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Simulation and education

Improved recall of handover information in a simulated emergency – A randomised controlled trial

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Abstract

Background: Handovers during medical emergencies are challenging due to time-critical, dynamic and oftentimes unorderly and distracting situations. We evaluated the effect of distraction-reduced clinical surroundings during handover on (1) the recall of handover information, (2) the recall of information from the surroundings and (3) self-reported workload in a simulated in-hospital cardiac arrest scenario.

Methods: In a parallel group design, emergency team leaders were randomly assigned to receive a structured handover of a cardio-pulmonary resuscitation (CPR) either inside the room ("inside group") right next to the ongoing CPR or in front of the room ("outside group") with no audio-visual distractions from the ongoing CPR. Based on the concept of situation awareness, the primary outcome was a handover score for the content of the handover (0–19 points) derived from the pieces of information given during handover. Furthermore, we assessed team leaders' perception of their surroundings during the scenario (0–5 points) and they rated their subjective workload using the NASA Task Load Index.

Results: The outside group ($n = 30$) showed significant better recall of handover information than the inside group ($n = 30$; mean difference = 1.86, 95% CI = 0.67 to 3.06, $p = 0.003$). The perception of the surroundings ($n = 60$; mean difference = −0.27, 95% CI = −0.85 to 0.32, $p = 0.365$) and the NASA Task Load Index ($n = 58$; mean difference = 1.1; $p = 0.112$) did not differ between the groups.

Conclusions: Concerning in-hospital emergencies, a structured handover in a distraction reduced environment can improve information uptake of the team leader.

Keywords: Handover/handoff, SBAR, Working memory, Medical emergency, Simulation, Patient safety

Introduction

Patient handover is a necessity to facilitate sufficient information transfer in health care. Clinical trials assessing the impact of handover report mixed results with risks to the patient and worse outcome.[1,2] A poorly conducted handover might negatively impact on workflow and lead to misinterpretation or loss of information. During handovers of medical emergencies, the complexity of such situations[3–5] may foster loss of information. However, research also showed that a standardized and structured handover can improve the outcomes of patients.[6–9] In the present study, we investigated whether a handover under distraction-reduced, "protected" conditions outside of a room in which an emergency is ongoing (i.e., not in the immediate vicinity and without direct visual or auditory access to the emergency), could improve the perception and understanding of information given during the handover compared to being in close vicinity of the ongoing emergency situation.

Recent studies on handovers mostly focused on routine work in operating theatres, obstetrics and corresponding anaesthetic care or regular shift handovers in care units.[10–13] In medical emergencies, however, handover from one team to another is challenging due to the time-critical and fast-paced situation involving multiple staff members. These complex situations[3–5] may impair the ability to focus on the person providing the handover and the content of the handover. As a result, missed information may reduce situation awareness of

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https://doi.org/10.1016/j.resplu.2024.100612

Received 27 January 2024; Received in revised form 25 February 2024; Accepted 7 March 2024

team members and jeopardise adequate and timely therapy and hence affect patient safety and outcome.[14] The concept of situation awareness (SA) describes the general understanding of knowing "what is going on and what needs to be done."[14] The concept distinguishes three levels including the perception of elements of the environment such as vital sign data (SA level 1), the integrated comprehension of the meaning of the perceived elements such as a diagnosis (SA level 2) and projection of the future such as necessary therapeutic measures (SA level 3).

The aim of our study was to investigate the effect of a reduction in audio-visual distractions on information transfer by handover during a medical emergency. Participants therefore received a structured handover either inside the room ("inside group" = control group) right next to the ongoing CPR or in front of the room ("outside group" = intervention group) with no audio-visual distractions from the ongoing CPR.

Our main **hypotheses** were that (1) the outside group would show a better SA level 1 regarding recall of handover information (only primary outcome) and performance (SA level 2/3) compared to the inside group (secondary outcome).

Regarding further (side) effects of our intervention (all secondary outcomes), we hypothesized: that (2) lower subjective workload was measured by the NASA Task Load Index (NASA TLX)[15,16] for the outside group compared to the inside group; that (3) analogously to common findings in research on SA utilising the SAGAT,[14,17,18] more experienced physicians would show increased information uptake as well as lower subjective workload.[15,16] As part of an intervention check we expected that (4) the dwell times measured by an eye-tracking device of participants in the outside group would be significantly higher than in the inside group.

