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MEDICATION ERRORS IN EMERGENCY DEPARTMENTS: TYPES, CAUSES AND PREVENTIVE STRATEGIES

HARRIET BRAMWELL[1]*, ELENI MAVRIDIS[2], OSKAR LINDQVIST[3]

Affiliation

[1]Department of Social Pharmacy, Exmoor Institute of Pharmaceutical Sciences, Taunton, United Kingdom
[2]Department of Pharmacy Practice, Macedonia Plain Institute of Pharmacy, Serres, Greece
[3]Department of Social Pharmacy, Norrland Institute of Clinical Pharmacology, Umea, Sweden

*Corresponding author: Harriet Bramwell, h.bramwell@eips.ac.uk
ORCID iD: Harriet Bramwell 0000-0001-4210-1123; Eleni Mavridis 0000-0001-2552-3666; Oskar Lindqvist 0000-0001-3109-4319

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Abstract

Emergency departments combine undifferentiated patients, urgent decisions, frequent interruptions and verbal orders, conditions in which medication errors are easy to make. This narrative review, which reports no new data, summarises published evidence on how medication errors are defined and counted, the types and causes described in emergency care, and the preventive strategies that have been tried. Prescribing, administration and medication-history errors recur across studies, with children and high-alert drugs carrying particular risk. Pharmacist involvement, computerised order entry, barcode technology, standardised protocols and attention to human factors each reduce errors in some settings. Inconsistent definitions, voluntary reporting and a shortage of studies measuring patient harm remain the principal limitations of the evidence.

1. INTRODUCTION

A patient arrives with chest pain and an unknown medication list. The department is full, two other patients need attention, and a verbal order is given for an infusion at a dose the nurse has to calculate. Scenes like this explain why emergency care is regarded as one of the riskiest places in which to give medicines. The landmark report from the Institute of Medicine estimated that preventable adverse events in hospitals caused tens of thousands of deaths a year in the United States and helped to place medication safety on the policy agenda [1]. Earlier studies had already shown that adverse drug events were among the most common hospital injuries, and that many were linked to errors that could be prevented [2, 3, 4].

Emergency departments differ from wards in ways that matter. Patients are unfamiliar to staff, histories are incomplete, and treatment must often begin before the diagnosis is settled. Doctors, nurses and pharmacists work in shifts under time pressure, and teams change during the course of a single patient's stay. Croskerry and Sinclair described emergency medicine as a practice prone to error because of this mix of uncertainty, crowding, cognitive load and interruptions [5]. Medication errors in this setting are not only a matter of an individual slip. They are the product of a system in which several weak points line up, an idea expressed in the well-known Swiss cheese model of accident causation [6].

This article reviews the published literature on medication errors in emergency departments. It reports no new data. The sections that follow address how errors are defined and measured, why they occur, which types are most often described and in which groups, and what preventive strategies have been evaluated. Recommendations from the World Health Organization under its global challenge on medication safety provide a policy frame for the discussion [7, 8, 9]. The review draws on observational studies, voluntary reporting systems, intervention trials and guidelines. It does not claim to be systematic, and the aim is to give practitioners and pharmacy managers a clear, critical picture of the evidence as it stood in 2023.

It helps to picture the medication-use process as a chain of stages: selecting the drug and dose, writing or entering the order, transcribing it, preparing and dispensing the product, administering it, and monitoring the response. Early work on hospital adverse drug events showed that errors clustered at the beginning of this chain, in ordering and transcription, and that most were intercepted only by chance [3, 4]. In emergency care the chain is compressed. The same clinician may select, order, prepare and give a drug in a few minutes, and each handover that would normally supply a check is removed. This compression explains why the emergency department is a recurrent subject of safety research despite its short episodes of care [10, 11].

Errors in the emergency department also differ from those in outpatient clinics because the opportunities for a second check are fewer. In many wards, a prescription is reviewed by a pharmacist before the first dose is given, and the nurse who administers it has time to read the chart. In emergency care, a drug may be ordered, drawn up and given within minutes, without any independent screening. For that reason, authors have argued that the emergency department needs safeguards built into the process itself, such as standard concentrations, dose calculators and double checks for the most hazardous drugs, rather than relying on individual vigilance [11, 12].

