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Feasibility of hand disinfection in paediatric advanced life support (PALS): A simulation study

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S U M M A R Y

Background: Hand disinfection is often omitted during emergencies because it may delay life-saving treatments. As healthcare-associated infections significantly worsen patient outcomes, the categorical omission of hand disinfection in emergencies should be re-evaluated. Real-world observations on this subject tentatively indicate compliance rates of <10%. In an adult simulation study, we have previously shown that proper hand disinfection without delaying patient care is feasible in >50% of scenarios. However, no comparable data have been published regarding emergencies in infants or children.
Aim: This observational study aimed to assess the feasibility of hand disinfection in simulated paediatric patients requiring advanced life support (PALS).
Methods: We observed 32 simulations of life-threatening conditions. Two observers counted all possible moments for administering hand hygiene, according to the World Health Organization protocol, and assessed them for time-neutral feasibility.
Results: In the 32 scenarios, the feasibility of hand disinfection for all WHO moments ranged from 78.3 to 100%. Of all 573 hand disinfection moments, 552 (96.3%) were deemed feasible.
Altogether 208 (36.3%) occurred before aseptic tasks. Of these, 187 (89.9%) were considered feasible. Hand disinfection for WHO-2 moments feasibility showed to be at least 50% in the cases. A total of 189 (90.9%) of all WHO-2 hand disinfections were applied by the role of the "iv-manager". Scenarios with shockable rhythms and peri-arrest showed higher feasibility ratios than those without.
Conclusions: The categorical omission of hand disinfection in PALS seems to be no longer acceptable or appropriate. The feasibility of hand hygiene should be re-evaluated in real-world scenarios.

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Introduction

Hand hygiene is fundamental to preventing healthcare-associated infection which may have high levels of morbidity, mortality, and economic burden in adults, infants, and children [1,2]. Hand hygiene is time-consuming and is regularly omitted - for life-saving procedures when prompt action is required, such as resuscitation attempts or trauma treatment [3,4]. This omission may be considered reasonable in stressful situations, particularly in the absence of evidence supporting the systematic implementation of hand hygiene in emergency guidelines [5–7] and resuscitation training [8–10]. This may result in low adherence to hand hygiene procedures, particularly by emergency medical services personnel [11–13]. However, justifiable lower rates of hand hygiene in cases where hand hygiene is not feasible do not equate to the omission of hand hygiene in all situations.

Few data are available concerning infections associated with emergency treatments. One cohort study demonstrated that emergencies may result in a higher risk of respiratory and gastrointestinal infections in older patients [14], although the study did not focus on hand hygiene. Fever, inflammation, and infection are all common manifestations following cardiac arrest events. Fever is associated with reduced survival rates and neurological outcomes in comatose patients [15]. Bloodstream infections harm the overall outcomes of vulnerable patients, prolong their lengths of stay in intensive care units (ICUs), and result in higher healthcare costs—particularly in older patients [16]. However, the number of preventable bloodstream, respiratory, urinary tract, and wound infections acquired during emergencies remains unclear.

In 2023, we showed that hand or glove disinfection was feasible in simulated adult emergency situations [17] using the World Health Organization (WHO) Five Moments of Hand Hygiene program [18] and found that >50% of all occasions had feasible moments for performing hand hygiene without delaying patient care.

However, not all emergencies involve adult patients. In 2021, >24,000 children aged around 15 years old visited emergency departments in the United States, and approximately 22.5% of these were categorised as "emergent" or "urgent" cases [19]. In 2022, approximately 1.3% of out-of-hospital cardiac arrests in Germany occurred in patients aged <18 years [20].

There is a lack of information in the literature concerning the feasibility of hand hygiene in paediatric emergencies. This is challenging, as children are generally more immunocompetent than adults and thus may face different challenges. Paediatric cases are generally perceived as being highly stressful to healthcare staff and family members [10,21–23]. They may require a higher emphasis on patient and medication safety to avoid complications and second-victim effects. Preventable secondary infections are likely to aggravate psychological burdens and necessitate interventions or medications that are more susceptible to tertiary errors and complications.

