Can an emergency department clinical "triggers" program based on abnormal vital signs improve patient outcomes?

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ABSTRACT

Background: Because abnormal vital signs indicate the potential for clinical deterioration, it is logical to make emergency physicians immediately aware of those patients who present with abnormal vital signs.

Objectives: To determine if a clinical triggers program in the emergency department (ED) setting that utilized predetermined abnormal vital signs to activate a rapid assessment by an emergency physician-led multidisciplinary team had a measurable effect on inpatient hospital metrics.

Methods: The study design was a retrospective pre and post intervention study. The intervention was the implementation of an ED clinical "triggers" program. Abnormal vital sign criteria that warranted a trigger response included: heart rate <40 beats/minute or >130 beats/minutes, respiratory rate <8 breaths/minute or >30 breaths/minute, systolic blood pressure <90 mm Hg, or oxygen saturation <90% on room air. The primary outcome investigated was the median days admitted with secondary outcomes of median days in special care unit, in-hospital 30-day mortality and proportion of patients who required an upgrade in inpatient care level.

Results: There was no difference in median days admitted for inpatient care (3.8 v. 4.0 days, $p = 0.21$) or median days spent in a special care unit (5.0 v. 5.6 days, $p = 0.42$) between the groups. There was no difference in the percentage of in-hospital patient deaths (6.0% v. 5.6%, $p = 0.66$) or frequency of upgrade in level of care within 24 hours (4.9% v. 4.0%, $p = 0.52$).

Conclusions: In our study, the implementation of an ED clinical triggers program did not result in a significant change in measured inpatient outcomes.

RÉSUMÉ

Contexte: Comme des signes vitaux anormaux peuvent être annonciateurs d'une détérioration clinique, il est logique d'informer immédiatement les médecins d'urgence de l'état des patients qui ont des signes vitaux anormaux.

Objectif: L'étude visait à déterminer si un programme de « déclencheurs » cliniques au service des urgences (SU) reposant sur la présence de signes vitaux anormaux prédéterminés, mis en œuvre afin de permettre une évaluation rapide des malades visés par une équipe pluridisciplinaire sous la conduite d'un médecin d'urgence pouvait se traduire par un effet mesurable sur des critères de mesure chez les malades hospitalisés.

Méthode: Il s'agit d'une étude rétrospective, à échantillons distincts, de type avant et après une intervention, suivant la mise en œuvre d'un programme de déclencheurs au SU. Étaient considérés comme des critères de signes vitaux anormaux justifiant la mise en branle du programme une fréquence cardiaque < 40 ou > 130 battements/min, une fréquence respiratoire < 8 ou > 30 cycles/min, une pression systolique < 90 mm Hg ou une saturation en oxygène < 90 % à l'air ambiant. Le principal critère d'évaluation était le nombre médian de jours d'hospitalisation, et les critères d'évaluation secondaires consistaient en le nombre médian de jours passés dans un service de soins spécialisés, en la mortalité hospitalière au bout de 30 jours et en la proportion de patients dont l'état avait nécessité un relèvement du niveau de soins durant le séjour à l'hôpital.

Résultats: Aucun écart n'a été enregistré entre les groupes en qui concerne le nombre médian de jours d'hospitalisation (3,8 contre [c.] 4,0 jours; $p = 0,21$) ou le nombre médian de jours passés dans un service de soins spécialisés (5,0 c. 5,6 jours; $p = 0,42$). Il n'y avait pas de différence non plus quant au pourcentage de la mortalité hospitalière (6,0 % c. 5,6 %; $p = 0,66$) ou à la fréquence du relèvement du niveau de soins en 24 heures (4,9 % c. 4,0 %; $p = 0,52$).

Conclusion: Dans le modèle présenté ici, la mise en œuvre d'un programme de déclencheurs au SU ne s'est pas traduite par des changements importants de résultats cliniques mesurés chez les malades hospitalisés.

Keywords: Clinical Triggers, Patient Outcomes, Abnormal Vital Signs

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INTRODUCTION

Background

Triage is the initial assessment and sorting of patients, and is utilized in the emergency department (ED) setting to determine clinical priority and appropriate area for treatment. Over the years, a number of ED triage scales have been created, revised, implemented, and studied in attempts to ensure the accuracy of triage categorization.[1-7] Vital signs are often included in triage assessments and help guide triage classification and resultant timeliness of provider evaluation.