2. DEFINITIONS, FREQUENCY AND MEASUREMENT

What counts as a medication error? A systematic review of the literature found dozens of different definitions, differing in whether they include only events that reach the patient, whether they require a deviation from a standard, and whether they cover prescribing, dispensing, administration and monitoring [13]. Ferner and Aronson proposed clarifying terms, separating errors from adverse reactions and classifying errors by the stage of the process in which they occur [14]. A medication error is generally an unintended failure in the drug treatment process that leads, or could lead, to harm. An adverse drug event is harm caused by a medicine, whether or not an error was involved. The two overlap, but they are not the same.

Severity is usually classified with the index issued by the National Coordinating Council for Medication Error Reporting and Prevention, which runs from errors that do not reach the patient, through those that reach the patient without harm, to those causing temporary or permanent harm or death [15]. Many emergency studies report mostly near misses and no-harm errors, which is reassuring but also reveals how many opportunities for harm exist. Standard reference books on medication errors describe the principal categories, such as wrong drug, wrong dose, wrong route, wrong patient and

omission, and these have become the basis for most classification schemes in research and incident reporting [10].

Methods of detection strongly influence reported rates. Voluntary reports capture only a fraction of events, and they tend to emphasise those that cause harm or those that staff find easy to describe. Chart review finds more but depends on what is documented. Direct observation, in which a trained observer follows nurses during drug rounds, gives the highest rates, because it detects errors the staff themselves did not recognise. Textbooks on medication errors make the same point, that no single detection approach is adequate and that a combination gives the most complete picture [10, 13]. When comparing studies, one must therefore ask not only how many errors were found but how they were looked for and over what denominator.

Within these limits, the figures are worrying. A study of a busy emergency department found that errors were frequent and that many involved medication, with a notable share involving medicines [16]. Reports of adverse drug events in patients presenting to emergency departments found that a substantial share were judged preventable and that some were serious enough to need admission [17, 18]. A systematic review of adverse events related to emergency care concluded that medication-related problems were among the more common types, with a wide range of estimates between studies [19]. Pharmacist surveillance in emergency settings identified and intercepted errors on a regular basis, a finding that is considered in more detail below [20].

Near misses deserve as much attention as harmful events. A mistaken order caught by a nurse before the dose is drawn up counts as an error that did not reach the patient, and it teaches the same lessons as one that did. Safety scientists have long argued that near misses are far more frequent than injuries and provide a richer source of data [3]. Counting only harm leaves most of the information unused. In emergency departments, where an intercepting colleague is often nearby, interception rates may be high, which can make a department look safer than it is if the denominator and the capture of catches are not reported. Studies that report both errors and interceptions, with the stage of detection, offer the most balanced view [15, 17, 20].

Trigger tools offer a different route to measurement. Instead of waiting for reports, reviewers search records for clues, such as use of an antidote like naloxone, an abrupt stop of a drug, or an abnormal laboratory result, and then examine the case for an error or adverse event. This method has been used to track harm over time in inpatient settings, and it adapts well to emergency records. It finds events that voluntary systems miss and is relatively inexpensive, although the clues chosen determine what is found. Some studies combine triggers with pharmacist review and obtain higher yields. A department that adopts one standard method and repeats it periodically gains a trend, which is more useful than a single count [10, 21].

A distinction between errors made in the emergency department and those that arrive with the patient helps clarify responsibility. Many patients present because of an adverse drug event caused elsewhere, such as an interaction, an overdose of an anticoagulant or a reaction to a recently started drug. Outcomes of emergency patients presenting with such events have been described in a large Canadian cohort, in which a notable share required hospital admission [18]. The emergency team then has to recognise the cause, stop or reverse the offending drug and document the event. This role in detecting and reporting community-acquired events is sometimes overlooked in counts of departmental errors, but it forms part of the medication safety workload of the unit.

3. CAUSES AND CONTRIBUTING FACTORS

Reason's model of human error separates active failures, the slips and lapses of people at the sharp end, from latent conditions in the organisation, such as staffing, design of workspaces, equipment and policies [6]. It has become the standard way of thinking about medication errors, and it directs attention to the system when something goes wrong. In the emergency department, latent conditions include crowding, boarding of

admitted patients, shortage of senior staff and lack of access to previous records. Active failures include miscalculations, selection of the wrong vial, mis-keying a dose or forgetting to reassess an infusion. Seeing both layers makes it clear that retraining individuals will not solve a problem rooted in the workflow [11, 22].

