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Ward-based in situ simulation: lessons learnt from a UK District General Hospital

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ABSTRACT

Introduction In situ simulation (ISS) enables multiprofessional healthcare teams to train for real emergencies in their own working environment and identify latent patient safety threats. This study aimed to determine ISS impact on teamwork, technical skill performance, healthcare staff perception and latent error identification during simulated medical emergencies.

Materials and methods Unannounced ISS sessions (n=14, n=75 staff members) using a high-fidelity mannequin were conducted in medical, paediatric and rehabilitation wards at Stepping Hill Hospital (Stockport National Health Service Foundation Trust, UK). Each session encompassed a 15 min simulation followed by a 15 min faculty-led debrief.

Results The clinical team score revealed low overall teamwork performances during simulated medical emergencies (mean±SEM: 4.3±0.5). Linear regression analysis revealed that overall communication (r=0.9, p<0.001), decision-making (r=0.77, p<0.001) and overall situational awareness (r=0.73, p=0.003) were the strongest statistically significant predictors of overall teamwork performance. Neither the number of attending healthcare professionals, their professional background, age, gender, degree of clinical experience, level of resuscitation training or previous simulation experience statistically significantly impacted on overall teamwork performance. ISS positively impacted on healthcare staff confidence and clinical training. Identified safety threats included unknown location of intraosseous kits, poor/absent airway management, incomplete A–E assessments, inability to activate the major haemorrhage protocol, unknown location/dose of epinephrine for anaphylaxis management, delayed administration of epinephrine and delayed/absence of attachment of pads to the defibrillator as well as absence of accessing ALS algorithms, poor chest compressions and passive behaviour during simulated cardiac arrests.

Conclusion Poor demonstration of technical/non-technical skills mandate regular ISS interventions for healthcare professionals of all levels. ISS positively impacts on staff confidence and training and drives identification of latent errors enabling improvements in workplace systems and resources.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Prior to the COVID-19 pandemic, in situ simulation (ISS) on a gastroenterology ward was found to drive identification of latent errors in education/training, equipment, medication and multiprofessional teamworking and positively impact on staff confidence and role recognition. Informed by this success, the medical education department expanded the ISS programme to medical, paediatric and rehabilitation wards at Stepping Hill Hospital following the COVID-19 hiatus.

WHAT THIS STUDY ADDS

⇒ This study demonstrates that non-technical skills (NTSs) including communication, decision-making and situational awareness are strong significant determinants of good teamwork performance during simulated emergencies and that ISS continues to positively impact on staff confidence and drives identification of latent errors informing trust-wide education programmes and quality improvement projects. In contrast, this study found that multiprofessional teamwork performances were generally low and that healthcare professionals' varying levels of training did not appear to guarantee efficient teamwork.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Together, these findings mandate regular ward-based ISS interventions for all healthcare staff and highlight the importance of widening implementation of NTS in the context of ISS in national under and postgraduate training programmes for healthcare professionals.

INTRODUCTION

In-hospital medical emergencies require dynamic interactions between healthcare team members directed towards rapid patient stabilisation. The multiprofessional ward team is the first to respond to a medical emergency. Teams frequently encompass doctors of all grades (foundation year 1 and 2 trainees (FY1 and FY2), junior/senior clinical fellows (JCF and SCF), internal medicine trainees (IMT) years 1–3, specialist trainees (ST) and consultants), nurses of all grades, advanced clinical practitioners (ACPs), physician associates (PAs) and medical/nursing students. All team members provide varying levels of medical knowledge as well as technical and non-technical skill sets (NTSs). Evidence from military and aviation communities indicates that while individual technical skills (TS) provide the foundation for effective teamwork, they alone are not sufficient.[1–5] Instead, Morgan *et al* established that individual cognitive, behavioural and attitudinal actions or NTS were necessary for efficient interdependent teamwork performance.[6] The medical community has also recognised the importance of NTS within the healthcare setting. Typical NTSs in healthcare include (1) planning, preparation and prioritisation, (2) situation awareness and perception of risk, (3) decision-making, (4) communication and (5) teamwork and leadership.[7] Importantly, the lack of NTS accounts for most adverse events during medical emergencies.[8–10]

In situ simulation (ISS) is simulation-based education which takes place in a clinical setting,[11] empowers ward-based healthcare teams to come together and train for real emergencies[12] and improves teamworking, clinical patient care and patient morbidity and mortality outcomes.[13 14] Furthermore, ISS is an efficient method for monitoring team performance and providing constructive feedback within the multiprofessional teams' own clinical setting.[15] Our simulation team demonstrated that ward-based ISS was a powerful tool to identify latent errors in education/training, equipment, medication and teamworking on a gastroenterology ward during simulated medical emergencies.[12] We also showed that ISS was well perceived by healthcare staff and positively impacted on participant confidence and role recognition.

At Stepping Hill Hospital (District General Hospital, Stockport National Health Service Foundation Trust, UK), we have a faculty team accredited in simulation practice and ALS as well as experienced in delivering high-quality ward-based ISS. Our team comprises at least three faculty members (consultant/facilitator, observer and equipment operator). The simulations are unannounced which enhances the fidelity/realistic feeling of a medical emergency.

