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Hand hygiene in emergencies: Multiprofessional perceptions from a mixed methods based online survey in Germany

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ABSTRACT

Introduction: Despite high vulnerability to infection, hand disinfection compliance in emergencies is low. This is regularly justified as the disinfection procedure delays life support, and instead, wearing disposable gloves is preferred. Simulation studies showed higher achievable compliance than detected in real-life situations. This study aimed to explore healthcare providers' attitudes toward hand disinfection and using gloves in emergencies.

Methods: We conducted an anonymous online survey in Germany on the attitude and subjective behavior in the five moments of hand hygiene in a closed environment and an open convenience sampling survey. Statistics included paired student's *t*-tests corrected for multiple testing. For qualitative analysis, we employed a single-coder approach.

Results: In 400 participants, we detected low priority of WHO-1 (before touching a patient) and WHO-2 (before clean/aseptic procedure) hand hygiene moments, despite knowing the risks of omission of hand disinfection. For all moments, self-assessment exceeded the assessment of colleagues ($p < 0.001$). For WHO-3, we detected a lower disinfection priority for wearing gloves compared to contaminated bare hands. Qualitative analyses revealed five themes: basic conditions, didactic implementations, cognitive load, and uncertainty about feasibility and efficacy.

Discussion: Considering bias, the study's subjective nature, the unknown role of emergency-related infections contributing to hospital-acquired infections, and different experiences of healthcare providers, we conclude that hand disinfection before emergencies is de-prioritized and justified by the emergency situation regardless of the objective feasibility.

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Conclusion: This study reveals subjective and objective barriers to implementation of WHO-1 and WHO-2 moments of hand disinfection to be further evaluated and addressed in educational programs.

What is already known?

- Hand hygiene contributes to the reduction of hospital-acquired infections.
- Hand hygiene in emergencies is seldom used as it may delay life support.
- Possibility of hand hygiene in emergencies is underestimated

Data availability

Data is available on request.

What this paper adds?

- WHO-1 and WHO-2 indications are mainly sacrificed, with responders partially denying the feasibility or efficacy at all, and some having introduced in their daily practice.
- The potential lethal risk of hand hygiene omission is known to the responders.
- Implementation of hand hygiene in emergency medicine relies on its implementation in education and quality control.

Data availability

Data is available on request.

1. Introduction

1.1. Background and rationale

Hand disinfection reduces hospital-acquired infections such as ventilator-associated pneumonia, catheter-associated urinary tract infections, surgical site infections, catheter-associated bloodstream infections, and sepsis. Infections result in increased morbidity and mortality, poor quality of life (Allegranzi and Pittet, 2009; Pittet et al., 2009; Mathai et al., 2010), and a higher economic burden on hospitals and society (Leistner et al., 2013; R. Leistner et al., 2014; R. Leistner et al., 2014). The best effects of hand disinfection are observed in departments that are highly compliant with hand disinfection protocols.

Unfortunately, omitted hand disinfection does not provide feedback to staff as infections do not occur after every omission (a specific event following poor hand disinfection is seldom). Furthermore, infections can occur days or weeks after missed hand disinfection opportunities (sometimes even after hospital discharge) or after multiple patient contacts by different persons. Thus, infection prevention and control specialists and medical educators face the challenge of convincing medical teams to perform the time-consuming and subjectively distracting hand disinfection process, of which the efficacy in a single case or occasion is impossible to quantify.

Especially in emergencies, hand disinfection might be de-prioritized to reach more tangible objectives. Thus, it is omitted regularly in emergencies as the subjective perception is that there is no time for it, and it may delay life-saving procedures (Haac et al., 2017; Jeanes et al., 2018). Unfortunately, the definition of an emergency is ambiguous, volatile, and transcendent, and its experience is situation-, resource- and competency-dependent. For example, a cardiopulmonary resuscitation may be overwhelming for teams if they are understaffed or insufficiently trained. Another well-staffed group or another larger group might experience it as a standard procedure in the same situation. Whether protocol adherence is dependent on the above factors is controversial, and some researchers have shown that it is independent of a specific problem but rather depends on the environment (Al-Damouk et al., 2004) and stress (Carter et al., 2016).