Cognitive factors deserve more weight than they usually receive. Croskerry described how clinicians in busy settings rely on mental shortcuts, such as anchoring on a first impression, which are efficient but vulnerable to bias [23]. In prescribing, a doctor may reach for a familiar drug or dose from memory without checking a reference, and under pressure this is more likely. Studies of prescribing errors in hospitals identified lack of knowledge, failure to apply it, inadequate review of the patient's history and tiredness as common contributors [22, 24]. These findings come from inpatient settings, but the same factors operate in the emergency department, and in an environment of continuous decisions they may be magnified.

Interruptions are a well-documented hazard. Observational work with nurses in hospital wards found that each interruption during medication administration was associated with a higher risk of a procedural failure and clinical error, and that the risk and severity of errors increased with the number of interruptions [25]. The emergency department generates interruptions constantly, through alarms, telephone calls, new arrivals and requests from colleagues. Another observational study found that errors in intravenous medication administration were common, that most were procedural, and that adherence to correct procedures was partly related to the experience of the nurse [26]. Intravenous drugs are widely used in emergency care, so these findings are directly relevant.

Crowding and staffing shape the whole environment. When departments are full, patients wait on trolleys in corridors, care is delivered in places not designed for it, and staff are stretched across more patients than usual. Observers have described these conditions as a setting that favours slips, with frequent task switching and little time to cross-check calculations [5, 16]. Verbal orders, common in resuscitation and in busy periods, add a further risk because they avoid written checks. Some authors suggest that departments should limit verbal orders to genuine emergencies and always require read-back and later documentation, a low-cost rule that reduces misunderstanding of drug names and numbers [11, 12].

Information problems are another leading cause. A patient's medication list may be unknown, out of date or wrong. Systematic review evidence shows that medication history errors at hospital admission are very common, with at least one discrepancy found in a large proportion of patients [27]. A study of unintended discrepancies at admission found that many had the potential to cause harm [28]. Emergency physicians depend on information from patients, relatives, community pharmacy records and prescription lists, and gaps at this stage propagate into later errors, because the admitting team inherits the emergency record. Accurate medication history taking, ideally by a trained pharmacist or technician, is therefore regarded as a key safety step [9, 27].

Drug characteristics play a part. Some medicines carry a higher risk of serious harm if misused, and the Institute for Safe Medication Practices maintains a list of such high-alert drugs, including anticoagulants, insulin, opioids, concentrated electrolytes, sedatives and neuromuscular blockers [29]. Look-alike names and similar packaging add confusion, as do multiple concentrations of the same product. The World Health Organization identified high-risk situations, such as polypharmacy, unfamiliar settings and the use of high-alert drugs, as areas for action [8]. In emergency care these conditions often occur together, which helps to explain why even experienced clinicians make errors that appear obvious in retrospect.

Training and supervision matter as well. In many hospitals, the emergency prescriber is a junior doctor in rotation, who may not have used the drug before and has no time to look it up. Systematic review evidence on prescribing errors in hospital inpatients identified inexperience, lack of knowledge of the drug, poor communication and inadequate

supervision among the most common contributors [24]. A prospective study in British hospitals reached similar conclusions and highlighted the role of the ward environment and team factors rather than carelessness [22]. Accessible dosing references, senior review of high-risk orders and induction training on the department's own formulary are the practical responses suggested by these findings.

4. TYPES OF ERROR AND AT-RISK GROUPS

The types of error most commonly described are summarised in table 1 and counted by category in fig. 1. Prescribing errors, such as wrong dose, wrong drug and missed allergy or interaction, appear in nearly every study. Administration errors include wrong rate for an infusion, wrong route, wrong patient and omitted doses. Medication-history and transition errors arise when information is lost between care settings. Dispensing errors occur less often in the emergency department, because many drugs come from automated cabinets or ward stock, but selection errors still happen. The table lists representative findings only, and each row rests on the cited source alone [16, 21, 24, 28, 30].

