days, and at least 4 days.

The data abstractor used an objective approach to determine appropriateness of therapy by comparing antimicrobial selection to available culture and sensitivity results. Therapy was deemed inappropriate if a bug-drug mismatch was identified and not addressed, an antibiotic was continued despite negative culture results, or an antibiotic was not initiated despite positive culture results where an active infection was suspected. To ensure data extraction quality a second member of the research team (EB), who did not practice in the PED at the time of data collection, evaluated the data extractor's assessment of appropriateness for each patient encounter. For listed diagnoses that may have warranted antimicrobial use despite negative cultures (e.g. acute otitis media, pneumonia, cellulitis), appropriateness of antimicrobial choice was further determined by assessing adherence to local guidelines by members of the research team (EB

and KMM). If disagreement arose, a third member of the research team (KFH or MM) was consulted. Appropriateness was categorized as "unable to assess" in patients who were receiving antimicrobial agents on admission or had received an antimicrobial agent within the past 48 h and had a negative culture that may have resulted from recent antimicrobial use.

Data analysis

Results pre- and post-implementation were summarized descriptively using mean (standard deviation), median (interquartile range) and frequency (count). Return visit rates and appropriateness of antimicrobial therapy pre- and post-implementation were compared using Chi-squared test, Students t-test or Wilcoxon rank sum test where appropriate. Time to patient notification was compared using ordinal logistic regression. The proportional odds assumption was tested.

Results

A total of 1070 patient encounters in the pre-implementation phase and 1040 patient encounters in the post-implementation phase were included in our study. Baseline characteristics of the patient population are outlined in Table 1. Overall, 2277 microbiologic tests were completed in our study population. Urine cultures were the most commonly ordered microbiologic test (39.4%, 898/2277). Overall, 75.1% of microbiologic tests were negative (76.1%, 890/1169 pre-implementation and 74.1%, 821/1108 post-implementation). The most commonly isolated organisms in both arms were Group A *streptococcus* (32.9%, 97/295 pre-implementation vs. 48.1%, 139/289 post-implementation) and *Escherichia coli* (24.1%, 71/295 pre-implementation vs. 24.9%, 72/289 post-implementation).

The most responsible physician documented a total of 2123 diagnoses for 2110 patient encounters discharged from the PED. A diagnosis was missing or unknown in 25 patient encounters. Figure 1 provides the top 10 most common diagnoses documented on discharge from the PED overall and in each study arm. Approximately 10% of patient encounters were categorized as "ongoing workup" to confirm the diagnoses (12.5%, 135/1078 pre-implementation vs 7.1%, 74/1045 post-implementation). The most frequently documented diagnosis overall was acute pharyngitis (9.8%, 106/1078 pre-implementation vs 16.5%, 172/1045 post-implementation). Approximately a quarter of patient encounters (22.1%, 466/2110 encounters) were prescribed at least one empiric antimicrobial agent (total of 471 antimicrobial agents prescribed) on discharge from the PED. The most commonly prescribed empiric antimicrobial agent in both arms of the study was

Table 1 Baseline characteristics of patients discharged from the pediatric emergency department

Characteristic	Pre-implementation N = 1070	Post-implementation N = 1040	*P* value
Age in years, mean (SD)	5.8 (4.4)	6.1 (4.4)	0.14
Gender			0.22
Female	58%	61%	
Male	42%	39%	
Microbiologic testing (N = 2275 tests)	N = 1169	N = 1108	P < 0.001
Urine culture	37.6%	41.3%	
Throat culture	29.9%	37.7%	
Other	32.3%	21%	
Medication allergy			0.40
Yes	9%	8%	
No	89%	90%	
Current antibiotic use			0.13
Yes	11%	10%	
No	88%	90%	
Previous antibiotic use in past 90 days			< .001
Yes	6%	3%	
No	94%	97%	
Empiric antimicrobial agent prescribed			0.1433
Yes	23.5%	20.7%	
No	76.5%	79.3%	