The aims of this study were (1) to identify determinants of good teamwork performance during simulated medical emergencies, (2) to examine the impact of ISS and simulation-based debriefing on staff perception of medical, paediatric and rehabilitation wards and (3) to determine whether ISS would continue to be efficient in identifying and addressing latent patient safety threats including TS errors. We hypothesised that (1) overall team communication during a simulated medical emergency would correlate with overall teamwork performance, (2) ISS would be well perceived by multiprofessional ward-based healthcare teams and (3) ISS would continue to be a powerful resource in identifying and addressing latent errors.

MATERIALS AND METHODS

Each participant was required to consent to participating in the study and to sharing any anonymised data collected for future presentations and/or publications. This study did not involve patients or the public.

High-fidelity mannequin

The advanced multipurpose simulator HAL S3201 (Gaumard, Simulators for Health Care Education, Florida, USA) including live vital parameter monitoring was used to perform ISS.

Study participants and design

ISS sessions (n=14, n=75 healthcare professionals) were preagreed with lead nursing staff/consultants of respective wards and conducted between February and July 2022 following easing of hospital-based COVID-19 measures. ISS sessions remained unannounced to the remaining healthcare staff in respective wards. Each ISS session entailed a 15 min simulated medical emergency (±cardiac arrest) followed by a 15 min faculty-led debrief. The simulation was initiated by sounding the alarm prompting an emergency multiprofessional team response. Each ISS session was conducted by a trained faculty team encompassing at least one facilitator, one operator and one observer. A structured debrief informed by 'The London Handbook of Debriefing'[16–18] took place following each session. The debrief was led by a trained faculty member who provided constructive feedback to the emergency response team and addressed any questions or concerns. Following the debrief, attending healthcare professionals (n=3–7 participants per simulation) consented to participating in the study. Following consent, study participants were asked to anonymously complete a questionnaire capturing baseline parameters as well as the modified Simulation Effectiveness Tool questionnaire to measure the responding team's perception and ISS impact.[19] A total of n=75 staff members participated in this study, however, some participants did not fully complete the questionnaire. The clinical teamwork score was employed to rate multiprofessional teamwork performance during the simulated emergency[20] and the Safety Engineering Initiative for Patient Safety framework was used to categorise identified latent errors.[21]

Statistical analysis

The GraphPad Prism software V.9.0.0 (California, USA) was used to perform statistical analysis and compute graphs. All parameters were assessed for Gaussian distribution using the Shapiro-Wilk test. Log_{10}-transformation was performed for non-normally distributed parameters prior to statistical analysis. Cohort characteristics are presented as mean±SEM. Unless otherwise indicated, the Pearson correlation coefficient was employed for correlation analysis. A $p<0.05$ was considered statistically significant.

RESULTS

Composition of multiprofessional teams attending simulated medical emergencies

Team members' backgrounds varied between each simulation encompassing nursing/medical students, nurses (bands 2–7), 1 ACP, PA, FY1 and FY2, JCF/SCF, IMT and ST3+ trainees. On average, each team member had 6.6±2.3 years of clinical experience (range: 0–34 years) and had

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previously attended 1.8±0.9 ISS sessions (range: 0–10 sessions). Team members were predominantly female (n=51), aged between 26 and 35 years (n=34) and BLS-trained (n=34). Each simulated emergency was attended by an average of five healthcare professionals (range: 3–7 healthcare professionals). Summarised cohort characteristics are presented in table 1.

ISS reveals low teamwork ratings during simulated medical emergencies

The faculty team employed the clinical teamwork score[20] to immediately rate observed NTS[7] during simulated emergencies (online supplemental table 1). Average prioritisation was 3.6±0.6, situation awareness was 3.3±0.4, decision-making was 4.1±0.5, communication was 3.8±0.5, directed communication was 3.4±0.5, closed-loop communication was 2.2±0.5, teamwork performance was 4.3±0.5 and performing as leader/follower was 3.8±0.5 per simulation. Further items including orientating new members using situation, background, assessment, recommendation, resource allocation, target fixation, role clarity and patient-friendly teamwork received similar low scores. Together, these data demonstrate a lack of NTS among attending healthcare staff of all backgrounds and levels of training indicating a potential significant risk in the real event of a medical emergency. Although most overall teamwork performances received poor scores, a minority were marked with higher scores (figure 1A). To identify potential determinants of good overall teamwork performance linear regression analysis was performed between assessment items within the clinical teamwork score and overall teamwork performance (figure 1).

Overall communication strongly correlates with overall teamwork performance during simulated emergencies

We observed a strong significant correlation between overall communication and overall teamwork performance (figure 1A, r=0.9, p<0.001). Furthermore, overall decision-making (figure 1B, r=0.7, p<0.001), overall situational awareness (figure 1C, r=0.73, p=0.003), transparent thinking (figure 1D, r=0.71, p=0.005), closed-loop communication (figure 1E, r=0.7, 0.005), role clarity (figure 1F, r=0.7, p=0.006), performing as a team leader/follower (figure 1G, r=0.7, p=0.005) and target fixation (figure 1H, r=0.63, p=0.02) strongly and positively correlated with overall teamwork performance. The full correlation analysis of assessment items of the clinical teamwork score versus overall teamwork performance is presented in online supplemental table 2. These findings indicate that good communication between team members is of key importance during emergencies.