This study evaluated hand hygiene feasibility in emergency scenarios involving infant and paediatric patients, simulated in the American Heart Association (AHA) Pediatric Advanced Life Support Course (PALS)].

We hypothesised that hand hygiene is feasible without delay for emergency procedures in ≥60% of all WHO indications for hand hygiene (Hypothesis 1) and in ≥50% of scenarios preceding aseptic procedures (Hypothesis 2).

Methods

Study design and setting

We conducted a prospective observational study with one PALS provider and two PALS refresher courses provided by Notfallmedizinisches Trainingszentrum in Singen e.V./Training Center for Emergency Medicine (Singen, Germany).

Two licensed American Heart Association (AHA) instructors oversaw 5–7 healthcare providers (the participants) per course, as well as their treatments on manikins in hypothetical PALS scenarios (Table I). These cases were selected from 20 prototypical emergencies in infants and children, including upper and lower airway obstruction, lung tissue disease, disordered breathing control, arrhythmia, obstructive shock, hypovolaemic shock, distributive shock, and cardiac arrest [10]. In each PALS scenario, the participants assumed one of six generic resuscitation team roles: the "compressor" (who assesses the patient's condition and delivers chest compressions, if required), the "airway manager" (who maintains the patient's airway, delivering ventilation and oxygen support if required), the "intravenous (IV) medication manager" (who established vascular access, intravenous (IV) or intraosseous (IO), prepared any required drugs, and delivered them appropriately), the "monitor/defibrillation manager" (who attached defibrillation electrodes, assesses the patient's heart rhythm, and applies electric shocks if indicated), the "time-keeper/recorder" (responsible for documentation), and the coordinating "team leader". The participants changed their roles after each scenario.

One of the two course instructors choreographed the case (the "instructor"), while the other (the "observer") observed the participants' approaches and assessed resuscitation quality, as well as whether hand hygiene would have delayed the subsequent emergency procedures.

One of the two contributing observers collecting the data was a fully licensed infection control and critical care specialist with a qualification in medical education. The other was a critical care professional with a qualification in disaster medicine. Both were also licensed experts in antimicrobial stewardship who had been trained to observe the five moments of hand hygiene and evaluated one another's data. They used an electronic version of the marking sheet (Aktion Saubere Haende) to assess the moments of hand hygiene and took notes on the simulated scenarios. They did not provide feedback to the participants regarding hand

Table I
Description of the 32 scenarios

No.	Scenario
1	Child (7y) with upper airway obstruction due to allergic reaction
2	**Child (11y) with collapse at a sports event, out-of hospital cardiac arrest with bystander CPR, ventricular fibrillation**
3	Infant (4m) with supraventricular tachycardia
4	Child (5y) with lymphocytic leukaemia, septic shock by infected central line
5	Infant (5m) with bronchiolitis, respiratory failure
6	Infant (9m) with hypovolemic shock due to Norwalk virus infection
7	**Infant (2m) with sudden infant death syndrome, asystole**
8	Child (7y) with beta-receptor antagonist intoxication
9	Infant (6m) with pneumothorax during general anaesthesia
10	Child (5y) with pneumonia and respiratory distress
11	**Child (12y) with collapse due to channelopathy, ventricular fibrillation**
12	Infant (7m) with supraventricular tachycardia and shock
13	Child (9y) with lymphocytic leukaemia, septic shock by infected central line
14	**Infant (1m) with sudden infant death syndrome, asystole**
15	**Child (9y) with ventricular fibrillation in school class**
16	**Child (8y) with allergic reaction and upper airway obstruction, later CPR**
17	Child (10y) fall from 10 meters at a construction site, neurogenic shock
18	Infant (8m) with bronchiolitis and respiratory failure
19	**Child (7y) at the dentist. Collapse after local anaesthesia, single ventricle, Fontan circulation**
20	Child (9y) drowning in a pool on a cruise ship
21	**Child (11y) with collapse due to channelopathy, ventricular fibrillation**
22	Child (14y), pulmonary embolism
23	Child (11y), abdominal trauma, hypovolaemic shock
24	Child (9y), asthma attack
25	Infant (7m), upper airway obstruction
26	**Infant (2m) with sudden infant death syndrome, asystole**
27	**Child (7y) pulseless electric activity**
28	Child (6y), pneumonia, respiratory distress
29	Child (12y), Waterhouse-Friedrichsen-Syndrome, sepsis
30	Child (12y), supraventricular tachycardia
31	Child (10y), stable ventricular tachycardia
32	**Child (10y), pulseless ventricular tachycardia**