*Data may not sum 100% as some characteristics were missing or unknown

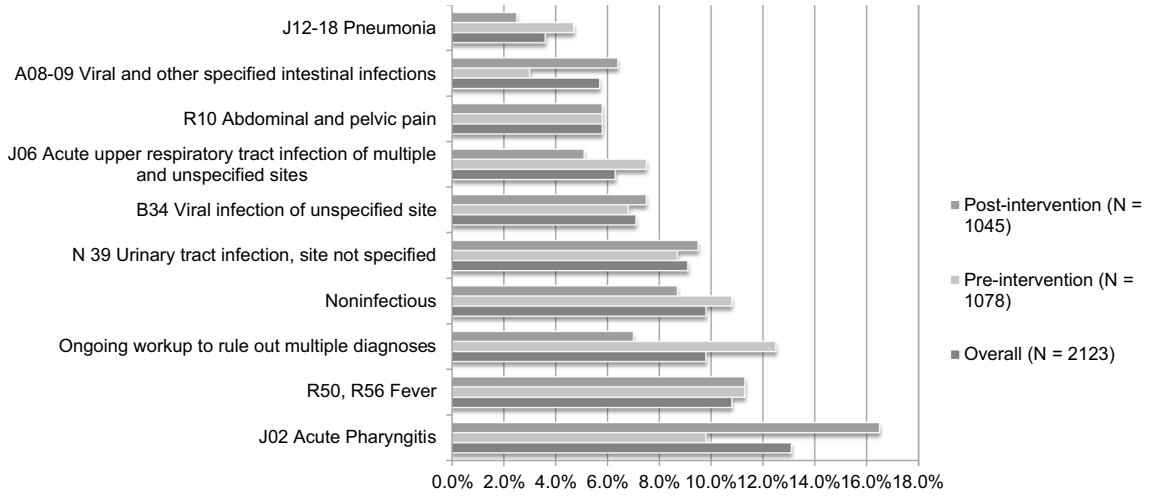

Fig. 1 Top 10 documented diagnoses at discharge from the pediatric emergency department

cephalexin (28.2%, 71/ 252 pre-implementation vs 31.1%, 68/219 post-implementation).

Significantly fewer patients received follow up by the PED (12.1%, 130/1070 vs. 15.3%, 159/1040, $p = 0.038$) or a modification in drug therapy based on microbiology results in the pre-implementation phase as compared to the post-implementation phase (10.0%, 108/1070 vs. 14.0%, 146/1040, $p = 0.005$). Of patients who received follow up from the PED, time to initial contact with the patient and/or caregiver within the first day after discharge occurred more frequently in the post-implementation phase (53.3%, 80/150) as compared to the pre-implementation phase (40.3%, 52/129, $p = 0.0298$). Table 2 outlines time to notification by implementation phase.

Rate of return visits to the PED within 96 h in the pre-implementation phase was similar to the return visit rate in the post-implementation phase (12.1%, 129/1070 vs. 9.6%, 100/1040, $p = 0.07$, respectively). The most common reason for return visits was failure to improve (8.5%, 91/1070 pre-implementation vs. 6.4%, 67/1040 post-implementation, $p = 0.0719$). Combined return visit rate to the PED or hospitalization within 30 days also showed no statistically significant difference between pre- and post-implementation (22.1%, 237/1070 vs. 19.9%, 207/1040, $p = 0.21$, respectively). Reasons for return visit within 96 h and 30 days are outlined in Figs. 2 and 3.