Additionally, the exact number of preventable infections associated with emergencies is unknown, but studies show increased infection rates after visiting an emergency department (Quach et al., 2012; Liang et al., 2018). Using a PubMed and Google Scholar analysis, we could not find studies focusing on “emergency-associated infections”, rather than nosocomial infections, that account for the whole length of stay, including many standard and emergencies. Thus, the role of the “emergency narrative” is unclear. Conversely, the absence of evidence for emergency hand and glove disinfection does not equate the lack of efficiency thereof. Moreover, hand disinfection is an established medical practice known to lower infection occurence (Allegranzi and Pittet, 2009; Pittet et al., 2009; Sax et al., 2007; WHO, WHO 2009), and no study proves its inefficiency in emergencies, indicating a categorical imperative to use it whenever possible and when it does not delay or hinder life-saving procedures.

Recent studies on hand disinfection compliance in trauma emergencies on the most vulnerable patients are discouraging, showing 0–7 percent protocol adherence rates (Haac et al., 2017). Furthermore, healthcare workers empirically do not offer a positive attitude or insight for hand disinfection ("It is a waste of time"). In our preceding studies in a simulation manikin setting, we could show that hand disinfection is possible in about 50 percent of all cases – even in resuscitation (Bushuven et al., 2022). In this project, 90 % of all hand disinfection moments occurred under the responsibility of the "medication manager". Proposed solutions for effective hand disinfection by the medication manager included time-sparing glove disinfection (Scheithauer et al., 2016), prefilled syringes or, if possible, an assistant to the medication manager.

Currently, emergency hand and glove disinfection are not taught in resuscitation training and are not explicitly recommended in resuscitation guidelines (Nolan et al., 2021; Vadakkencherry Ramaswamy et al., 2021). However, patients in cardiac arrest or peri-i-arrest are very vulnerable to secondary infection, worsening their neurological outcome and ruining the resuscitation effort (Dietrichs et al., 2021).

In summary, the acceptability of emergency hand and glove disinfection, its feasibility in practice in trained and untrained teams, and its effectiveness in preventing nosocomial infection remain to be determined.

1.2. Objectives

We aimed to inductively explore German healthcare providers in emergency medicine for their experiences, attitudes, and estimations on emergency hand and glove disinfection for themselves and other emergency medical system providers.

2. Methods

2.1. Study design and setting

We conducted a cross-sectional anonymous online convenience survey in a closed (a) and open setting (b) to reach at least 150 participants (see Supplement A). The researcher group developed the study and pretested it in a group of six experienced healthcare providers for feasibility, face- and content validity. After this, we tested the survey on 100 emergency medicine providers, 60 of whom completed the validation ("closed group") to test face, content, and construct validity. From July to September 2023, we recruited further participants from local emergency and disaster medicine networks and social media platforms via the German Association of Paramedic Sciences ("open group"). The survey is displayed in Appendix A in an English version translated by DeepL (DeepL SE, Cologne, Germany) and corrected by the authors for idiomatic consistency.

2.2. Participants

Responders were eligible to participate when working honorary, part-time, or full-time in emergency medicine and agreeing to answer the survey. The exclusion criterion was a refusal to participate. All responses were used, regardless of whether they completed the survey ('completers') or dropped out prematurely ('drop-outs'). As we did not modify the survey after the pilot phase, we merged participants' answers from the closed and open groups in the analysis.

2.3. Variables and analysis

The survey consisted of nine demographic variables (age, sex, qualification in emergency medicine, experience in emergency medicine, occupational situation, educator status in international training formats, educator status in emergency medicine, educator status in other disciplines, experience of hand disinfection training in emergency training). These were followed by estimations on subjective feelings for the use of gloves (item 9), emergency hand and glove disinfection preceding an emergency case (10), emergency hand or glove disinfection after a case (11), and wearing a respirator mask during a case (12). For these items 9–12, we used a visual slider from −100 (completely unimportant) to 100 (extremely important). Further, we asked the participants how often they performed an emergency hand or glove disinfection before touching a patient (WHO-1) (13), before conducting an aseptic procedure (WHO-2) (14), after contamination of their own hands with body fluids (WHO-3) (15), after contamination of gloves with blood or secretions (WHO-3) (16), after hand-over (WHO-4) (17), and after contact to the patient surroundings (WHO-5) (18). These items were duplicated for the participants to assess their colleagues emergency hand or glove disinfection use in these situations (items 18–24). All items 13–24 were answered using a visual slider (see Appendix B) ranging from "never" (−100) to "always" (+100) with "0″ as the neutral option in-between. The next items comprised the estimations of maximum credible risks of omitted hand disinfection or use of non-sterile medical gloves: risk to the participant in case of not wearing gloves when necessary (25), the risk to a patient in case of omitted hand disinfection (26), the risk to oneself in case of omitted hand disinfection (27), and the risk for a colleague in case of omitted hand disinfection (28). All items 25–28 used a slider question ranging from "not dangerous" (−100) to "lethal" (+100) with "0″ as the neutral answer. In item 29, we asked for the estimated count of possible hand disinfections according to international standards during CPR. In item 30, we asked for the percentage of hand disinfections possible during CPR without delaying other emergency procedures. In item 31, we asked whether hand disinfection should be omitted whenever it may delay other techniques, using a Likert-scale ranging from "do not agree" to "fully agree." Items 32 and 34 were free text entries on the participants' opinion on the statement that a study had shown that 50 % of hand disinfection moments were achievable without time delay during adult CPR (32) and on glove disinfection (34). Item 33 was a slider question about whether they agree on glove disinfection as an alternative to