Scenarios in bold are discussed in the manuscript due to non-feasible hand disinfections.

hygiene during the course to maintain its structure] and to avoid bias.

Variables

The variables included the five WHO moments [18] and estimated the feasibility of administering hand hygiene at each one. The two moments WHO-1 ("Before touching the patient") and WHO-4 ("After touching a patient")/WHO-5 ("After touching the patient's environment and surroundings") were assumed to be feasible once per participant per case. The WHO-3 moment ("After exposure to body fluids") was assessed under the recognition that contaminations are seldom simulated. WHO-2 moments ("Before clean/aseptic procedures") included the insertion of IV or intra-osseous (IO) access, endotracheal intubation or the use of supraglottic airway devices, pericardiocentesis, thoracocentesis, and the preparation and administration of intravenous medications. After recognising each moment, the observer categorised whether hand hygiene for 30 s would have been feasible for the participant without delaying the emergency procedure (0=not feasible; 1=feasible). Participants were not expected to conduct hand hygiene during the course and were not observed for proper technique during simulated or real hand hygiene, but only whether they performed it.

Additionally, we assessed the duration of the scenario, the duration of the simulated cardiopulmonary arrest, duration of chest compressions, and the chest compression fraction, as recommended by the American Heart Association as the criteria for evaluating the quality of resuscitation efforts.

Table II
PALS scenarios with a description of feasible hand disinfection. Scenarios in bold are discussed individually in the results section. WHO-4 and WHO-5 are presented together

No.	Group members	Feasibility of HD (All) (%)	Feasibility of HD (WHO-2) (%)	SUM hand disinfection	SUM handisinfection feasibile	SUM hand disinfection not feasible	WHO1_ ALL	WHO1_ Feasible	WHO1_ Not feasible
1	5	100	100	20	20	0	5	5	0
2	5	95.7	92.3	23	22	1	5	5	0
3	5	100	100	13	13	0	5	5	0
4	5	100	100	18	18	0	5	5	0
5	5	100	100	16	16	0	5	5	0
6	5	100	100	13	13	0	5	5	0
7	5	78.3	61.5	23	18	5	5	5	0
8	5	100	100	19	19	0	5	5	0
9	5	100	100	14	14	0	5	5	0
10	5	100	100	13	13	0	5	5	0
11	5	100	100	21	21	0	5	5	0
12	6	94.7	85.7	19	18	1	6	6	0
13	6	100	100	20	20	0	6	6	0
14	6	81.0	55.6	21	17	4	6	6	0
15	6	85.7	66.7	21	18	3	6	6	0
16	6	100	100	16	16	0	6	6	0
17	6	100	100	18	18	0	6	6	0
18	6	100	100	21	21	0	6	6	0
19	6	100	100	19	19	0	6	6	0
20	6	100	100	18	18	0	6	6	0
21	6	100	100	23	23	0	6	6	0
22	6	100	100	17	17	0	6	6	0
23	6	100	100	16	16	0	6	6	0
24	6	100	100	18	18	0	6	6	0
25	6	100	100	15	15	0	6	6	0
26	6	83.3	50.0	18	15	3	6	6	0
27	6	80.0	50.0	20	16	4	6	6	0
28	6	100	100	17	17	0	6	6	0
29	6	100	100	15	15	0	6	6	0
30	6	100	100	15	15	0	6	6	0
31	6	100	100	17	17	0	6	6	0
32	6	100	100	16	16	0	6	6	0
MINIMUM		78.3	50.0	13.0	13.0	0.0	5.0		
MAXIMUM		100	100	23.0	23.0	5.0	6.0		
MEAN		96.8	92.6	17.9	17.3	0.7	5.7		
STANDARD DEVIATION		6.7	15.9	2.9	2.5	1.4	0.5		
SUM				573	552	21	181		