Appropriateness of antimicrobial therapy based on microbiology test results was assessed in 975/1070 of patients in the pre-implementation phase and 951/1039 of patients in the post-implementation phase. The remaining patients were categorized as "unable to assess". A third reviewer adjudicated appropriateness of therapy in 2.1% (22/1070) of patient encounters in the pre-implementation phase and 1.7% (18/1040) of patient encounters in the post-implementation phase. A significantly higher rate of inappropriate antimicrobial therapy was identified in the pre-implementation phase (7.0%, 68/975) compared to the post implementation phase (4.8%, 46/952), $p = 0.046$. The most common reason for inappropriate antimicrobial therapy in both arms was continuation of an antimicrobial agent despite negative microbiology results (4.1%, 40/975 pre-implementation vs. 4.3%, 41/952 post-implementation, $p = 0.8233$).

Discussion

Results from this study provide additional evidence to support delivery of a pharmacist-led microbiologic review and follow up service. This is the first Canadian study to report on the impact of pharmacists within an interdisciplinary team of healthcare providers in this capacity. In addition, this is the first study to report on pharmacist participation in this type of intervention with independent prescribing authority. Finally,

Table 2 Time to patient or caregiver notification in days

	< 1 day	1 to < 2 days	2 to < 3 days	3 to < 4 days	At least 4 days
Pre-intervention (N = 129)	40.3% (52)	16.3% (21)	27.1% (35)	7.8% (10)	8.5% (11)
Post-intervention (N = 150)	53.3% (80)	14.0% (21)	20.7% (31)	8.0% (12)	4.0% (6)

Odds ratio post-intervention vs pre-intervention = 1.631, 95% confidence interval (1.053 – 2.527)

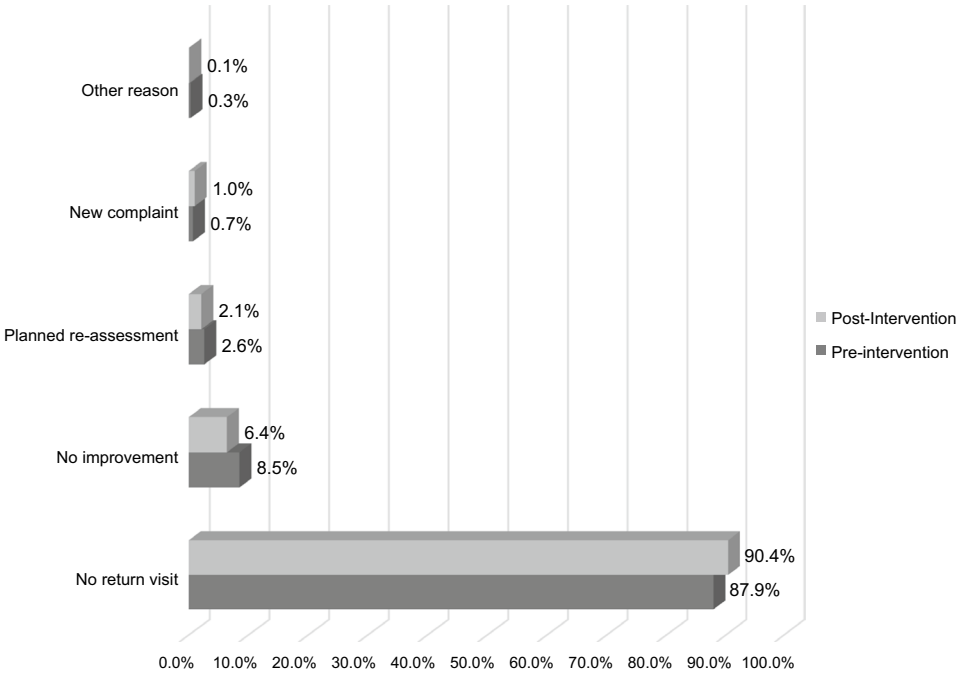

Fig. 2 Reason for return visits to the pediatric emergency department within 96 h