ISS continues to positively impact on healthcare staff confidence and clinical training

When questioned on matters of confidence, a majority of participating healthcare staff strongly agreed to feel

Table 1 Baseline cohort characteristics

Parameters	Cohort (n=75)
Anthropometric	
Female/male/prefer not to say (n)	51/23/1
Age 18–25 years (n)	9
Age 26–35 years (n)	34
Age 36–45 years (n)	18
Age 46–65 years (n)	14
Professional background	
Nursing and medical students (n)	4
Nurses and healthcare assistants (bands 2–7) (n)	42
Advanced clinical practitioners and physician associates (n)	4
Foundation year doctors (FY1 and FY2) (n)	6
Junior and senior clinical fellows (n)	13
Internal medicine trainees (n)	3
Specialist registrars (n)	3
Number of healthcare professionals per in situ simulation session (mean±SEM and range)	5.3±0.3 (3–7)
Highest level of in-date resuscitation training	
Number of professionals with ILS training (n)	19
Number of professionals with BLS training (n)	34
Number of professionals with ALS training (n)	22
Years of clinical experience (mean±SEM and range)	6.6±2.3 (0–34)
Number of previously attended in situ simulations(mean±SEM and range)	1.8±0.9 (0–10)
Number of in situ simulations in hospital departments and simulation scenarios	
Acute medical unit (n): myocardial infarction/CA, pulmonary embolism/CA, chest pain/CA	3
Cardiology/coronary care unit ward (n): 2' anaphylaxis/CA, morphine toxicity/CA	3
Gastroenterology ward (n): upper gastrointestinal bleed/CA	1
Paediatric ward (n): sepsis without CA	1
Hyperacute stroke unit (n): anaphylaxis/CA	1
Diabetes/endocrinology ward (n): urosepsis/CA, anaphylaxis/CA, morphine toxicity/CA	3
Stroke rehabilitation ward (n): anaphylaxis/CA	1
Department of medicine for older people (n): urosepsis/CA	1
Total number of in situ simulations (n)	14

ALS, advanced life support; BLS, basic life support; CA, cardiac arrest; ILS, immediate life support;