The numbers shown in for the columns Feasibillity of HD (All) and Feasibility of HD (WHO-2) for the 32 cases are percentages. The other numbers for the 32 cases are counts.

Materials and equipment

The course used Laerdal® infant and child resuscitation manikins (Resusci Junior® QCPR—Airway and Resusci Baby® QCPR—Airway; Laerdal, Stavanger, Norway) and an ALSi Monitor ® (iSimulate; 3b Scientific GmbH, Hamburg, Germany). Single-use medical equipment including cannulas, syringes, bag-valve masks, ampules, and suction devices, that are typically available in German hospitals and emergency medical services were also used. We recorded WHO indications via a modified digital checklist, according to the German (Aktion Saubere Haende) marking sheet.

Study size

Based on the methodology used in our previous adult study, we determined that a total of 30 cases would be sufficient to

WHO2_ ALL	WHO2_ Feasible	WHO2_ Not feasible	WHO3_ ALL	WHO3_ Feasible	WHO3_ Not feasible	WHO4/5_ ALL	WHO4/5_ Feasible	WHO4/5_ Not feasible	All WHO-2 by Airway manager	All WHO-2 by compressor	All WHO-2 by IV-Manager
10	10	0	0	0	0	5	5	0	1	0	9
13	12	1	0	0	0	5	5	0	2	0	11
3	3	0	0	0	0	5	5	0	0	0	3
8	8	0	0	0	0	5	5	0	0	0	8
5	5	0	1	1	0	5	5	0	2	0	3
3	3	0	0	0	0	5	5	0	0	0	3
13	8	5	0	0	0	5	5	0	0	0	13
9	9	0	0	0	0	5	5	0	1	0	8
4	4	0	0	0	0	5	5	0	0	1	3
3	3	0	0	0	0	5	5	0	0	0	3
11	11	0	0	0	0	5	5	0	0	0	11
7	6	1	0	0	0	6	6	0	0	0	7
8	8	0	0	0	0	6	6	0	0	0	8
9	5	4	0	0	0	6	6	0	1	0	8
9	6	3	0	0	0	6	6	0	0	0	9
4	4	0	0	0	0	6	6	0	0	0	4
6	6	0	0	0	0	6	6	0	0	0	6
9	9	0	0	0	0	6	6	0	0	0	9
7	7	0	0	0	0	6	6	0	0	0	7
4	4	0	2	2	0	6	6	0	0	0	4
11	11	0	0	0	0	6	6	0	2	0	9
5	5	0	0	0	0	6	6	0	0	0	5
4	4	0	0	0	0	6	6	0	0	0	4
6	6	0	0	0	0	6	6	0	4	0	2
3	3	0	0	0	0	6	6	0	1	0	2
6	3	3	0	0	0	6	6	0	0	0	6
8	4	4	0	0	0	6	6	0	2	0	6
5	5	0	0	0	0	6	6	0	1	0	4
3	3	0	0	0	0	6	6	0	0	0	3
3	3	0	0	0	0	6	6	0	0	0	3
5	5	0	0	0	0	6	6	0	1	0	4
4	4	0	0	0	0	6	6	0	0	0	4
3.0			0.0			5.0			0	0	2.0
13.0			2.0			6.0			4.0	1.0	13.0
6.5			0.1			5.7			0.6	0	5.9
3.0			0.4			0.5			0.9	0.2	2.9
208			3			181			18	1	189

draw statistically meaningful conclusions and enable robust comparisons.