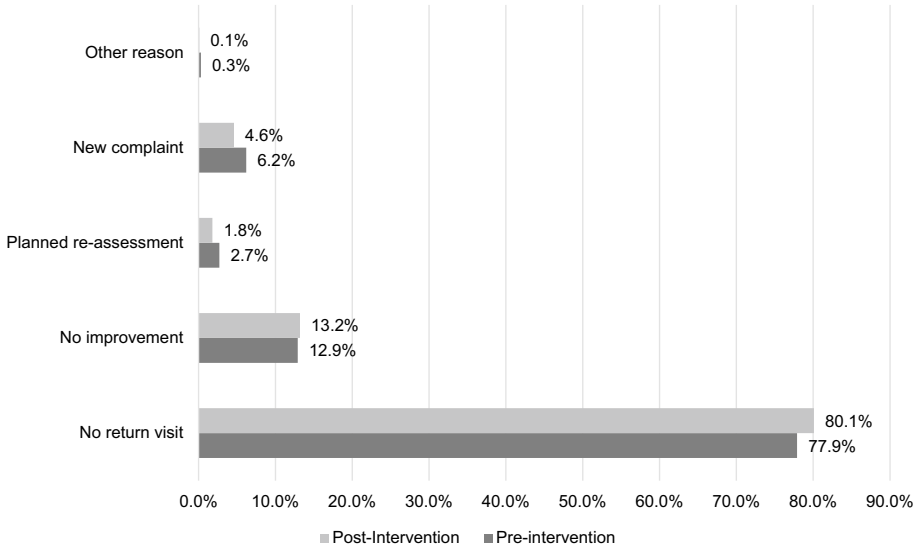

Fig. 3 Reason for return visits to the pediatric emergency department or hospitalization within 30 days

our results provide evidence to support pharmacists in this role who practice in a pediatric emergency setting.

Studies in other settings provide evidence to support integration of pharmacists into the microbiologic review and follow up process for patients discharged from the ED. The largest retrospective study by Randolph et al. demonstrated a significant reduction in unplanned ED readmission rates within 96 h through implementation of pharmacist-managed review of microbiologic testing and follow up [8]. Consistent with our findings, pharmacist review and follow up has also shown a reduction in the number of days to patient and/or provider notification of culture results [9] and a decrease in the proportion of antimicrobial revisions that were deemed inappropriate [10]. These studies assessed involvement of a pharmacist practicing within a multidisciplinary team providing microbiologic review and follow up to adults discharged from EDs.

Although our study provides additional evidence to support the role of pharmacists in providing microbiologic review and follow up to patients discharged from PEDs, a number of limitations should be considered. Our study was a retrospective chart review. Due to the unique nature of our study setting and limited number of hospitals in Canada offering this service, other types of designs including a randomized controlled trial or quasi-experimental designs such as a controlled before-after study were not feasible.

Since data were collected retrospectively, we were unable to clarify information in medical records with the healthcare team. In addition, lack of documentation in some instances led to missing data elements. Exact time (in minutes) to caregiver notification could not be determined due to lack of documentation in some medical records which led us to compare time to notification in days. Furthermore, due to lack of provincial electronic medical records we were unable to determine if patients sought care at healthcare facilities outside our PED however, since this is the only PED in the region many patients would return to this facility for further care if it were needed. We also considered events or changes in PED policies and procedures that may have impacted results. During our study period, a new electronic application was launched to disseminate empiric guidelines for management of infectious syndromes. We do not believe release of this application impacted results as our primary outcome evaluated impact of the service on antimicrobial prescribing at follow up based on microbiology test results and not empiric antimicrobial prescribing. No other major changes in practice or policies were likely to have impacted microbiologic test review and follow up in our PED.

Conclusion

Our study demonstrates the benefit of incorporating a pharmacist into the microbiologic test review and follow up process for pediatric patients discharged from a PED. Involvement of a pharmacist in this capacity may lead to more judicious use of antimicrobial agents and more efficient follow up with patients and/or caregivers. Other PEDs evaluating processes to improve efficiency and improve care to patients with suspected infections discharged from the PED may benefit from the experiences described.

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Conflicts of Interest Authors of this manuscript have no conflicts of interest to disclose.

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