Analysis of voluntarily reported errors from emergency departments across the United States found that the most common types were wrong dose, omission and wrong drug, with a large share of events originating at the prescribing and administration stages [21]. Most reported errors caused no harm, though a small proportion reached the patient and required monitoring or treatment. The authors noted that the contributing factors included performance deficits, distractions and communication failures. Such reporting systems reveal patterns but do not give rates, since the number of opportunities for error is unknown. They remain valuable for learning, particularly when reports are reviewed by a multidisciplinary team and fed back to staff promptly [12, 21].

Children are a group at heightened risk. Dosing depends on weight, and calculations are required for almost every drug, so mistakes of tenfold are possible through a misplaced decimal point. A study at a paediatric emergency department found that errors were common and linked to factors such as the number of drugs prescribed and the age of the patient [30]. A research letter reported large errors in the dosing of medicines for children, with a proportion of doses deviating by well over a tenth from the intended amount and a number differing by a factor of ten [31]. A systematic review of interventions concluded that computerised order entry with decision support, standardised dosing and pharmacist review reduced paediatric medication errors [32].

Table 1: Types and causes of medication error described in emergency care and the preventive measures studied

Error type or setting	Published finding or preventive measure	Ref.
Busy emergency department all errors	A notable share of errors involved medicines	[16]
Voluntary reports US emergency departments	Wrong dose, omission and wrong drug most often reported	[21]
Prescribing errors inpatient studies	Knowledge gaps, fatigue and incomplete history are common causes	[22, 24]
Paediatric emergency care	Errors linked to dose calculation, number of drugs and age	[30, 31]
Paediatric interventions review	Order entry, standard dosing and pharmacist review reduced errors	[32]
Intravenous administration	Mostly procedural errors; nurse experience and procedure adherence relevant	[26]
Interruptions ward observation	Each interruption raised risk and severity of administration errors	[25]
Barcode administration	Fewer administration errors and potential adverse drug events	[33]
Medication history at admission	Discrepancies common; many with potential for harm	[27, 28]
Pharmacist in emergency department	Many ordering errors intercepted before reaching patients	[20]

Older adults present a different pattern. They take many medicines, have reduced renal clearance and often attend the emergency department because of a drug-related problem. Their lists are long and difficult to verify, which magnifies the risk of omission or duplication at the interface between

settings [9, 27]. Adverse drug events in this age group involve anticoagulants, hypoglycaemic agents, opioids and sedatives disproportionately [17, 18, 29]. Dose adjustment for renal function is easily overlooked in an acute setting, where laboratory results may not be available at the time of prescribing. Targeting these patients for pharmacist medication review has been proposed as an efficient use of resources, though evidence from emergency departments specifically remains limited [20].

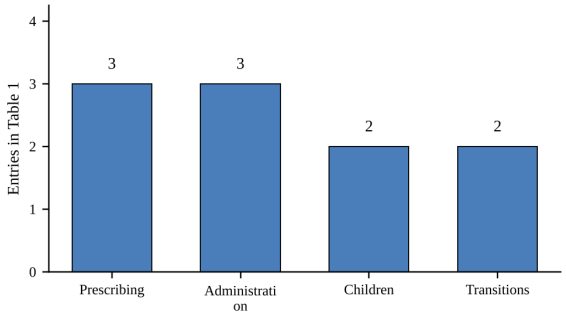


Fig. 1: Number of entries in table 1 by error category

Critically ill patients in resuscitation areas raise other issues. Verbal orders are widespread and tolerated in resuscitation, since writing delays treatment. They carry risk of mishearing, especially for drugs with similar names or for numbers spoken in noisy conditions. Practices such as read-back, in which the person receiving the order repeats it aloud and the prescriber confirms, are encouraged by safety organisations, and standard dilution tables for emergency infusions help to reduce calculation errors [11, 12]. Emergency drugs are often prepared in a hurry, sometimes without labels, and a syringe of unknown content is an invitation to error. Labelling every syringe and keeping emergency kits organised in a consistent layout are simple measures with a sound basis in human factors [6].

Certain drug classes appear again and again. Anticoagulants, insulin, opioids, sedatives and concentrated electrolytes are repeatedly linked to serious events in studies of adverse drug events and are named on safety lists of high-alert medicines [17, 18, 29]. For anticoagulants, errors include wrong dose, missed interaction and failure to monitor, and the consequence of bleeding or clotting can be severe. Opioid errors involve overdoses from mistaken concentration or route, and insulin errors involve confusion of units or products. An emergency department can usefully select a short list of such drugs, build specific protocols for them and audit adherence, as recommended in guidance on high-risk situations [8, 29].