Because abnormal vital signs frequently indicate the potential for clinical deterioration, it is rational to make physicians aware of those patients who present with or develop abnormal vital signs as soon as possible. In the inpatient setting, rapid response teams (RRTs) or medical emergency teams (METs) have become increasingly common as a mechanism to respond to acute changes in patient clinical stability with variable improvement in patient outcome.[8-11] These dedicated multidisciplinary teams are typically composed of providers who are not part of the primary team caring for the patient. A clinical triggers program based on abnormal vital signs was introduced at Denver Health Medical Center as a variation of the RRT program that utilized the primary team caring for the patient as the principal respondents to patients with deteriorating conditions.[12]

The concept of immediately alerting a physician-led team to patients who present with or develop abnormal vital signs in the ED seemingly makes sense. This would allow for a more rapid patient assessment and ordering of earlier diagnostic studies and interventions. In the ED setting, one study[13] showed a reduction in time to physician evaluation, first intervention, and first antibiotic when utilizing an adopted clinical triggers model based on abnormal vital signs; while another study[14] showed a reduction in time to physician decision and time to disposition decision. Neither study investigated patient specific clinical outcomes as a measure of the utility of the triggers program. We hypothesized that this type of response in the ED setting would result in improved inpatient outcomes.

Objective

The objective of this study was to determine if an ED clinical triggers program that utilized predetermined abnormal vital signs to prompt an immediate response by a physician-led team would improve inpatient clinical outcomes. We sought to determine the benefit of the triggers program by comparing inpatient days admitted before and after implementation of the program. Secondary outcomes included days spent in a special care unit, 30-day in-hospital mortality, and frequency of upgrade in level of care once admitted to the hospital.

METHODS

Study design and setting

The study was a retrospective, pre-post intervention study of ED patients meeting trigger criteria for one year prior and one year following implementation of an ED clinical triggers program. The hospital institutional review board approved the study design.

The study was performed in a 200-bed community teaching hospital affiliated with a major academic medical school with an ED volume of approximately 37,000 adult and pediatric patients per year. Board-certified emergency medicine physicians and emergency medicine residents from two affiliated residency programs primarily staff the ED along with internal medicine residents and physician assistants from the study institution. Physicians and nurses both utilized the same proprietary electronic documentation and tracking program, the ChartMed v0.5 based off FileMaker Inc. Platform (Santa Clara, CA), to record patient encounters.

In our standard triage protocol, ambulatory patients and some lower-acuity ambulance patients (the latter based on Emergency Medical Services (EMS) notification) are first triaged by nursing staff. That triage process includes a brief description of presenting complaint, a full set of automated vital signs, and if time permits, past medical history, past surgical history, social history, medications and allergies. Patients arriving by ambulance are generally triaged at the bedside if space is available. Nurses utilize the Emergency Severity Index (ESI), a five-level ED triage algorithm, in order to determine priority of patient evaluations. The ESI triage is based on the acuity of the patients' health care problems and the number of resources their care is anticipated to require with ESI level 1 indicating greatest complexity and ESI level 5 indicating lowest complexity. Following triage, patients

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are evaluated by physicians in an order determined by the charge nurse. Although all patients had vital signs recorded in triage prior to the intervention, a trigger mechanism based on abnormal vital signs did not exist prior to the implementation of the triggers program.

Patients who require admission to the hospital can be admitted to one of several locations depending on the severity of illness, co-morbidities, and complexity and frequency of nursing tasks required. These include: Intensive Care Unit (ICU) – both medical and surgical, Ward – telemetry with and without continuous oxygen saturation monitoring capability, medical or surgical wards, or a Step Down Unit (SDU) – an intermediate between the ICU and ward with enhanced nursing capabilities not available on the regular floors. For purposes of this study, patients admitted to the SDU and ICU were combined and termed "special care units".