Methods

Study design

We conducted a randomized, parallel group study in a high-fidelity medical simulation environment using a scenario involving a patient suffering from an in-hospital cardiac arrest (IHCA) and requiring cardio-pulmonary resuscitation (CPR). The participants were the arriving team leaders of the emergency team and either received the handover outside of the room (outside group) or inside the room (inside group) where the CPR was happening. Following the Goal Directed Task Analysis method,[19] we developed a situation awareness global assessment technique (SAGAT)[14,17,18] probe for our specific scenario to assess SA (cf. supplement 5). Furthermore, to assess whether participants in the outside group paid more visual attention to the person proving the handover, the participants wore a mobile eye tracker.

Data collection

The data was collected in the simulation and training environment of the University Hospital Würzburg, Department of Anaesthesiology, Intensive Care, Emergency and Pain Medicine, Würzburg, Germany. The local university ethics committee approved the study (190/21-sc). Written informed consent was obtained from all participants. All participants were recruited from the local Department of Anaesthesiology, Intensive Care, Emergency and Pain Medicine. Data collection took place during two weeks in November 2021.

Participants

The inclusion criterion for the participants was the graduation as physician and experience as team leader during CPR. More specifically, participants were required to have the German certificate for pre-hospital emergency medicine (for which at least two years of training in the field of acute care medicine is required) or to have finished at least one year on an intensive care unit and had led the hospital's medical emergency team (cf. Fig. 2).

Randomisation

Author PF assigned the participants randomly and unknown to the other researchers to the two groups using a computer-based randomisation method at the beginning of each data collection session.

Medical background of the scenario and simulation environment

The medical background for the simulated scenario was an R-on-T event caused by a temporary epimyocardial pacemaker device resulting in ventricular fibrillation in a post cardiac surgery patient. This ventricular fibrillation had so far not been detected by an automatic electric defibrillator during the automated rhythm analysis.[23–25] In the standardized handover, a reference to the active pacemaker was given. For realism, the cases described in the literature[23–25] were adapted to the circumstances of the local work environment. The confederates were trained for the scenario and instructed to continue with CPR as told by the participant, but to neither aid or distract the participants nor to impede their actions. We used a high-fidelity patient simulator (HPS®, CAE Healthcare, Sarasota, FL, USA) and common medical equipment (cf. supplements 2/3).

Experiment

First, participants provided informed consent and we showed the simulation environment to ensure a basic familiarity with the room and equipment, while specific clues to the ensuing scenario remained hidden. Next, participants put on an eye tracker (SMI Eye Tracking Glasses, Teltow, Germany) and a portable microphone. They were handed a mobile telephone and were sent to their starting position in the hallway (Fig. 1).

Second, the scenario started with a code call to an ongoing CPR on a cardiosurgical intermediate care (IMC) unit. So far, the CPR was led by the IMC physician who delegated the handover to the specialist nurse who primarily was taking care for the patient during that shift. After arrival participants either received a handover by the IMC nurse outside of the patient room with the door closed or inside the patient room (Fig. 1). The handover was conducted with a uniform script following the Situation Background Assessment Recommendation (SBAR) pattern[20,21] (cf. supplement 1). Both groups received the exact same information on the current situation, past medical history of the patient, as well as on the efforts of the ongoing CPR and further actions were recommended. We always used the same person as handover nurse. This nurse had to memorize a script of the handover and did several practice rounds before the experiment took place. The handover reflected positive communication behaviour, to avoid interference, since positive communication behaviour (e.g., looking into the eyes, friendly greeting on arrival) influences team-based performance in simulated critical situations positively.[22] The length of the handover was therefore standardized. For quality control, we did measure its length from the video material ("first sentence" to "last sentence", cf. Table 1). There was a signifi-