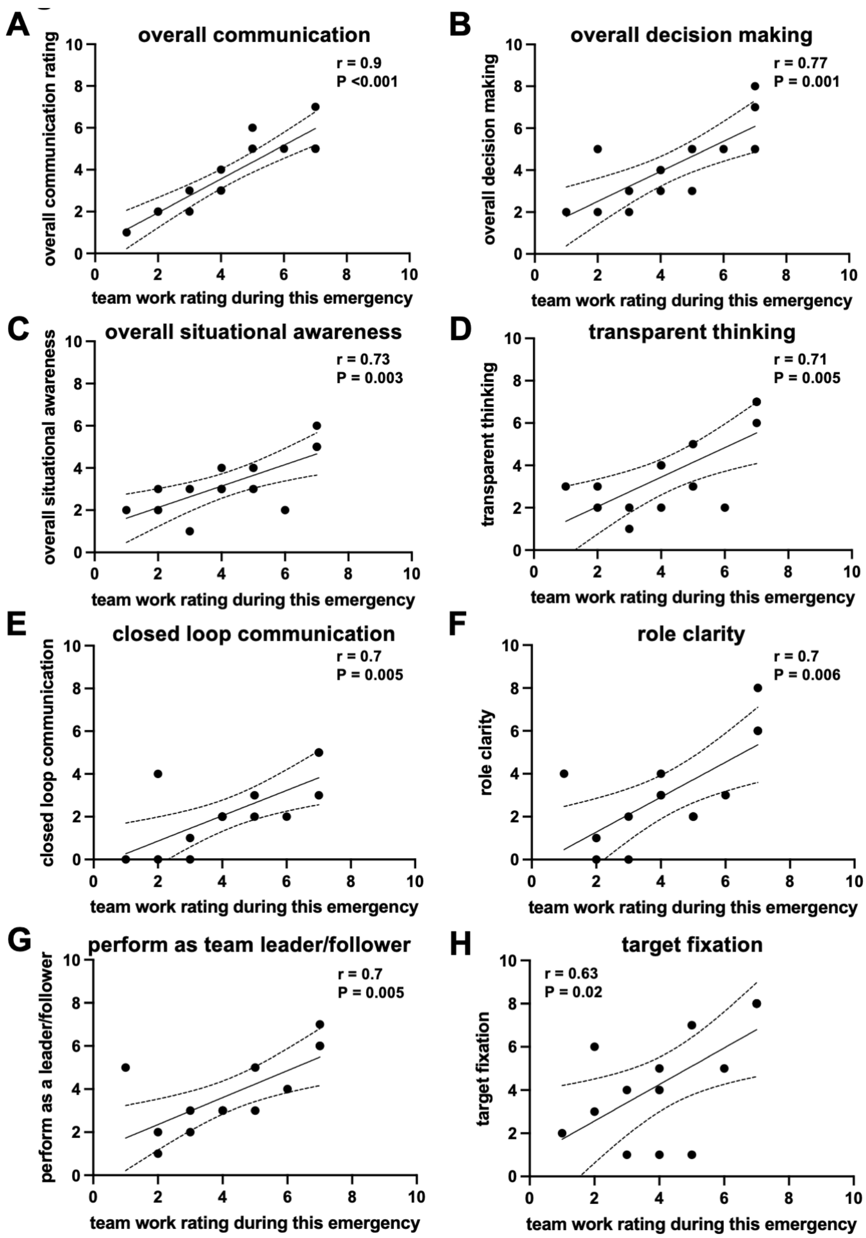

Figure 1 Overall communication is the strongest determinant of good overall teamwork performance during simulated medical emergencies. Linear regression analysis was used to examine potential correlations between individual teamwork score items and overall teamwork performance. (A) The association between overall communication and overall teamwork performance, (B) the association between overall decision making and overall teamwork performance, (C) the association between overall situational awareness and overall teamwork performance, (D) the association between transparent thinking and overall teamwork performance, (E) the association between closed-loop communication and overall teamwork performance, (F) the association between role clarity and overall teamwork performance, (G) the association between performance as leader/follower and overall teamwork performance and (H) the association between target fixation and overall teamwork performance. Continuous black lines indicate the correlation coefficient, dotted black lines indicate 95% CI bands and closed black dots indicate conducted ISS sessions. P value s<0.05 were considered significant. ISS, in situ simulation.

more confident in their assessment skills (85%, n=60 of 71), their ability to prioritise care/interventions (78%, n=58 of 74), communicating with their patients (75%, n=58 of 72), teaching their patients about their illnesses/interventions (68%, n=50 of 73), providing actions that foster patient safety (78%, n=56 of 72) and using evidence-based practice to provide care (73%, n=49 of 68). 86% of questioned participants (n=62 of 72) felt better prepared to respond to changes in their patients' conditions (figure 2). 70% of participants (n=41 of 70) strongly agreed that they were empowered to make a clinical decision. When questioned on the usefulness of simulation-based debriefing, nearly all participants felt that debriefing was a constructive evaluation of the simulation (94%, n=65 of 69), was valuable in enhancing clinical judgement (93%, n=66 of 71), allowed for communication of feelings prior to focusing on the medical emergency scenario (90%, n=64 of 71)