Selection of participants

The study population consisted of all patients aged 18 and older presenting to the ED from July 10, 2011 to July 9, 2013. This is the one-year of patient encounters prior to and the one-year after the institution of the triggers program. The start date and study time period were selected based on convenience. The "trigger patients" were those who met any one of the predetermined ED trigger vital sign parameters:

1. Heart rate of <40 or >130 beats/minute
2. Respiratory rate of <8 or >30 respirations/minute
3. Systolic blood pressure of <90 mm Hg
4. Oxygen saturation of <90% on room air

Patients less than 18 years old and those who left without being seen (LWBS) were excluded from the study group. Major trauma, cardiac arrest, stroke, or acute ST-elevation myocardial infarction patients were also excluded as they were identified as high-risk by pre-existing alerts and were classified as "prior alert mechanism".

Intervention

On July 10, 2012, after a comprehensive education process for both physicians and nurses, the ED clinical triggers program was initiated. The education process included a combination of review at departmental staff meetings, electronic notification of the process change, individual or small group sessions with all staff, and postings throughout the department prior to the process change.

If any patient met the specified vital sign criteria at initial nursing triage a trigger alert occurred. In this process, the nurse placed an overhead page stating "Trigger patient to room X" with the expectation that the ED attending physician, ED resident, ED nurse, and ED technician responsible for the assigned patient room would report to the specified location immediately.

To ensure compliance, the nursing portion of our proprietary electronic documentation system was modified so that any vital sign entered that met trigger criteria generated a pop-up dialog window notifying the nurse that the patient required a trigger alert. The nurse had to acknowledge the abnormal vital sign as a trigger before he/she would be able to move on to further electronic documentation.

All other patients were included in the data analysis, even if they skipped the standard triage process, if their initial vital signs met the predetermined trigger criteria. Similarly, patients arriving by ambulance were included if they met the predetermined trigger vital sign criteria whether they went directly to a bed or to the waiting room. Abnormal prehospital vital signs were not included. For all patients, only the first set of vital signs were analyzed for inclusion in the study. Patients who developed trigger vital signs during their ED course were not included.

METHODS AND MEASUREMENTS

Initial vital signs for all patient encounters were extracted using the proprietary electronic documentation and tracking system. All patient encounters that met one or more of the predetermined vital sign abnormalities were then identified through a data sort of all initial vital signs by the creator of the electronic documentation and tracking system. From this list, patient encounters where a trigger vital sign occurred were identified and added to the data analysis. After identifying all patients who had trigger vital signs recorded we excluded those patients who met a prior alert mechanism (major trauma, cardiac arrest, stroke, or acute ST-elevation myocardial infarction) by manual review of the medical record.

Additional data extracted from the ED documentation and tracking system included patient age, gender, triage ESI level (1-5), disposition (admitted, transferred,

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discharged, LWCE), and admission location (ICU, SDU, Ward).

For patients admitted to the hospital, data was retrieved from the hospital's health care analytic system Midas+ Solutions (Tucson, AZ, USA), which collects data from the health information system Meditech (Westwood, MA, USA). The hospital analytic system tracked the length of time each patient was admitted to a particular hospital location, including upgrade or downgrade in location. This data was used to calculate the exact number of hours each patient was admitted to the ICU, SDU, or Ward. In-hospital patient deaths that occurred within 30 days of admission were tracked and recorded using the data from the Midas+ health care analytic system.

Outcomes

The primary outcome for the study was median days admitted. Secondary outcomes included days spent in a special care unit, 30-day in-hospital mortality, and frequency of upgrade in level of care once admitted to the hospital. Patients were analyzed as pre- and post-intervention groups.

Analysis

The characteristics of the pre- and post-intervention groups as well as the overall patient population were compared using a chi-square with Yates correction-two tailed test. The frequency of trigger criteria met and the patient variables were differentiated using Fisher's exact test. Median inpatient days for all admissions, unit admissions, and ward admissions were separately compared between the pre-trigger and post-trigger groups with a two-sample *t*-test used to determine statistical significance, with *p*-values reported where appropriate with an alpha set at 0.05 as being significant. Differences in mortality for all patients, unit admissions, and ward admissions were evaluated using Fisher's exact test. Upgrades in level of care for all patients, SDU to ICU, and Ward to either unit were compared using a two-sample *t*-test. For all tests *p*-values were reported where appropriate with an alpha set at 0.05 as being significant.