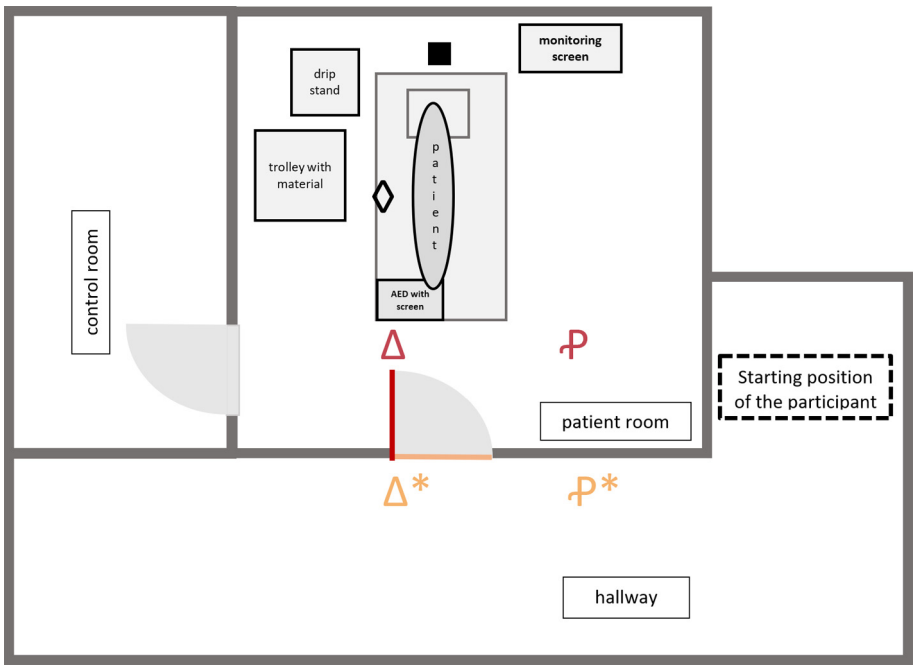

Fig. 1 – Sketch of the experimental set-up. The starting position was around the corner, where the participants (P) received the emergency call (ongoing cardio-pulmonary resuscitation on a cardiosurgical intermediate care). Depending on the group, they were routed by directives either in front of the shut door (orange door position, additionally marked with an asterisk) or inside the patient room (red door position) to receive the handover. Participants in the outside group were routed inside the room directly after the handover and the nurse giving the handover (△) took the same place as in the control group. The intermediate care (IMC) physician (solid black square shape) was ventilating the patient at the head of the patient bed. A second IMC nurse (diamond shape) provided chest compressions.

cant minor difference of three seconds. This can be explained by the fact, that in the inside group the time of entering the room is included in the duration of the handover, as this took place between the introduction of the nurse and the continuation of the handover. In the outside group entering the room took place right after the last sentence of the handover.

In both groups, the scenario stopped 60 seconds after the end of the handover and the participants were immediately led outside the room by an experimenter. The post-handover period was set to 60 seconds, as the primary aim was to evaluate how much information was successfully transferred by the handover under both conditions as well as to give the participants the opportunity to perform the necessary defibrillation.

Third, the participants answered four questionnaires. The first questionnaire was designed to check recall of the information presented during the handover (SA level 1), information that derived from the surroundings during the scenario (see the supplement 4 for a list of all items), as well as to address the comprehension of the situation (SA level 2) and intended further actions (SA level 3). Following best practice, we adapted the Goal Directed Task Analysis method to construct the SA questions[19] (cf. supplements 5). Some questions (10 items), such as *"Did resuscitation efforts start immediately?"*, had to be answered employing a 4-point rating scale (i.e., surely yes; rather yes; rather no; surely no), others (13 items), such as *"To what frequency was the pacemaker set?"* through open notes or figures (cf. supplement 4 for all items). The second questionnaire was the NASA TLX to evaluate subjective workload. The third questionnaire included open questions as well as rating scales to address the perceived quality and realism of the simulation.[26] The fourth questionnaire consisted of questions concerning demographical and work experience data.

Fourth, the eye-tracking device was reobtained and – if requested – feedback on the medical background of the scenario was given. All participants were asked not to discuss the content of the scenario with other physicians prior to their participation. The experiment was tested with four volunteers who later did not participate.

Analysis

For the analysis of the SA level 1, one point was scored for every correct answer for each item (cf. supplement 4 for scoring of the single items). As our only primary outcome, we calculated an SA level 1 score for all information that was given during the handover ("handover score" including 19 items). As in a medical emergency information from the surroundings (e.g. "Is equipment for intubation ready and prepared?") can be critical for on-time and high-quality therapy, we calculated – as a secondary outcome – a separate score based on information that could be perceived from other environmental sources ("surroundings score" including five items).