Statistical methods

An explorative, descriptive analysis was conducted using Microsoft Excel® for Microsoft 365 MSO, version 2404 64-bit (Microsoft Corp., Redmond, WA, USA).

We tested Hypothesis 1 descriptively and confirmed that undertaking hand hygiene procedures was considered feasible by the observers in 60% of the measured WHO moments for the cases.

We tested Hypothesis 2 descriptively and confirmed that undergoing hand hygiene procedures was considered feasible by the observers in 50% of the WHO-2 moments.

Results

Eighteen physicians and one paramedic attended the three PALS courses. These were held from October 2022 to March 2023, and each scenario lasted between 03:55 and 20:00 min (mean [M]=08:05 mins, standard deviation [SD]=2:55 mins). The chest compression fraction ranged between 69% and 97% (M=85.1 SD=8.6 mins).

The results are presented in Table II.

We analysed 32 PALS scenarios comprising 573 hand hygiene moments. Of these, 552 (96.3%) were defined as feasible and 21 (3.6%) as not feasible. All 181hand hygiene WHO-1 moments observed were feasible; 187 (89.9%) were feasible and 21 (10.1%) were not feasible for the 208 WHO-2 moments observed: 3/3 WHO-3 moments observed were feasible, and all 181 WHO-4 and WHO-5 moments were feasible.

The number of WHO moments for hand disinfection per scenario ranged between 13 and 23 (M=17.9, SD =2.9), with a feasibility ratio of 78.3–100% (M=96.8 SD=6.7), which confirmed Hypothesis 1.

The number of WHO-2 moments per scenario ranged between 3 and 13 (M=6.5, SD=3), and the feasibility rate ranged between 50 and 100% within each scenario (M=92.6 SD=15.9), confirming Hypothesis 2.

Only 21 of 208 WHO-2 moments (10.1%) would have delayed life-saving procedures. Of all 208 WHO-2 indications, 18 (8.7%) had to be conducted by the "airway manager" (e.g. intubation, inhalant drugs), 1 (0.5%) by the "compressor" (needle decompression), and 189 (90.8%) by the "IV-manager" (IV or IO access, preparation and administration of IV and IO drugs.).

Of the 21 unfeasible WHO-2 moments 19 (90.5%) were under the responsibility of the medication manager and 2 (9.5%) under the responsibility of the airway-manager:

In case 2 (cardiac arrest), we observed one unexpected administration of epinephrine during the delivery of cardiopulmonary resuscitation because the medication manager was distracted by team members. Hand hygiene is generally feasible at such moments but was not in the situation observed.

In cases 7, 14, 26, and 27, which simulated cardiac arrest caused by sudden infant death syndrome (SIDS), the manikin was asystolic or had pulseless electric activity, thus necessitating the immediate administration of intravascular epinephrine. Consequently, the need for prompt vascular access, as well as preparation and administration of epinephrine made hand hygiene unfeasible to implement in the early minutes of the resuscitation.

In case 12, the participant treated an infant with supraventricular tachycardia. One WHO moment in this scenario was deemed unfeasible, because the IV administration of sodium chloride after adenosine is impractical. Because adenosine has a half-life of 3 seconds, performing hand hygiene between the delivery of adenosine and sodium chloride is impractical, even in non-emergencies.

Case 15 (stable ventricular tachycardia progressing to asystole) required the delivery of epinephrine immediately following the diagnosis of asystole. Neither of the two potential moments for hand hygiene in that scenario would have been conducive to the rapid administration of epinephrine. Toward the end of the case, after the spontaneous return of circulation, the child developed bradycardia—which necessitated another immediate dose of epinephrine to prevent a second instance of cardiac arrest.