5. PREVENTIVE STRATEGIES

Pharmacists have been studied most thoroughly as an intervention. In a prospective, multicentre study, emergency pharmacists documented large numbers of interventions, many of which intercepted errors in ordering before they reached the patient, and the authors concluded that clinical pharmacy services in the emergency department could prevent a considerable number of errors [20]. The activities included medication history taking, dosing advice, review of orders, assistance with resuscitation and education. Emergency pharmacist roles are now established in several countries, though coverage is often limited to daytime hours. Evidence for effects on patient outcomes is weaker than evidence of interception, a distinction that needs to be kept in mind when interpreting claims of benefit [9, 12, 20].

Computerised provider order entry is the best studied technological measure. An early study reported that order entry and a team intervention reduced serious medication errors considerably in hospital wards [34], and a related analysis found a reduction in non-intercepted serious errors after implementation [35]. A later evaluation of hospitals adopting such systems reported a decrease in medication errors [36], while a systematic review and meta-analysis found that the effect on preventable adverse drug events was uncertain, though errors fell [37]. Order entry works best with decision support that checks dose, allergy and interaction. Poorly designed systems with too many alerts can cause alert fatigue, and they may introduce new errors, so local tailoring is essential.

Barcode technology addresses administration. Scanning the patient's wristband and the medicine label before a dose confirms that the right drug is being given to the right patient.

A study in an American academic centre found that barcode-assisted medication administration reduced non-timing administration errors and potential adverse drug events, with benefits attributable to fewer wrong-drug and wrong-dose events [33]. Emergency departments pose special difficulties, because patients may be unidentified, drugs are often given from stock and the speed of care discourages scanning. Workarounds can defeat the technology. Even so, barcode scanning for non-urgent emergency medications and in observation units is feasible, and its use in resuscitation may improve as systems adapt [11, 33].

Costs and staffing models for emergency pharmacists vary. Some hospitals employ pharmacists dedicated to the department for part of the day, others use a pharmacist stationed nearby who responds to calls, and others provide remote verification of orders. The multicentre study of interventions suggested that even limited coverage intercepted important errors, and the authors argued that the activity justified the position [20]. A review of strategies for reducing errors concluded that pharmacist participation, standardisation, technology and reporting systems should be combined [12]. Rigorous economic studies are scarce, so decisions on staffing are often made on the basis of risk assessment and local priorities and not on formal cost-effectiveness analysis [12, 20].

Standardisation is a cheap and underused strategy. Preparing infusions in fixed concentrations, using pre-filled syringes where available, keeping dosing charts for children on the wall, and agreeing a single formulary of emergency drugs all cut the number of choices clinicians face. Tall-man lettering for look-alike names, separate storage for concentrated electrolytes and distinct packaging for high-alert medicines are recommended by safety bodies [7, 29]. Guidance on medication safety in high-risk situations urges teams to establish procedures for these drugs and to audit compliance [8]. Such measures reduce reliance on memory, which is the most fragile component of any system, particularly during the sixth hour of a night shift.

Improving information transfer is another element. Structured medication reconciliation at the point of arrival, using at least two sources of information such as patient interview and community pharmacy or primary-care records, is recommended in the World Health Organization guidance on transitions of care [9]. Evidence shows that pharmacy technicians and pharmacists obtain more complete medication histories than busy physicians, and that errors in the history are common in unselected patients [27, 28]. Providing prescribers with accessible summary care records, and ensuring discharge information from the emergency department reaches the community pharmacist and general practitioner, extends safety beyond the department's walls and prevents errors from reappearing after discharge [9].

Education and cognitive strategies sit alongside system changes. Croskerry has argued that clinicians can be taught to recognise common biases and to apply forcing strategies, such as pausing to ask what else could explain the picture or what could go wrong with the chosen drug [23]. Checklists and prompts at the point of prescribing can serve the same purpose. Simulation-based training for resuscitation drugs gives staff the chance to practise calculations and preparation under realistic stress. Evidence that such training reduces actual medication errors is sparse, but it is a plausible complement to other measures and has few downsides, provided that it does not replace system fixes [6, 12].