For the analysis of SA levels 2 and 3, we examined the occurrence of three major steps (awareness of pacemaker device -> reanalysis -> defibrillation) towards a solution of the case derived from the cardio-surgical subsection of the European Resuscitation

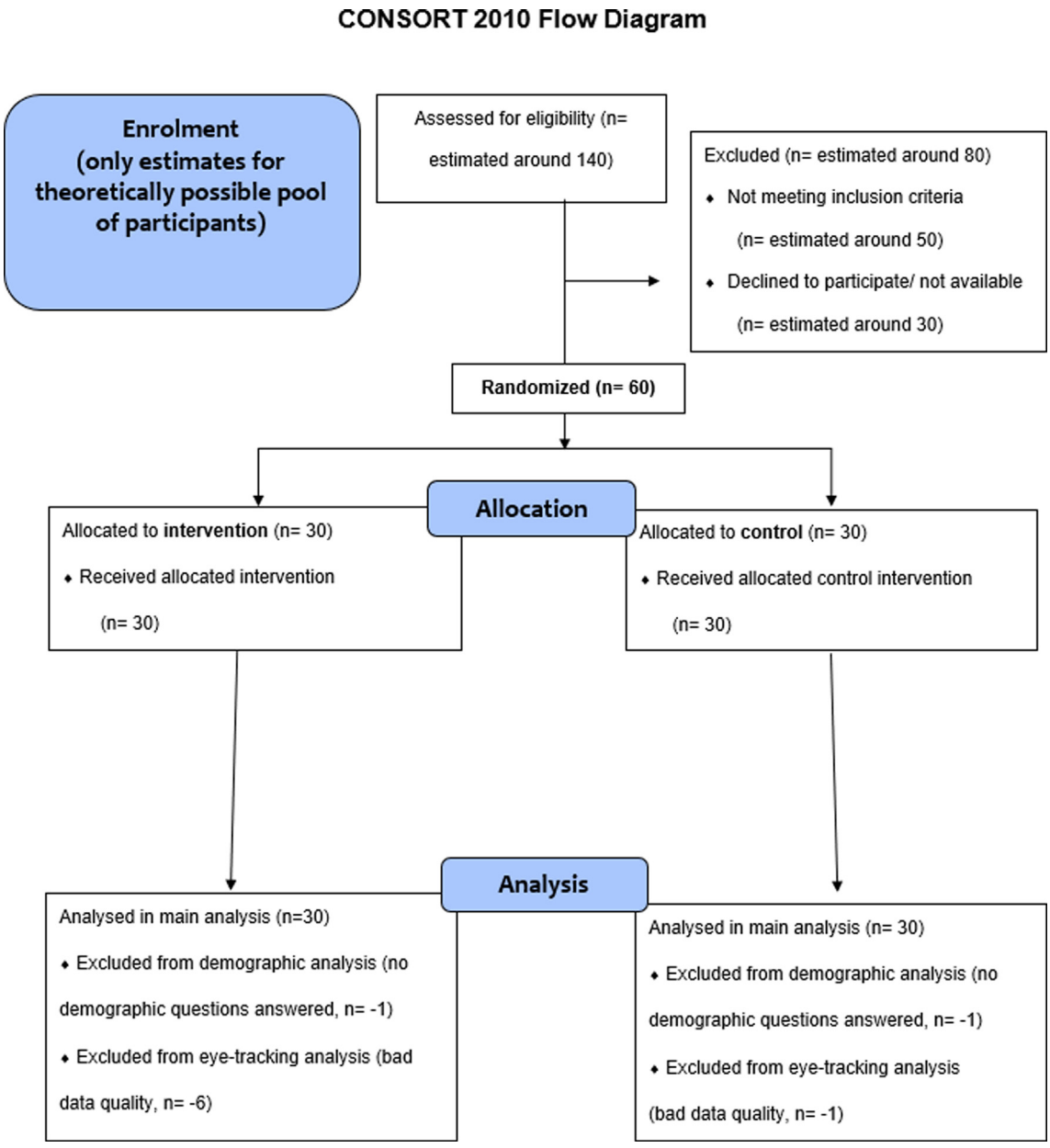

Fig. 2 – Flow Diagram. Based on Consolidated Standards of Reporting Trials guidelines.