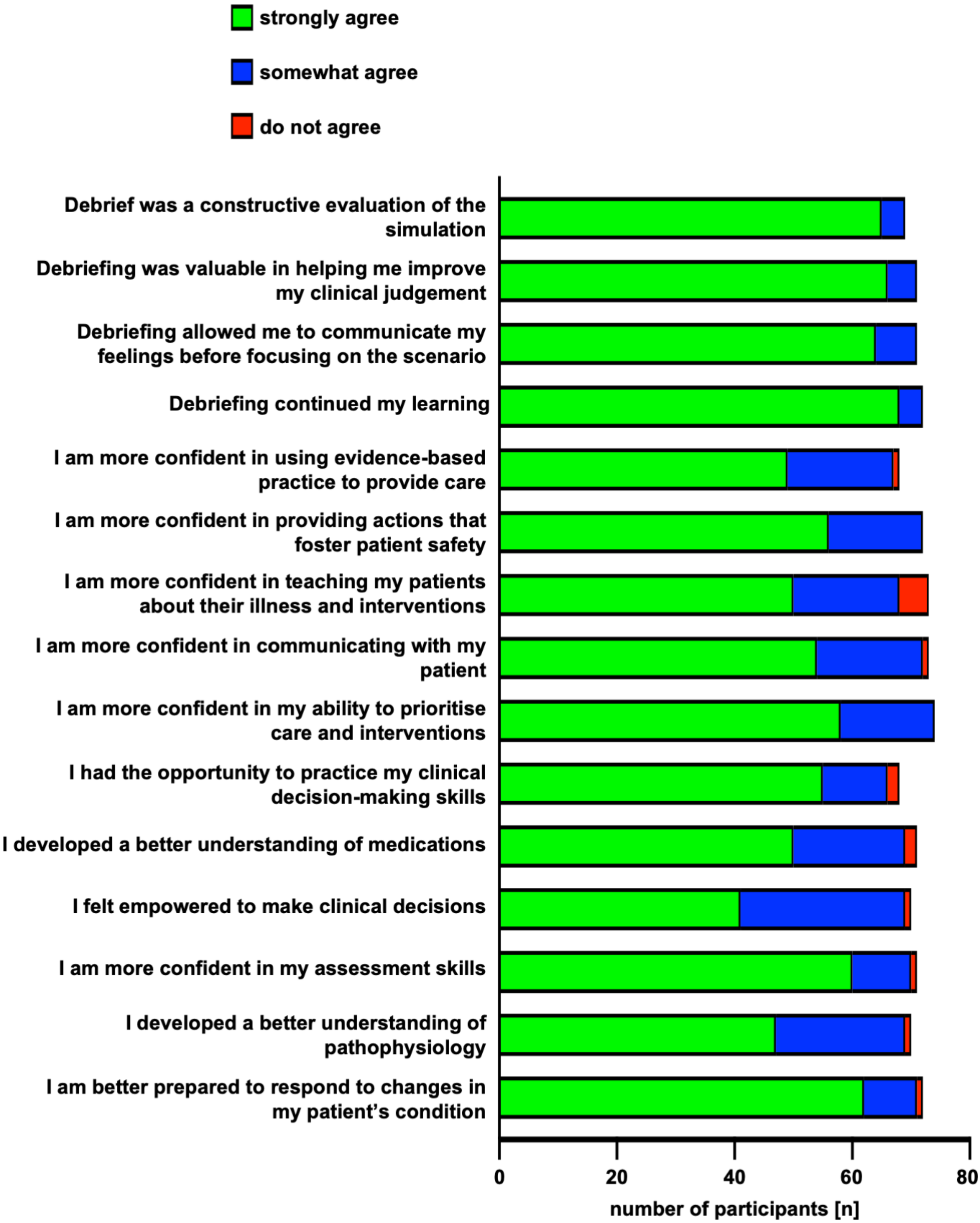

Figure 2 In situ simulation positively impacts on healthcare staff confidence and training. Following each simulation session, the SET-M questionnaire was handed out to simulation participants to measure the multiprofessional team's perception. Data were collected from n=75 participants and are presented as cumulative frequency (green colour indicates strongly agree; blue colour indicates somewhat agree and red colour indicates strongly disagree). SET-M, modified Simulation Effectiveness Tool.

Table 2 Summary of identified latent errors

Organisation of work	Task	Person
► Unknown location of IO kit (100% of scenarios requiring IO) ► Poor or absent airway management (70%) ► Incomplete ABCDE (54%) ► No scribe/timekeeper (54%) ► Ineffective leader (46%) ► Team allowed poor compressions (38%) ► Team unfamiliar with resuscitation drugs and doses (15%) ► Team members did not check for DNACPR (7%) ► MHP was not on the trolley (7%) ► Team did not know how to activate the MHP (this has now changed to calling 2222)	► Administration of epinephrine during cardiac arrest too slow (38%) ► Unknown dose of epinephrine in anaphylaxis (100% of anaphylaxis simulations×on a revisit ISS this was not an issue) ► Unknown location of epinephrine for anaphylaxis (100% of anaphylaxis simulations×on a revisit ISS this was not an issue) ► Connection of pads to defibrillator too slow or did not happen (23%, now eliminated as new defibrillator has pads attached) ► Pad placement too slow (15%) ► Hs and Ts recall too slow (15%)	► No closed-loop communication (62%) ► Poor delegation of tasks (46%) ► Did not access algorithm to support patient management (38%) ► Leader role unclear (15%) ► Poor chest compressions (15%) ► Passive behaviour during cardiac arrest (15%) ► Unsafe shocking (15%)

ABCDE, airway, breathing, circulation, disability, exposure; DNACPR, do not attempt cardiopulmonary resuscitation; Hs, hypovalaemia, hypo/hyperkalaemia, hypothermia; IO, intraosseous; ISS, in situ simulation; MHP, major haemorrhage protocol; Ts, tension pneumothorax, tamponade, toxin.

and continued the participants' learning (94%, n=68 of 72) (figure 2).

Together, these findings demonstrate that ISS and debriefing continue to strongly promote healthcare staffs' confidence and learning as well as instilling the feeling of being better prepared for medical emergencies.

ISS remains a powerful tool to identify latent patient safety threats in acute and downstream medical wards

Latent errors were classified as organisation of work-related, task-related or person-related errors (table 2).

Organisation of work-related errors included but were not limited to unknown location of intraosseous (IO) kits (all scenarios requiring IO access), poor or absent airway management in 70% of scenarios requiring airway management, incomplete airway, breathing, circulation, disability, exposure assessment in 54% of scenarios, absence of timekeeper in 54% of scenarios, ineffective leadership in 46% of scenarios and inability to activate the major haemorrhage protocol (MHP). Most notably task-related latent patient safety threats encompassed unknown location and dose of epinephrine for anaphylaxis management in all simulated anaphylaxis scenarios, delayed administration of epinephrine during cardiac arrest in 34% of simulated cardiac arrest scenarios and delayed or absence of attachment of pads to the defibrillator in 23% of simulated cardiac arrest scenarios. Within person-related latent errors the faculty team identified absence of closed-loop communication in 62% of simulated scenarios, poor delegation of tasks in 46% of simulated scenarios and absence of accessing ALS algorithms to support management in 38% of simulated scenarios as leading errors. Further latent errors included lack of clarity of leader role, poor chest compressions, passive behaviour during cardiac arrest and unsafe defibrillation.

Overall, these data demonstrate that ISS continues to be a powerful tool in identifying latent errors in a multitude of acute and downstream medical wards in a District General Hospital setting.

The degree of clinical experience and level of resuscitation training are not associated with overall teamwork performance

The number of attending female (r=−0.24, p=0.4) and male (r=0.35, p=0.22) healthcare staff per ISS session did not significantly impact on overall teamwork performance. There was a non-significant positive association when correlating the number of staff aged between 18 and 25 years attending ISS sessions and overall teamwork performance (r=0.34, p=0.23) (online supplemental table 3). In contrast, we detected non-significant negative associations between team performance scores and the number of attending multiprofessional staff members aged between 26 and 35 years (−0.49, p=0.08) and staff members aged between 36 and 45 years (r=−0.42, p=0.13). Whereas we observed a non-significant positive association between the number of attending FY trainees and overall teamwork performance (r=0.45, p=0.11) we did not detect any association between the number of attending STs, IMTs, JCF/SCFs, ACPs/PAs, nurses and nursing/medical students and overall teamwork performance and communication. There was no significant association between overall teamwork performance and the number of participants per simulation (figure 3A, r=−0.04, p=0.88), mean