Sample size justification

From assessment of prior hospital data, we estimated the special unit admission rate for trigger patients to be 30%. In order to detect a 20% relative rate reduction of dates admitted in the ICU, we determined that we needed at least 859 patients per group, or 1,718 patients total, to detect a difference with 80% power and alpha set at $p = 0.05$. Again from evaluation of prior hospital data, one year of enrollment for each group would safely provide this patient volume.

RESULTS

Characteristics of study patients

The study population consisted of all patients aged 18 or older presenting to the ED from July 10, 2011 to July 9, 2013. Table 1 reflects the study characteristics of the total patient population and Table 2 shows an analysis of the trigger patients.

In the year prior to the ED triggers program there were a total of 37,740 patient encounters, while in the year after the intervention there were a total of 36,225 patient encounters. The percentage of patients that were excluded because of age <18 years, left without being seen (LWBS), and those that met "prior alert mechanisms" were similar in both groups. Based on the

Table 1. Characteristics of overall patient population

	Pre-trigger	Post-trigger	*p*-value
Total Patients	37,740	36,225	
Disposition			
ICU	597 (1.6)	537 (1.5)	0.29
SDU	802 (2.1)	876 (2.4)	0.009*
Total Unit (ICU + SDU)	1399 (3.7)	1413 (3.9)	0.19
Ward	9515 (25.2)	8514 (23.5)	<0.0001*
All Admits	10914 (28.9)	9927 (27.4)	0.006*
Discharged	25,286 (67.0)	24,763 (68.4)	0.083
Transferred	846 (2.2)	726 (2.0)	0.03*
LWCE	694 (1.8)	809 (2.2)	0.0002*

*p-value < 0.05.
Values reported as n (%) unless otherwise stated.

Table 2. Characteristics of study subjects

	Pre-trigger	Post-trigger	*p*-value
Total Patients	37,740	36,225	
Age <18 Years Old	2045 (5.4)	1975 (5.5)	0.85
LWBS	520 (1.4)	549 (1.5)	0.12
Trigger Criteria Met	1407 (3.7)	1132 (3.1)	<0.001*
Prior Alert Mechanism	80 (5.7)	60 (5.3)	0.73
Trigger Patients	1327 (3.5)	1072 (3.0)	<0.001*
Median Age	69	70	0.63
Percent Female	54.9%	54.2%	0.77

*p-value < 0.05.
Values reported as n (%) unless otherwise stated.

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predefined abnormal vital sign trigger criteria, there were 1,327 patients (4%) who had a vital sign meeting trigger criteria in the pre-intervention group and 1,072 patients (3%) who had a vital sign meeting trigger criteria in the post-intervention group. The percentage of patients who met trigger criteria in the pre-intervention group compared to the post-intervention group was statistically different ($p < 0.001$). The median age of patients and the percentage of female patients were similar in both groups.

Table 3 outlines the specific trigger criteria met for each of the comparative groups.

The percentage of triggers was similar for all vital sign criteria except when comparing the aggregate number of patients who met the abnormal respiratory rate parameters. The patient variables for both groups including ESI comparison and disposition location are shown in Table 4.

When compared to the pre-trigger group, the post-trigger group had a proportionately higher rate of ESI 1 and 2 and a proportionately lower rate of ESI 3 Likewise, patients in the post-trigger group had a higher overall rate of admission, particularly admissions to the step down unit (SDU) and a lower overall rate of discharge. The percentages of patients transferred and who left without complete evaluation (LWCE) were the same in both groups.

Table 3. Trigger criteria met

	Pre-trigger	Post-trigger	*p*-value
Total Triggers	1,492	1,208	
SBP < 90	293 (19.6)	265 (21.9)	0.15
HR < 40	20 (1.3)	24 (2.0)	0.22
HR > 130	492 (33.0)	418 (34.6)	0.39
HR Total	512 (34.3)	442 (36.6)	0.23
RR < 8	8 (0.5)	3 (0.2)	0.36
RR > 30	297 (19.9)	207 (17.1)	0.07
RR Total	305 (20.4)	210 (17.4)	0.05*
Sat < 90%	382 (25.6)	291 (24.1)	0.37
More than one Trigger	159 (10.7)	127 (10.5)	0.95

*p-value < 0.05.
Values reported as n (%).
Patient may have met more than one trigger criteria.