Council Guideline 2021[27] both during the simulation as well as in the answers in the questionnaire. We did not differentiate between level 2 and 3 for these three steps, because comprehension and projection are very closely linked in this scenario (i.e., recognition of a ventricular fibrillation demanding defibrillation).

The NASA-TLX was calculated in its raw version without weighting of the single subscales as secondary outcome.[16] We collected demographic data like work experience in years, as well as CPR experience.

For the intervention check by eye tracking data, we computed the so-called percentage dwell time on the nurse providing the handover during the handover. We demanded a minimum coverage of fixations of 25% during the time and a maximum of non-assignable fixations of 15% as inclusion criteria for the analysis, as an excessive manifestation of those parameters suggests a low quality of the collected eye-tracking data (i.e. due to obstacles with glasses, make-up, etc). This led to an exclusion of seven data sets. To check interrater agreement, ten percent of the eye tracking videos were coded by a second rater. The interrater agreement of 1822 fixations showed very good agreement[28,29] with a Cohens kappa of 0.806 (95% CI 0.786–0.825).

The statistical analysis was conducted with IBM SPSS Statistics (Version 27.0. Armonk, NY: IBM Corp.). Due to the lack of applicable previous findings regarding the recall of information from handovers, we assumed a great effect size (d = 0.8). A power analysis (alpha = 0.05, beta = 0.8) resulted in a sample size of 2 $\times$ 26 participants. The α-level was set to 0.05. The distribution of the data was tested graphically and by Shapiro-Wilks-tests. Depending on scale

Table 1 – Demographics data, length of the two phases of the scenario and felt closeness to reality of the scenario separated for the outside and the inside group. Data are presented as frequencies, median [25th percentile-75th-percentile] or mean (±standard deviation). Statistical tests were Fisher's exact test (gender), $\chi 2$ test (CPR experience), two-sided Mann-Whitney-U-tests with effect size Pearson's r or two-sided T-tests for independent unpaired samples with effect size Cohen's d. Due to the lacking statements of two participants in the demographic section of the questionnaire n = 29 for gender, age, work and resuscitation experience.

	outside group (n = 30)	inside group (n = 30)	test-statistics
gender (female/male/missing)	14/15/1	9/20/1	p = 0.141
age (years)	36 [33–44]	37 [35–41]	p = 0.743, U = 399.5, Z = −0.327, r = 0.042
work experience (years)	7 [4–10]	8 [6–12]	p = 0.147, U = 327.5, Z = −1.451, r = 0.195
CPR experience (estimated times: 0–10/11–50/>51)	7/16/7	7/22/1	p = 0.0656
length of handover-phase (seconds)	51 (±2)	54 (±5)	p = 0.013, 95% CI [0.62; 5.12], d = −0.658
length of post-handover-phase (seconds)	65 (±12)	59 (±4)	p = 0.017, 95% CI [−10.63; −1.1], d = 0.644
felt closeness to reality of the simulation (0–20)	14.2 (±5.2)	15 (±4.8)	p = 0.522, 95% CI [−3.42; 1.76], d = −0.166
felt closeness to reality of the scenario's case (0–20)	17.9 (±1.6)	17 (±3.4)	p = 0.210, 95% CI [−0.51; 2.24], d = 0.329

and distribution of the data, we used Fisher's exact $\chi 2$-tests, Pearsons's correlation and $\chi 2$-tests, Mann-Whitney-U-tests and two-sided T-tests.

Results

We recruited 60 participants (female/male/missing: 23/35/2) with no overall dropouts. Details of the demographic data and scenario relevant data per group are shown in Table 1. For SA level 1, we observed a significant difference for the recall of information given during the handover between the two conditions. In the outside group (mean = 13.4, SD = ±2.43), the participants had on average almost two points more in the handover score than the inside group (mean = 11.6, SD = ±2.18; mean difference = 1.86, 95%CI = 0.67–3.06, p = 0.003). There was neither a significant difference for the perceived information from the surroundings in the separately calculated surroundings score nor for SA level 2/3 (Table 2).