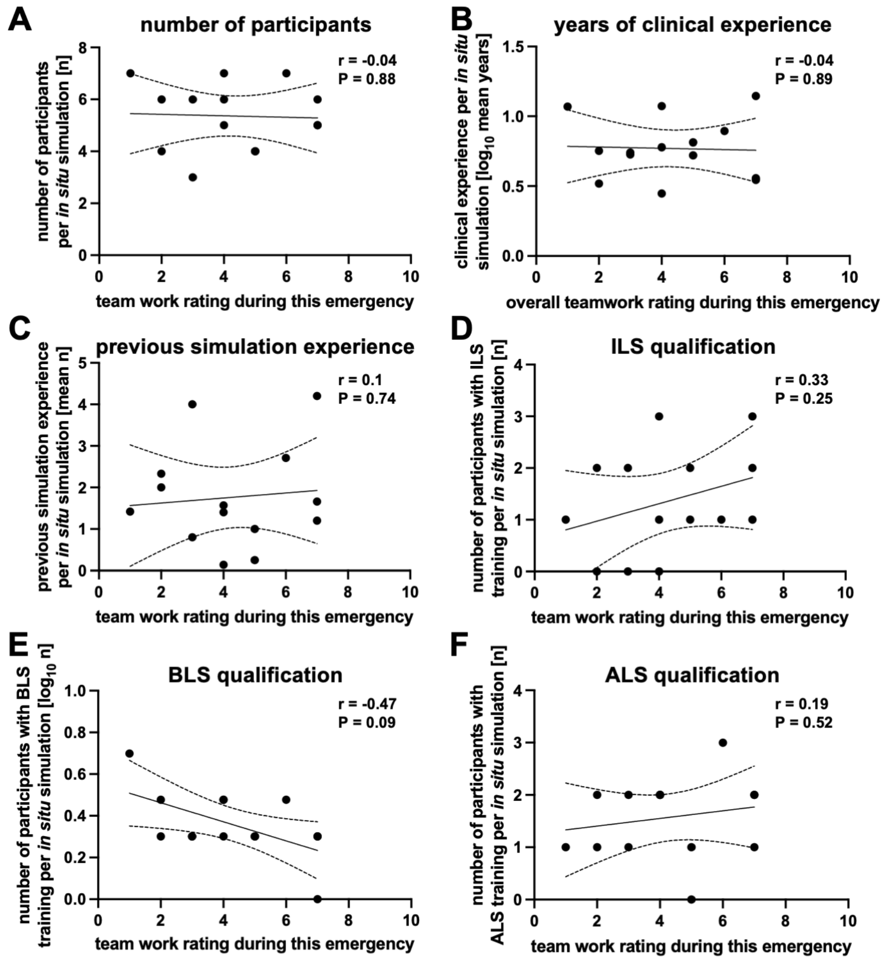

Figure 3 The level of clinical experience, previous simulation experience and level of resuscitation training do not correlate with overall teamwork performance during simulated medical emergencies. Linear regression analysis was used to examine potential correlations between baseline cohort characteristics and overall teamwork performance. (A) The association between the number of attending participants per simulation and overall teamwork performance, (B) the association between the degree of years of clinical experience per team and overall teamwork performance, (C) the association between the team's previous simulation experience and overall teamwork performance, (D) the association between the number of attending ILS-trained healthcare staff and overall teamwork performance, (E) the association between the number of attending BLS-trained healthcare staff and overall teamwork performance and (F) the association between the number of ALS-trained healthcare staff and overall teamwork performance. Within each scatter plot, continuous black lines indicate the correlation coefficient, dotted black lines indicate 95% CI bands and closed black dots indicate conducted ISS sessions. P values <0.05 were considered significant. ALS, advanced life support; BLS, basic life support; ILS, immediate life support.

years of participants' clinical experience per simulation (figure 3B, r=−0.04, p=0.89), the mean number of previously attended ISS sessions (figure 3C, r=0.1, p=0.77) and the number of ALS-qualified healthcare professionals per simulation (figure 3F, r=0.19, p=0.52). There was a non-significant positive association between the number of ILS-qualified staff attending the simulation and overall teamwork performance (figure 3D, r=0.33, p=0.25). In contrast, there was a non-significant negative association between the number of BLS-qualified staff attending the simulation and overall teamwork performance (figure 3E, r=−0.47, p=0.09). Similar non-significant associations were observed between the aforementioned parameters and overall communication scores during simulated medical emergencies.

Importantly, these findings show that in this study the professional background, degree of clinical experience as well as the level of resuscitation training do not significantly impact on overall teamwork performance during simulated emergencies.

DISCUSSION

We show that overall communication positively correlated with better overall teamwork performances during simulated emergencies and that ISS positively impacted on healthcare staff confidence/clinical training and remained a powerful resource in identifying latent patient safety threats in a District General Hospital setting.