The airway manager was responsible for 2 of 21 unfeasible moments (9.5%). These both occurred during case 27, where a simulated "cannot ventilate" situation resulted in hypoxia and the need to urgently insert a supraglottic airway.

Discussion

This observational study focused on WHO moments for hand hygiene in prototypical PALS cases.

We demonstrated that hand hygiene was feasible in most simulated emergencies, without delaying patient care. We also showed that hand hygiene before aseptic tasks (WHO-2 moments) was associated with the highest probability of omission and, this presents a risk of device-associated infections. We therefore confirmed both of our initial hypotheses.

We assumed 100% feasibility for WHO-1 moments in our simulations. However, this assumption merits real-world validation in both in-hospital and out-of-hospital settings. In most out-of-hospital situations, a team travels to the scene via ambulance or helicopter before approaching the patient. Thus, the 100% feasibility of hand or glove disinfection is valid for everyone, except the driver/pilot, as response teams are passively transported and therefore have sufficient time to accomplish it during transport or soon after arrival to the scene. For in-hospital scenarios, response teams are generally in emergency departments or ICUs. When an alarm is activated, such teams gather their equipment and travel to the scene using dedicated elevators or stairs to avoid any collisions. Hand hygiene may therefore be difficult to perform.

We showed that some WHO-2 moments were unfeasible for conducting hand hygiene. This occurred partially because of errors or distraction (case 2), in cases of cardiac arrest requiring immediate vascular access and administration of epinephrine (cases 7, 14, 26, and 27), or during airway-related cases with unanticipated difficulties (case 27). This was not surprising, as we found a similar pattern in our adult study on this subject [17]. As AHA resuscitation algorithms do not substantially differ between infants, children, and adults except for dosing epinephrine. This finding is consistent with those reported in prior studies.

Vascular access during emergencies is difficult and stressful for healthcare providers—particularly in infants and children with vasoconstriction who are in peri-arrest, cardiac arrest, shock, or have extreme anxiety concerning a painful procedure. In 2009, a round-table review by Rauch *et al.* reported that 5–33% of all children required >2 attempts before place vascular access was properly established, under normal conditions, even with the use of illuminating and ultrasonic devices [25]. After stabilisation, medical staff may hesitate to replace established access ports and prefer "safe" vascular access points, even if they may be contaminated. Access replacement because of anticipated contamination may be considered stressful or emotionally traumatising for both children and parents [26]. Peripheral catheter-associated septic thrombophlebitis and associated septic pulmonary embolism, or infectious endocarditis, are less common in children but are not well studied [27] They have been reported in children with comorbidities, such as chronic heart or renal failure [28,29].

Similar to the findings of our previous adult study [17], the IV-manager was found to be responsible for the most WHO-2 hand disinfection moments, including IV-placement, preparation of infusion bags, connecting 3-way stopcocks, preparation of IV medications, and IV drug delivery. Except for the airway manager, other team members seldom required hand disinfection. This excess burden on one team-member can lead to certain issues. First, ongoing hand hygiene may not be feasible when gloves are changed, indicating the need for glove disinfection [30] and prefilled syringes prepared under sterile conditions. Second, persons may be overwhelmed during the placement of vascular access and the preparation/delivery of IV medications. This distress can increase the risk of contaminating the peripheral line access or medication, dosing errors [24,31], and (for the IV/medication manager) psychological trauma as a secondary condition [23,32], particularly in paediatric cases. The role of the "IV-manager" should therefore be reviewed.

The WHO-3 moments could not be validly assessed in this simulation study because contamination was not part of the training. We simulated it only in cases 5 (nasal secretions) and 20 (blood contamination). Real-world observations may therefore help to better understand the contamination rates of hands, gloves, and clothing.

