Interventions to reduce mortality from in-hospital cardiac arrest: a mixed-methods study

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Scientific summary

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Background

Despite national guidance, regional collaborations and additional resources to facilitate change over the last two decades, data from the National Cardiac Arrest Audit (NCAA) show that a fourfold variation in in-hospital cardiac arrest (IHCA) rates and survival exists between hospitals in England. Resuscitation teams are called to around 20,000 IHCA events in England each year. Following an arrest, only 15% of patients will leave the hospital alive and fewer will have survived 3 months later. A substantial proportion of these patients will have shown signs of deterioration for up to 8 hours before the event, signs that have not been identified or acted on by staff. Avoidable deaths caused by poor clinical monitoring and response account for around one-third of all avoidable deaths in hospitals.

Improvement in standards of care for acutely ill patients and decreasing avoidable deaths are priorities for the NHS. In 2000, in an effort to address the critical care skills deficit on NHS wards, the Department of Health and Social Care recommended the implementation of nurse-led outreach teams [a form of rapid response team (RRT)], with both an educational role and a role in providing clinical support to wards. These teams also facilitated the introduction of track-and-trigger systems (TTSs) that let staff track a range of physiological parameters, including respiratory rate, blood oxygen levels, temperature, blood pressure and heart rate, to create scores. The scores trigger specific actions, which might include increased frequency of monitoring or a request for further support. Further recent initiatives include the promotion of the situation, background, assessment, recommendation (SBAR), a structured handover tool designed to improve the quality of communication of urgent patient information between ward staff and responders, and the implementation of a national, standardised TTS [the National Early Warning Score (NEWS)].

These interventions form components of a rapid response system, an approach advocated as an effective way to ensure that deteriorating patients are rescued before they go into cardiac arrest. In this system, the afferent arm is focused on the recognition of patient deterioration through the collection, interpretation and response to abnormal physiological parameters. The efferent arm brings staff with critical care skills to the patient bedside in a timely way. This system requires knowledgable staff who understand the implication of any changes in a patient's level of consciousness or physiological status to accurately convey any concern in order to secure the appropriate response. Education, TTSs, outreach teams and structured handover tools are the main components of the system and their overall impact on outcomes will depend on how well each of the individual components work.

The fact that variation in IHCA rates and survival persists suggests that either the effectiveness of the interventions is not as great as anticipated or that problems with implementation limit their effect. As the use of different configurations of these preventative interventions is well-established across the NHS, it is not possible to evaluate the impact of each component using experimentation (i.e. a randomised controlled trial). However, the opportunity of natural experimentation, which exploits variation in health care, exists. When combined with assessment of implementation fidelity to determine which aspects of an intervention have been delivered, it will be possible to gain a better understanding of the association between different arrangements of interventions and IHCA incidence and survival.

Study aims and objectives

The aim was to identify which packages of interventions for detecting and managing patient deterioration in acute hospitals were associated with the lowest IHCA rates, improved survival following arrest and

hospital mortality, and in doing so identify models of care that are likely to have most impact on decreasing avoidable mortality.

Our objectives were to:

1. design a typology of interventions based on previous research and an understanding of how interventions are implemented in practice
2. determine the association between different arrangements of interventions and IHCA rates and outcomes
3. identify service features associated with the lowest IHCA incidence and best outcomes, and to disseminate the findings across the NHS in order to guide service design.

Methods

We used a non-randomised study design exploiting existing variation both in health-care interventions and in outcomes (a natural experiment). The study involved evaluation of implementation fidelity, that is, the assessment of differences in the extent to which interventions have been implemented in practice and the moderating impact of different contexts. Scientific evidence for the effectiveness of the interventions that comprise the rapid response system [RRTs (outreach teams), TTSs, structured handover tools and continuing education] was systematically reviewed.

Qualitative interviews with a range of staff involved in the care of acutely ill patients across 13 acute hospital trusts identified key intervention components, processes and contextual factors affecting implementation. These findings formed the basis of an organisational survey distributed to all NCAA hospitals enabling mapping of service variation both cross-sectionally and across time. Findings from the survey allowed grouping of the hospitals into categories based on the intensity of service provision (e.g. presence of a non-24/7 vs. 24/7 outreach team).

Cross-sectional, interrupted time series and difference-in-difference approaches were used to assess associations between intervention intensity, intervention changes over time and IHCA rates and outcomes.

Results

Educational interventions contribute to improving doctors' and nurses' confidence and knowledge when caring for acutely ill patients, but their impact on patient outcomes has rarely been considered. The majority of hospitals ran formal courses directed at improving ward-based management of acutely ill patients, such as the multiprofessional ALERT™ (Acute Life-Threatening Events Recognition and Treatment) course (Queen Alexandra Hospital, Portsmouth, UK; see www.porthosp.nhs.uk/departments/alert/alert.htm). Much value was placed on ward-based teaching where junior staff could learn while providing care to patients. Finding time for this teaching was becoming increasingly difficult because of workload demands. Evidence suggests that handover tools lead to improvements in information transfer and fewer omissions, both of which are key concerns when communicating information about an acutely ill patient between ward staff and a responder. By 2015, SBAR had been widely adopted across the NHS with almost 90% of hospitals promoting its use. Despite a broad range of activities to encourage uptake, ranging from briefings at induction to stickers by telephones, nurses felt reluctant to use SBAR in practice as it felt like an unnatural way to communicate, especially in front of patients. Owing to the lack of adequate variation across hospitals or across the study time period, it was not possible to determine the association of either formal education or SBAR with IHCA rates or survival.