We aimed to identify determinants of good multiprofessional teamwork performance during simulated emergencies. Attending response teams were composed of an average of five healthcare professionals with varying backgrounds and levels of clinical experience. We found that attending multiprofessional teams generally scored low values in all assessed categories. Most strikingly, the average score of closed-loop communication was 2.2±0.5 per simulated emergency. Since poor communication contributes to most errors made during medical emergencies,[8 9] this is a critical finding. Overall communication was strongly and positively associated with overall teamwork performance (R=0.9, p<0.001). In contrast, neither the number of attending healthcare professionals, their professional background, age, degree of clinical experience, level of resuscitation training nor previous simulation experience significantly impacted on overall teamwork performance. It may be speculated that low levels and likely lack of retention of NTS contributed to these poor results driving potential risk during real medical emergencies. We found that overall communication was the most significant predictor of good overall teamwork performance. However, given the low number of n=14 simulations these data must be interpreted with caution. To address this pitfall, the medical faculty will increase the frequency of ward-based ISS in the future and then compare findings to this study. Overall, these results appear to be in line with observations made in the military and aviation communities which show that effective interdependent teamwork relies on a combination of technical and NTS.[1–6] This raises the question of how ISS may be used to develop and strengthen NTS of individual providers in the future.

It is important to note that mass learning approaches such as ALS courses strongly emphasise the importance of NTS for effective teamwork.[8] However, our data demonstrate that the number of ALS-trained healthcare staff did not positively impact on teamwork performance. In addition, the American Heart Association guidelines for cardiopulmonary resuscitation recommend additional brief and frequent booster sessions as this approach is associated with improved TS retention over 12 months.[22] ISS studies informing this guideline mainly focused on TS such as quality of chest compressions and rapid defibrillation but did not specifically determine the impact of ISS on NTS during simulated cardiac arrests.[23–29] The guidelines also state that it is reasonable to conduct ISS-based resuscitation training in addition to traditional training and recognise the role of ISS in development of individual provider TS and team-based skills such as communication, leadership, role allocation and situational awareness.[22] Overall, the effectiveness of these guidelines is reflected by the fact that top performing US hospitals excelling in in-hospital cardiac arrest (IHCA) survival maintain frequent simulation sessions at regular intervals.[30] As discussed, it is an established fact that frequent and brief ISS training sessions improve retention of TS, however, very little is known about the effectiveness of simulations on NTS[31] and, indeed, on retention of NTS following training. Our data certainly indicate low NTS levels during simulated emergencies. Two potential reasons come to mind. First, it may be hypothesised that NTSs of healthcare staff are poorly retained over time. Second, frequent healthcare staff rotation and high turnover make it more unlikely for the same team to repeatedly work together during emergencies and this may negatively impact on overall team performance. Future ISS studies are required to address these hypotheses.

It may be speculated that an increase in ward-based ISS frequency may positively impact on NTS development/retention of healthcare staff. Regular ISS sessions improved participants' confidence in NTS over a period of 4 months.[32] In addition, the authors demonstrated that a combination of short instructions on NTS and ISS strengthened longer retention of NTS. Roberts *et al* showed that brief training exercises changed teamwork and communication behaviours of trauma teams and these changes were sustained at a 3-week interval.[33] In line with these findings, video-assisted leadership and technical instructions following a simulated CPR scenario showed sustained efficacy after a 4-month duration.[34] Together, these studies provide evidence that frequent ISS sessions combined with NTS training result in retention of NTS. However, these studies did not investigate the impact of ISS±NTS training beyond 4 months and, hence, it may be speculated that, like retention of CPR skills, frequent ISS sessions are necessary to consolidate NTS.

Another strategy is to broaden implementation of NTS in undergraduate and postgraduate medical training programmes. Indeed, the General Medical Council considers NTS as part of domain 6 'Capabilities in patient safety and quality improvement' within their Generic Professional Capabilities Framework.[35] Given the assumption that NTSs are best taught in the work place, most UK medical schools rely on clinical placements for NTS training of their students.[36] However, Brown *et al* identified a gap in NTS training when questioning 300 medical students and doctors indicating a need for deaneries and medical schools to review NTS training to include more than just communication skills.[37] Based on this, Watmough *et al* demonstrated that simulated emergency scenarios for final-year medical students from Liverpool University helped them to prepare as junior doctors in terms of dealing with emergency situations.[38] Regarding postgraduate teaching, the Joint Royal Colleges of Physicians' Training Board has incorporated simulation-based education into the IMT curriculum.[39] It appears equally important that NTS training should also be embedded into nursing training programmes to support future nursing staff who form an integral part of multiprofessional emergency response teams. To this end, a review by Lewis *et al* highlights the importance of high-fidelity simulations in developing NTS in nursing.[40]

In line with findings by Uttley *et al*, this study demonstrates that ward-based ISS continues to be well received by healthcare staff at Stepping Hill Hospital. Nearly all the questioned study participants felt that ISS and simulation-based debriefing positively impacted their confidence, clinical learning and role recognition as well as instilled the feeling of being better prepared for real medical emergencies. Positive staff perception of ISS on multiple acute and downstream hospital wards is reassuring as it indicates that this ISS design is generally well perceived and provides a constructive learning environment.

In line with previous studies,[12 41] we demonstrate that ISS remains a powerful tool to identify latent patient safety threats in multiple acute and downstream medical wards. Identification of threats enabled subsequent improvements in workplace systems and resources with the aim of enforcing future patient care and safety. Poor or absent airway management, the unknown location of IO kits and the inability to activate the MHP during simulated major haemorrhage scenarios were leading threats within organisation of work-related errors. Within task-related errors, we most notably identified absent knowledge of location and dose of epinephrine in simulated anaphylaxis scenarios, absence of the alteplase drug during a simulated pulmonary embolus scenario in the Acute Medical Unit and delayed administration of epinephrine as well as delayed or absent attachment of pads to the defibrillator during simulated cardiac arrest scenarios. Regarding the safe and correct use of defibrillators during cardiac arrests, the faculty team found that the most common issue was that healthcare staff failed to attach the pads to the defibrillator after placing them on the high-fidelity mannequin. Critical person-related errors included but were not limited to absence of closed-loop communication in most scenarios, poor delegation of tasks and absence of accessing algorithms to support the patient. We highlight and feedback areas of development during the debrief. In addition, the medical faculty provide a detailed report to the lead nurse of the ward on which the simulation took place. This report encompasses a detailed summary of observations made during the simulation as well tailored constructive feedback and solutions.