In each case, the WHO-4 and WHO-5 moments were rated as 100% feasible for undertaking hand hygiene. This is valid in most real-world situations, as there is sufficient time to perform hand hygiene during debriefing. Nevertheless, overcrowding in emergency departments [33] may lower protocol adherence.

This study had several limitations. First, low-fidelity simulations may differ somewhat from reality. They comprise obstacle-free training locations, stable 6-person team compositions, and no distractions from other events, bystanders, mobile phones, or hierarchies. Nonetheless, they have been recognised as being capable of effectively training life-support providers and teams [8,34]. Even if the feasibility of hand or glove disinfection is low in real-world situations, the key message of this simulation study remains that hand hygiene is feasible in many cases, at ratios that are clearly above the current reported prevalence of hand hygiene in trauma bays [3]. However, real-world observations are warranted to re-evaluate the influence of complex communication and human- or team-related factors that may be under-recognised in high- and low-fidelity training, before they are reviewed for implementation in education and training. Because these are highly structured and specific, their proper implementation may prove difficult. Thus, future research should focus on observations of modified PALS courses and reproducible multi-rater observations of real-world scenarios. This may lead to deeper insights into the actual feasibility of hand and glove disinfection in complex, stressful, and emotionally distracting situations, such as paediatric peri- and cardiac arrest cases.

Second, we excluded almost all WHO-3 moments. This was done because the scenario setup was unsuitable for this type of simulation. Therefore, the number of moments may be even higher in real-world scenarios.

Third, the need for hand hygiene in such situations remains unclear, particularly in terms of "number needed to treat" or "number needed to harm." To our knowledge, no data are currently available regarding resuscitation-associated hospital infections in children or adults. Hand hygiene should therefore be justified, either by data or ethically.

Fourth, we used only 32 PALS scenarios, with a high proportion of SIDS cases. Therefore, selection bias may have affected the number of feasible moments, depending on each course instructor's choice. As a result, the number of feasible moments should be interpreted cautiously. Nevertheless, none of our prototypical cases showed a feasibility rate of <50%.

Last, the three courses mainly consisted of physicians by chance during the regular course registration process. Since although nurses and paramedics are part of the main target groups of PALS other distributions would be possible. However, as the entire PALS training concept — which defined our observation setting - focuses on roles and processes instead of professions this is completely in line with the methodology and the aim of our study. Potentially, there could have been differences in hand hygiene adherence across gender, age, profession, experience and perhaps professionals may differ in their attitudes to and acceptance of hand hygiene. However, the focus of this study was to question the assumption that emergencies override adherence to hand hygiene. If the validity of this question is supported by preliminary data, detailed analysis including risk and protective factors should be investigated accordingly.

Conclusions

Hand hygiene is feasible during simulated emergencies in infants and children, without delaying lifesaving actions. It seems reasonable that this may also be true for relevant hand hygiene moments in real life scenarios. Despite the optimised simulation settings and the limitations of this study, the categorical omission of hand hygiene in emergencies remains questionable. Future observational studies and evaluations of training formats, such as implementing hand hygiene after conditioning training in emergency algorithms, may be impractical. Further research is warranted to better characterise the feasibility and role of hand hygiene in emergencies to decrease infection risk and costs by increasing patient safety.

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Ethical approval

All PALS trainees were informed about the study and consented to the use of data and publication. The Ethical Committee Physicians Association Baden Wurttemberg, Germany, approved the studies involving human participants. Written informed consent for participation was not required for this study by the national legislation and the institutional requirements.

Availability of data and material

Data is available on request.

Authors contributions

The authors contributed to the study as follows:

M Bentele: coding, validation (PALS, BLS), primary draft, and supervision.

S Bentele: validation (PALS, BLS), primary draft, and supervision.

N Reinoso-Schiller: validation, primary draft.

S Scheithauer: validation, supervision, primary draft.

S Bushuven: conceptualization, case development, coding, primary manuscript.

All authors approved the final version of the manuscript.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Grammarly in order to optimize spelling and grammar. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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