Culture and learning systems underpin all of the above. A department in which staff fear blame will not report near misses, and without reports there is nothing to learn from. The systems approach advocated by Reason and by the Institute of Medicine emphasises open reporting, feedback and analysis of root causes, not punishment [1, 6]. Routine multidisciplinary review of reported errors, regular teaching based on local cases, and visible management support are all described as helpful [12, 21]. Reducing interruptions, for example with protected zones during drug preparation and visual signals such as a coloured tabard, has been tried, but evidence

for the effect on errors is still limited, despite the strong association between interruptions and errors in observational work [25].

6. LIMITATIONS AND FUTURE DIRECTIONS

The evidence base has clear gaps. Many studies are single-centre, descriptive and focused on process measures such as errors intercepted, not on outcomes that matter to patients, such as harm, hospital stay and death. Rates cannot be compared when definitions and methods differ so widely [13, 14]. Studies of preventive strategies in the emergency department specifically are fewer than those in inpatient wards, and many conclusions rest on extrapolation. Publication bias may also favour positive reports. For this reason, claims that a particular intervention will cut emergency errors by a stated percentage should be treated with caution unless supported by controlled evaluation in comparable settings [20, 37].

Another concern is the focus on prescribing and administration at the expense of other stages. Monitoring, for instance of anticoagulant effect or renal function after a dose, and communication at discharge receive less research attention in emergency care. Likewise, the role of crowding, which has increased in many health systems, is acknowledged but rarely quantified in relation to medication errors. Studies that link staffing levels, occupancy and time of day with error rates would help to inform resource planning. Some of the available evidence suggests that adverse events are more common during crowded periods, though the data on medication-specific outcomes are limited [16, 19].

Future work could usefully combine several designs. Prospective observational studies using direct observation or trigger tools could provide reliable baseline rates for specific types of error. Interrupted time-series or stepped-wedge studies could evaluate interventions such as pharmacist coverage, standard infusion concentrations or barcode scanning in routine practice. Qualitative research with frontline staff would clarify why safeguards are bypassed, a problem that technology alone cannot overcome. Reporting should follow agreed definitions, using the terminology clarified in the literature and the severity index of the national coordinating council, so that findings can be pooled [13, 14, 15]. A common core of indicators for emergency medication safety would be an obvious next step for professional bodies.

The balance of the literature tilts towards high-income countries. Most of the trials and system evaluations cited here come from North America and Europe, where electronic records, automated cabinets and clinical pharmacists are available. In low-resource settings, emergency care may be delivered by staff with limited access to references, to stable supplies or to any reporting mechanism. The World Health Organization challenge on medication safety applies to all countries, and its emphasis on simple measures such as reconciliation, clear labelling and safe handling of high-risk medicines may be the most transferable part of the evidence [7, 9]. Local studies describing baseline error patterns are needed in such settings before any imported intervention is judged suitable.

7. CONCLUSION

Medication errors in emergency departments are common, mostly of low severity but occasionally serious, and they arise from interacting causes: incomplete information, time pressure, interruptions, unfamiliar patients and high-alert drugs [16, 21, 25, 29]. Prescribing, administration and history-taking errors recur across studies, and children and older adults carry particular risk [18, 27, 30, 31]. Reason's systems view remains the most useful framework, since it directs prevention towards the design of work and away from blaming individuals [1, 6].

Preventive measures with supporting evidence include pharmacist participation, computerised order entry with decision support, barcode administration, standard concentrations and dosing tools, better medication reconciliation and a reporting culture that encourages learning [9, 20, 33, 34, 37]. The strength of that evidence varies, and most of it comes from wards or from process outcomes. Emergency departments should therefore adopt these measures with

careful local evaluation, using shared definitions and patient-centred outcomes, and researchers should address the shortage of controlled studies in this high-risk setting [13, 14, 19].

8. ABBREVIATIONS

ED-Emergency department, CPOE-Computerised provider order entry, ADE-Adverse drug event, ISMP-Institute for Safe Medication Practices, NCC MERP-National Coordinating Council for Medication Error Reporting and Prevention, WHO-World Health Organization, IV-Intravenous, IOM-Institute of Medicine

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10. AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

11. CONFLICT OF INTERESTS

Declared none

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