There was no significant difference between the two groups in the NASA TLX RAW (Table 2, for all sub-scales cf. supplement 6). Similarly, more work experience did not correlate with better results in the handover or surroundings score, nor with lesser subjective stress in the NASA TLX scales. The estimated experience in performing real life CPR showed significant negative correlation with the results in the handover score (n = 55, r = −0.277, p = 0.040, 95% CI = −0.506 to −0.013).

Analysing the visual attention, we observed a significantly higher percentage dwell time on the nurse giving the handover in the out-

Table 2 – Situation awareness by level (perception and comprehension/projection) and NASA TLX RAW separated for the outside and the inside groups. SA level 1: Handover score and the separately calculated surroundings score. Data are presented as means (standard deviation). Statistical tests are two-sided T-tests for independent unpaired samples with effect size Cohen's d. SA level 2/3: Number of participants that undertook critical steps and/or reported those steps in questionnaire that are linked to the solution of the scenario's case. Data are presented as frequencies. Statistical tests are Fisher's exact test. Odds ratios (OR) were used as effect size. NASA TLX RAW: Data are presented as means (±standard deviation). The range of the scale spreads from 0 to 20. Statistical test was a two-sided Mann-Whitney-U-test with effect size Pearson's r. Note, that higher values in this scale represent higher stress/workload.

	outside group (n = 30)	inside group (n = 30)	test-statistics
SA level 1: memory of the handover information/perception of the surroundings			
handover score (0–19)	13.4 (2.43)	11.6 (2.18)	p = 0.003, 95% CI [0.67; 3.06], d = 0.809
surroundings score (0–5)	3 (1.16)	3.2 (1.10)	p = 0.365, 95% CI = [−0.85; 0.32], d = −0.236
SA-Level 2/3: major steps towards a solution of the scenarios case			
aware of pacemaker device (yes/no)	13/17	6/24	p = 0.095, OR = 3, 95% CI [0.85; 11.7]
reanalysis done/suggested (yes/no)	5/25	3/27	p = 0.706, OR = 1.783, 95% CI [0.31; 12.68]
defibrillation done/suggested (yes/no)	7/23	6/24	p = 1, OR = 1.213, 95% CI [0.3; 5.1]
subjective workload			
NASA TLX RAW	11.7 (±2.24)	10.6 (±3.25)	p = 0.112, U = 319, Z = −1.587, r = 0.204

side group (M = 64.74, SD = 27.68) than in the inside group during the handover (M = 19.77, SD = 17.07; $p < 0.001$, $d = 1.96$, 95% CI = 32.59 – 57.34). Furthermore, the percentage dwell time on the nurse correlated significantly with the results in the handover score ($n = 54$, $r = 0.359$, $p = 0.008$, 95% CI = 0.100 to 0.571).

Discussion

This parallel design study demonstrated superior individual recall of handover information during an in-hospital emergency scenario, when the information was presented during a handover outside the emergency scene compared to a handover given inside the emergency scene. Adding to previous research on handovers,[22,30] our study showed that changing circumstances and conditions to more "protected" surroundings during the handover, i.e., not in the immediate vicinity and without direct visual or auditory access to the emergency situation, can improve the perception and recall of handover information for emergency physicians.

One of the major questions regarding handovers in clinical practice is their impact on situation awareness. We aimed for this question by intentionally designing a complex scenario with a "correct solution" (SA level 2/3). Probably due to the demanding and rare case we used, we witnessed a low rate of correct solution in the entire study population. A scenario of a longer duration and with a different level of difficulty could be used in further research to investigate the relation between SA level 1 and levels 2/3 in the context of handovers.

Within the limits of null hypothesis testing, the participants' perception of environmental information during the scenario and workload did not differ between groups. The non-inferiority in these two secondary outcomes might help against reservations towards an implementation of our intervention in clinical practice. It is noteworthy, that participants had high values of workload/stress in the NASA TLX during the handover scenario. These results coincide with those of a study on positive communication behaviour and team performance where during handover the stress levels of participants peaked.[22]

There was no support for our expectation that participants with more work experience would show increased information uptake as well as lower subjective workload. Contrarily, more experience with CPR was negatively correlated with recall of information. This observation may be explained by the so-called "intermediate effect" which has been observed when comparing novice/students, intermediates and experts. In relation to recall of information and diagnosis, intermediates were able to reproduce more information than both novices and experts.[31,32] This may be due to the expectations of more experienced team leaders to proceed as usual (i.e., standardised algorithm) or a better prioritization of information that needs to be remembered.