Findings of this ISS study have informed an educational programme to tackle identified latent patient safety threats in our wards. First, the medical education department delivered a ward-based multiprofessional in situ airway training programme in November 2022. This 2-week programme aimed to enforce recognition of airway compromise and subsequent management. Overall, the programme was very well perceived and a total of 412 staff members were trained. Second, the medical education department is arranging to conduct regular ward-based in situ training sessions on safe defibrillation, anaphylaxis management, thorough A–E assessments and a simulation-based module for identifying/managing nutritional needs. A joint project with the hospital's resuscitation team was initiated to identify appropriate healthcare staff for IO training, raise awareness of IO kit locations and offer an IO training course to identified staff members. The hospital's transfusion service will attend future MHP simulations to offer specialist support and mock codes will be run through the transfusion laboratory to increase the fidelity of the simulation. To address absent knowledge of location/dose of epinephrine for anaphylaxis and cardiac arrest management, identified wards were asked to disseminate ALS algorithms and the iResus app (https://www.resus.org.uk/library/iresus) as well as placing ALS algorithms on resuscitation trolleys. Furthermore, a trust-wide alert on anaphylaxis management has been published through our governance structure to cascade the information to other teams. To determine the effectiveness of these interventions, the medical faculty plan to compare ISS performance scores at 6-monthly intervals.

It is important to discuss the limitations of this study. The COVID-19 pandemic significantly restricted our ability to perform large-volume ward-based ISS. Since the easing of COVID-19 hospital measures, we conducted n=14 ISS sessions. In view of this low number of simulation sessions, study findings in general require careful interpretation. For example, the low number of repeats does not allow for multiregression analysis to determine the strongest determinant of overall teamwork performance or pick up on potentially subtle significant associations. We are currently working towards increasing simulation frequency and expanding the ISS programme to additional hospital wards in the coming months and years to overcome this limitation.

Furthermore, it is likely that participants' performance was influenced by the presence of faculty members during the simulation. It is also possible that the simulation rating by the faculty team may have been negatively influenced by individual rater bias. To ensure team performance ratings were objective, simulations were scored as a team. To further address these limitations, one may consider to record future simulations on video and ask faculty members to separately rate healthcare professionals' performance using standardised tools.

Emerging evidence suggests that ISS improves patient morbidity and mortality outcomes.[14] Importantly, this study does not capture the potential impact of our ISS programme on real-life clinical outcomes. One may consider to compare outcome measures such as survival from IHCA or admission to higher levels of care before and after conducting large-volume ISS. One may also argue that ISS is perceived differently compared with real-life events, thereby impacting the response during the simulation. However, arguably, simulations should be treated as real-life events when assessing the multiprofessional team response. As ISS performance scores were poor, it may be speculated that real medical emergency responses are equally ineffective with poor clinical outcomes. This statement, however, is highly speculative and should be addressed with further studies in the future.

Based on our findings and the importance of ISS in enforcing and enhancing patient care, we aim to continue and widen ISS-based training within our hospital. We aim to conduct at least four mock codes on participating wards per week, offer ward-based workshops tailored to identified areas of improvement and base simulations on risks identified within our hospital. We aim to collect more data during simulated medical emergencies including but not limited to the amount of time response teams require to recognise a simulated cardiac arrest or the time required to achieve definitive airway management. In addition, we also aim to address the following research questions in the future. First, will an increase of ISS frequency result in the enhancement and retention of NTS during simulated medical emergencies? Second, what is the longitudinal impact of ISS on patient care in a District General Hospital setting?

Overall, this study demonstrates that ISS continues to build on healthcare staff confidence and training, reinforces good practice, bridges knowledge gaps and identifies ward-based latent patient safe errors which in turn inform targeted interventions to ensure and strengthen patient care. Furthermore, our data underpins the importance of widening implementation of NTS in undergraduate and postgraduate training programmes for doctors and nurses.

Contributors JTS led on this project, performed statistical analysis, computed graphs, created figures/tables and wrote the manuscript. SD, WJ, AR, HS and ST acted as facilitators during simulations. NR acted as operator or observer during simulations. DS and JB arranged for in situ simulations on respective wards, provided feedback to respective wards, acted as operators/observers during simulations and facilitated data collection. DNB supported drafting of the manuscript and acts as guarantor. All coauthors reviewed and commented on the manuscript.

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Patient consent for publication Not applicable.

Ethics approval The Health Research Authority decision tool indicated that ethical approval was not required for this study. To still consider ethical implications, a participant information leaflet was handed out to team members to appraise them about the high-fidelity mannequin and the simulation's objectives. Each participant was required to consent to participating in the study and to sharing any anonymised data collected for future presentations and/or publications. This study did not involve patients or the public.

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