Table 4. Patient variables

	Pre-trigger	Post-trigger	*p*-value
ESI			
ESI 1	41 (3.1)	50 (4.7)	0.04*
ESI 2	782 (58.9)	776 (72.4)	<0.001*
ESI 3	477 (35.9)	235 (21.9)	<0.001*
ESI 4	27 (2.0)	11 (1.0)	0.07
ESI 5	0 (0.0)	0 (0.0)	1.00
Disposition			
ICU	224 (16.9)	207 (19.3)	0.13
SDU	217 (16.4)	210 (19.6)	0.04*
Total Unit (ICU + SDU)	441 (33.2)	417 (38.9)	0.004*
Ward	561 (42.3)	435 (40.6)	0.41
All Admits	1,002 (75.5)	852 (79.5)	0.021*
Discharged	295 (22.2)	202 (18.8)	0.043*
Transferred	27 (2.0)	17 (1.6)	0.45
LWCE	3 (0.2)	1 (0.1)	0.63

*p-value < 0.05.
Values reported as n (%).

MAIN RESULTS

The measured outcomes are shown in Tables 5-7. There was no difference between the pre-trigger and post-trigger groups in median days admitted (3.8 v. 4.0 days, $p = 0.21$) or median days spent in a special care unit (5.0 v. 5.6 days, $p = 0.42$) (Table 5). There was no difference in the percentage of in-hospital mortality within 30 days of admission (6.0% v. 5.6%, $p = 0.66$)

Table 5. Days admitted

	Pre-trigger	Post-trigger	*p*-value
All Admits - Total Days	3.8 (1.8-6.6)	4.0 (2.1-7.1)	0.21
Unit Admits - Unit Days	3.4 (1.9-6.6)	3.5 (1.9-7.0)	0.88
Unit Admits - Total Days	5.0 (3.1-8.8)	5.6 (3.0-9.4)	0.42
Ward Admits - Total Days	2.6 (1.3-4.4)	3.2 (1.6-5.1)	0.06

Values reported as median days (95% CI).

Table 6. Patient deaths

	Pre-trigger	Post-trigger	*p*-value
All Patients	80 (6.0)	60 (5.6)	0.66
Unit Admits	51 (11.6)	41 (9.8)	0.44
Ward Admits	27 (4.8)	19 (4.4)	0.36

Values reported as n (%).

Table 7. Upgrades in level of care

	Pre-trigger	Post-trigger	*p*-value
All upgrades (<24 hrs)	38 (4.9)	25 (4.0)	0.52
SDU to ICU (<24 hrs)	22 (10.1)	13 (6.2)	0.16
Ward to Unit (<24 hrs)	16 (2.9)	13 (3.0)	1.00
All upgrades (anytime)	76 (9.8)	57 (8.8)	0.58
SDU to ICU (anytime)	31 (14.3)	20 (9.5)	0.14
Ward to Unit (anytime)	45 (8.0)	37 (8.5)	0.82

Values reported as n (%).

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between the two groups (Table 6). There was a trend towards a decreased rate of upgrade in level of care from the SDU to the ICU within 24 hours (4.9% v. 4.0%, $p = 0.52$) and anytime during admission (10.1% v. 6.2%, $p = 0.16$). However, these differences were not statistically significant (Table 7).

DISCUSSION

In the ED setting, clinical triggers based on abnormal vital signs have been shown to have benefits in commonly measured ED metrics, most notably reducing delays between triage and medical evaluation.[13,14] This study investigated if a triggers system and resultant more timely medical evaluation would translate into long-term benefits such as improved inpatient metrics. However, when comparing median days admitted, median days spent in a special care unit, in-hospital death rate, or upgrade in level of care once admitted to the hospital, no difference was identified.

This was a single site study. We chose one-year time periods prior and after the intervention to compare. This study period was selected to reduce seasonal variations in patient demographics, presenting pathology, and experience of trainees. With a full year of patients in the pre- and post-intervention groups, the study was still underpowered to be able to identify significant changes in admitted days in the hospital, or in special care unit, or in-hospital mortality. Increasing the sample size to a large enough sample would have required the analysis of multiple pre- and post-intervention years. This would have introduced a number of confounders, such as other interventions implemented in the ED and in the hospital during the time period that may have had an effect on the outcomes.