Track-and-trigger systems are effective in improving the recording of patient physiological measures but, to date, uncertainty surrounds their impact on cardiac arrest rates and survival after an arrest.

Following the introduction of the NEWS in late 2012, there has been rapid uptake across the NHS with around 70% of hospitals reporting its use in 2015. There has also been increasing adoption of electronic TTSs replacing previous paper-based versions; by 2015, almost 30% of hospitals were using these systems. The widespread adoption of the NEWS by the NHS has been regarded positively by nursing staff, leading to familiarity across wards and between hospitals and increasing the safety of delegation of the task of taking observations to health-care assistants. Having objective information about a patient's condition has empowered nurses and strengthened their confidence in knowing when to call for help. Electronic systems that necessitated entry of a full set of observations, automatically calculating the patient's early warning score and directly alerting the appropriate responder, were felt to overcome the main limits of the paper-based system. Against a pre-existing trend of reduction in IHCA rates of 6.4% per year, use of the NEWS was associated with an additional lowering of the rate of IHCA by 8.4% per year and, separately, the introduction of an electronic TTS was associated with a lowering of the IHCA rate by an additional 7.6%. This study was not adequately powered to test the interaction between NEWS and electronic TTS interventions to determine if these effects were additive. However, these interventions had no additional impact on pre-existing trends for either hospital mortality or short- or longer-term survival after cardiac arrest.

The evidence that RRTs can reduce IHCA rates and hospital mortality has been growing over the last 20 years, but much of this accumulating evidence comes from studies with weak, uncontrolled before-and-after designs. Furthermore, RRTs are usually implemented with a new or updated TTSs. There has been a gradual adoption of nurse-led RRTs called 'outreach teams' in the NHS, particularly since 2000, and by 2015, 83% of NCAA hospitals reported having an outreach team, with a trend towards increasing hours of availability (24/7 team coverage rose from 25% to 40% from 2009 to 2015). Outreach teams appeared to have similar overarching roles (clinical care for critically ill patients on the ward, end-of-life decision-making and education and quality assurance) across the hospitals. However, there was little uniformity in terms of team composition (nursing grade or inclusion of allied health professionals), hours of coverage, level of autonomy (in areas such as prescribing or arranging admissions to intensive care units) or proportion of time devoted to education or improvement activities. Team members acknowledge the importance of their hospital-wide education and quality assurance roles in improving the care of acutely ill patients, but they were commonly drawn away from this work by increasing clinical workloads.

There appeared to be no additional reduction in the pre-existing trends for IHCA rates with either non-24/7 outreach teams or with 24/7 outreach teams. There was no impact on IHCA survival or hospital mortality over time. When analysis was restricted to IHCAs that occurred only on the wards, an association was found between increased intensity of outreach team implementation (a score based on team composition, function, autonomy and ability to meet demand) in 2015 and both short (return of spontaneous circulation for > 20 minutes and survival to hospital discharge) and long-term (30 day and 90 day) survival. This may reflect the expanding role of some teams in end-of-life decision-making leading to the appropriate exclusion of patients who are unlikely to benefit from cardiopulmonary resuscitation attempts.

Conclusions

The introduction of the NEWS and adoption of electronic TTSs were found to be associated with a reduction in IHCAs of 8.4% and 7.6% each per year, respectively. These declines were in addition to pre-existing trends. Introduction of the NEWS has standardised the TTSs used in the NHS. A standard approach addresses known barriers to effectiveness of TTSs, such as unfamiliarity with the scoring system or confusion over when to activate a response. Electronic TTSs counter residual problems with paper-based TTSs such as failure to undertake all required observations, miscalculation or reluctance of ward staff to trigger the appropriate responses. Both represent hospital-wide approaches to improving the care of acutely ill patients.

In contrast with the majority of previous studies, we found no association between either non-24/7 or 24/7 outreach teams and IHCA rates. There was also no association with survival over time, but there did appear to be an association with current team configuration, which might reflect the increasing role of outreach teams in implementing 'do not attempt cardiopulmonary resuscitation' (DNACPR) decisions. Outreach teams may contribute to the positive effect found with TTSs through their educational and quality improvement roles. However, it is possible that we failed to see a hospital-wide impact for outreach teams because of their mode of introduction or heterogeneity in organisation and implementation. Moreover, it may not matter what organisational form the responder arm of the rapid response system takes, as long as it is timely.

Implications

Our findings suggest that improvement in the afferent (trigger) arm of the rapid response system through increased standardisation and systems that both facilitate correct score calculation and automate the triggering of a response may have the greatest potential to reduce avoidable mortality associated with a failure to recognise and respond to deteriorating patients on the ward. The lack of association between IHCA rates or survival and outreach teams over time should not be interpreted as evidence of ineffectiveness, as teams may be important in delivering the benefits of TTSs through helping to educate ward staff, encouraging other forms of quality improvement and implementing appropriate DNACPR decisions. Our findings do not provide a clear picture on the best configuration for the efferent (response) arm of the rapid response system.

In-hospital cardiac arrest rates have been proposed as an indicator of the quality of care for acutely ill patients on hospital wards; however, IHCAs are rare with an average ward only seeing one or two per year. Furthermore, their frequency is not determined only by the effectiveness of preventative activities on the ward but also by the interplay between hospital case mix and the number of patients eligible for resuscitation. It is currently difficult to tease out the impact of these different factors without more detailed data becoming available.

Further research is required to determine which component of the TTS has the greatest effect on outcomes and to assess the potential impact of outreach teams at hospital and patient level.

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