Considering the eye tracking data, the distribution of visual attention during the handover phase was significantly higher on the nurse giving the handover for the outside group than for the inside group. Confirming the effectiveness of our manipulation, participants in the outside group spent visual attention to the person providing the handover. Furthermore, the positive correlation between attention on the person providing the handover and the SA level 1 score may indicate linear relation between the attention to the person providing the handover and what is apprehended during handover. This explanation is supported by research that showed a positive association of attention distribution and situation SA level 1 during tracheal intubation.[33]

Our study has several limitations. First, as the character of a medical emergency can be manifold, a CPR scenario was chosen to ensure sufficient acquaintance among the participants with the general management of the presented emergency situation. The intervention of performing the handover in front of the room can be regarded as maximum form of avoiding distractions. Notably, this intentionally chosen set-up for simulation brings along an experimental artificiality that stands in conflict with the common practice and recommendations for a CPR. For example, the avoidance of delays in key care steps (like early defibrillation for cardiac arrest with shockable rhythms, and therefore not conducting a structured handover first) is usually emphasized. In a real CPR situation, critical steps in care should not be delayed by receiving a full handover beforehand. Second, the study was conducted in a high-fidelity simulation environment which, despite the high ratings in felt closeness to reality, is different to real settings in relation to, for example, visual attention distribution.[34] Third, being equipped with an eye tracker may have influenced the participants' behaviour, although none of the participants stated that they felt distracted by wearing it and previous research showed that, for example, anaesthesiologists can induce general anaesthesia in real patients while wearing an eye tracker.[34] Fourth, we briefed the participants that all present staff were capable of their tasks and the basic measures of an advanced CPR (like compression, ventilation, rhythm analysis) were already ongoing. In reality, an arriving emergency team leader cannot be sure about this, and therefore will be forced to have a look inside the room. Our intervention that placed the location of the handover in front of the room should therefore be considered as a maximum form of shielding against distractions and might not be applicable in many clinical situations. But our findings could be applied to further medical experts that arrive during an already well performed CPR.

Because CPR is one of the most demanding and safety–critical situations for a handover in acute care medicine,[30] it can be expected that our findings still hold true for situations with lesser stress and complexity as well. Yet, further research should be done with different handover contexts, as well as other possible handover styles.[35,36] Further studies should also investigate the interaction of visual attention, auditory information perception and recall (e.g., by actively directing visual attention via indexing parallel to the respective auditory information), further examine interruptions and distractions during handovers[37] or study the amount of information that can be processed by healthcare workers, as well as the relation of SA level 1 and SA levels 2/3 in the context of handovers.

Conclusions

Overall, this study demonstrates that an intervention aiming to shield recipients of a handover during an emergency from audio-visual distractions can improve information uptake from auditively perceived content, while not being significantly inferior in information uptake from the surroundings nor in the subjective stress level. This finding should be incorporated into training and internal recommendations for handovers.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Paul Fischer: Writing – original draft, Investigation, Formal analysis, Conceptualization. **Robin Abendschein:** Methodology, Investigation. **Monika Berberich:** Investigation, Conceptualization. **Tobias Grundgeiger:** Writing – review & editing, Supervision, Methodology. **Patrick Meybohm:** Writing – review & editing. **Thorsten Smul:** Methodology, Conceptualization. **Oliver Happel:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Assigning codes for the areas of interest to the eye-tracking video data: Magdalena Hartmann, Institute Human-Computer-Media, Julius-Maximilians-Universität Würzburg, Oswald-Külpe-Weg 82, 97074 Würzburg, Germany.

Actors in the simulation: Johanna Heinze, Zohdi Khalil, Johanna Käufer, Jonas Pfeuffer, Salomea Löffl, Julius-Maximilians-Universität Würzburg.

Testing the experimental setting: Felix Hahn, University Hospital Würzburg, Department of Anaesthesiology, Intensive Care, Emergency and Pain Medicine, Oberdürrbacher Straße 6, 97080 Würzburg, Germany.

Answering the pre-staged online survey on the handover: several anonymous physicians at the hospitals of Ochsenfurt, Passau and Heidelberg.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100612.

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