The study was powered to prove a 20% reduction in days admitted which would be nearly a full day reduction from the baseline 4.0 admitted days in the pre-intervention group. Further, although there was a slight reduction in 30-day mortality, the study was not sufficiently powered to detect a difference in this infrequent outcome. We would suggest a similar study at a larger institution or system of hospitals with a sufficient number of trigger patients to determine if a trigger system could in fact improve inpatient outcomes.

There are several other possible reasons for the negative results of the study. There was a notable difference between the patient populations in the pre-intervention versus the post-intervention trigger groups. Patients that met abnormal vital sign criteria were less frequent in the post-intervention group (3.1%) as compared to the pre-intervention group (3.7%). There was also a higher rate of admission to the hospital (75.5% v. 79.5%) as well as admission frequency to a special care unit (33.2% v. 38.9%) in the post-intervention trigger group. This correlates with a higher percentage of patients categorized as either ESI 1 (3.1% v. 4.7%) or ESI 2 (58.9% v. 72.4%) in the post-intervention trigger group. The trend towards a higher ESI level may reflect a higher overall acuity in the post-intervention group. However, this could also indicate nursing triaging at a higher level when prompted to recognize the abnormal trigger vital signs. The trigger may have also improved physician's recognition of potentially ill patients, which may explain the higher rate of overall admissions and intensive care admissions in the post-intervention time period. However, this also may indicate a trend towards over-utilization of intensive care services.

There was also a notable difference when comparing the overall patient population in the pre- and post-intervention time periods. Unlike the trigger groups, the overall admission rate was higher in the pre-intervention population (28.9%) as compared to the post-intervention population (27.4%). However, the rate of admission to a special care unit was slightly higher in the post-intervention population (3.7% v. 3.9%). As a percentage of overall admissions the percentage of patients admitted to a special care unit was also significantly higher in the post-intervention population (12.8% v. 14.2%). These differences in patient populations indicates a generally sicker group of patients in the post-intervention group which could have led to failure to improve inpatient outcome.

This study is subject to the limitations associated with any retrospective design including incomplete data and inability to control for confounders. Because data were reviewed for all patient encounters that met abnormal vital sign criteria, all patients that were eligible for inclusion should have been identified.

Based on the predefined abnormal vital sign trigger criteria, there was a notable difference in the percentage of patients that had trigger vitals signs when comparing the pre-intervention group (1,327 patients or 4%) versus the post-intervention group (1,072 patients or 3%). Because the only criteria for inclusion as a trigger patient were the specified vital sign abnormalities, this difference should not be due to the intervention itself. Instead there was a difference in patient populations who had variability in the frequency of trigger vital signs.

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Patient encounters that met trigger vital sign criteria were included both before and after the intervention. It is possible that patients met abnormal vital sign criteria and the nurse did not activate the trigger response. We attempted to limit this effect by having an automatic notification to the nurse in the electronic charting system when an abnormal vital sign was present. In order to ensure compliance, the nurse had to acknowledge the abnormal vital sign as a trigger before they could complete further electronic documentation on that patient. There was no mechanism to track whether a trigger was actually called by the nurse.

The investigation used several quality metrics as surrogates for inpatient outcome. These included median days admitted, median days in a special care unit, in-hospital death rate, and frequency in upgrade in level of care once admitted to the hospital. It is possible that reducing time from triage to provider encounter would have no impact on the inpatient measures that were chosen in the study.

Patient deaths that occurred within 30 days of admission could only be tracked if the patient expired within the study facility. It is certainly possible that this could have resulted in an underestimation of the death rate as patients could have expired at home or at another nearby facility. The data was collected for both groups in the same manner and the differences between the groups were not significant.

CONCLUSIONS

In summary, the implementation of an ED clinical triggers program based on abnormal vital sign criteria had no measurable effect on inpatient outcomes measured by median days admitted, days in a special care unit, in-hospital death rate, or upgrade in level of care.

Competing Interests: None declared.

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