hand disinfection ("do not agree" versus "fully agree"). All sliders included steps of 10, forming 20-point Lickert scales for ordinal items (items 13–24, 31, 33) and estimation of percentages.

We did not detect survey fraud.

2.4. Study size

The minimum study size was estimated using power analyses (paired *t*-tests with the calculation of the effect size according to Cohen; G*power, University of Duesseldorf) with estimations of the survey items with minor differences between assessments of own and others. We calculated a minimum sample size of 147 participants, depending on the pre-test.

2.5. Statistics

Analyses were performed using SPSS 29.0 IBM (Armonk, New York, USA). We assumed normality for all variables, in line with the Central Limit Theorem (Fischer, 2011). Therefore, we used Pearson's correlations, unpaired and paired *t*-tests. In addition, we calculated effect sizes (Cohen's D) with interpretation according to Cohen. A two-tailed p value of < 0.05 was considered significant. Missing values were excluded using the listwise exclusion method. This means that any cases or observations in which the variables of interest are missing were not included in the analysis.

2.6. Qualitative

We conducted the qualitative analysis using an inductive single-coder approach according to Bradley (Bradley et al., 2007). We stopped coding after reaching data saturation. For this report, we translated German transcripts by DeepL (DeepL SE, Cologne, Germany) and checked them for idiomatic validity by an English native speaker. To semi-quantify representativity, we counted codes that

Table 1
Characteristics of participants. EMR= Emergency Medical Responder EMT= Emergency Medical Technician.

Parameter		Absolutes	Percent.
Sex	Female	120	30.0
	Male	260	65.0
	Non-binary	8	1.5
	Unknown	4	0.5
Age (y)	Mean	35.4	
	SD	10.7	
	Minimum	17	
	Maximum	63	
Highest qualification in Emergency Medicine	None	8	2.0 %
	Emergency-Medical-Responder (Sanitaetshelfer/-in)	36	9.0 %
	EMR/EMT-Basic (Rettungshelfer/-in)	21	5.3 %
	EMT-Basic (Rettungssanitäer/-in)	77	19.3 %
	EMT-Paramedic (Notfallsanitäter/-in)	137	34.3 %
	Physician (Aerztin/Arzt)	19	4.8 %
	EMS-Physician (Notaerztin/Notarzt)	43	10.8 %
	Nurses	21	5.3 %
	Intensive Care Nurses	35	8.8 %
	Others	3	0.8 %
Exposure to Emergency medicine cases	More than one incident per month	255	63.8 %
	Up to one incident in 3 months	81	20.3 %
	Up to one incident a year	23	5.8 %
	Up to one incident every 3 years	9	2.3 %
	Less than one incident every 3 years	0	0.0 %
	Non-answer / Drop Out	32	8.0 %
Occupational status	Full time only	165	41.3 %
	Full-time and voluntary	125	31.3 %
	Voluntary only	65	16.3 %
	Non-answer / Drop Out	45	11.3 %
Educator status for certified Emergency medicine courses	Yes	91	22.3 %
	No	308	77.0 %
	No answer / Drop-Out	1	0.3 %
Educator status for other Emergency medicine courses	Yes	159	39.8 %
	No	221	55.3 %
	No answer / Drop-Out	20	5.0 %
Educator status in other health professions	Yes	152	38.0 %
	No	228	57.0 %
	No answer / Drop-Out	20	5.0 %
Experience in hand disinfection training during CPR training	Yes	66	16.5 %
	No	318	79.5 %
	No answer / Drop-Out	16	4.0 %

were mentioned if representing more than five percent of the responders.

2.7. Ethical approval

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.

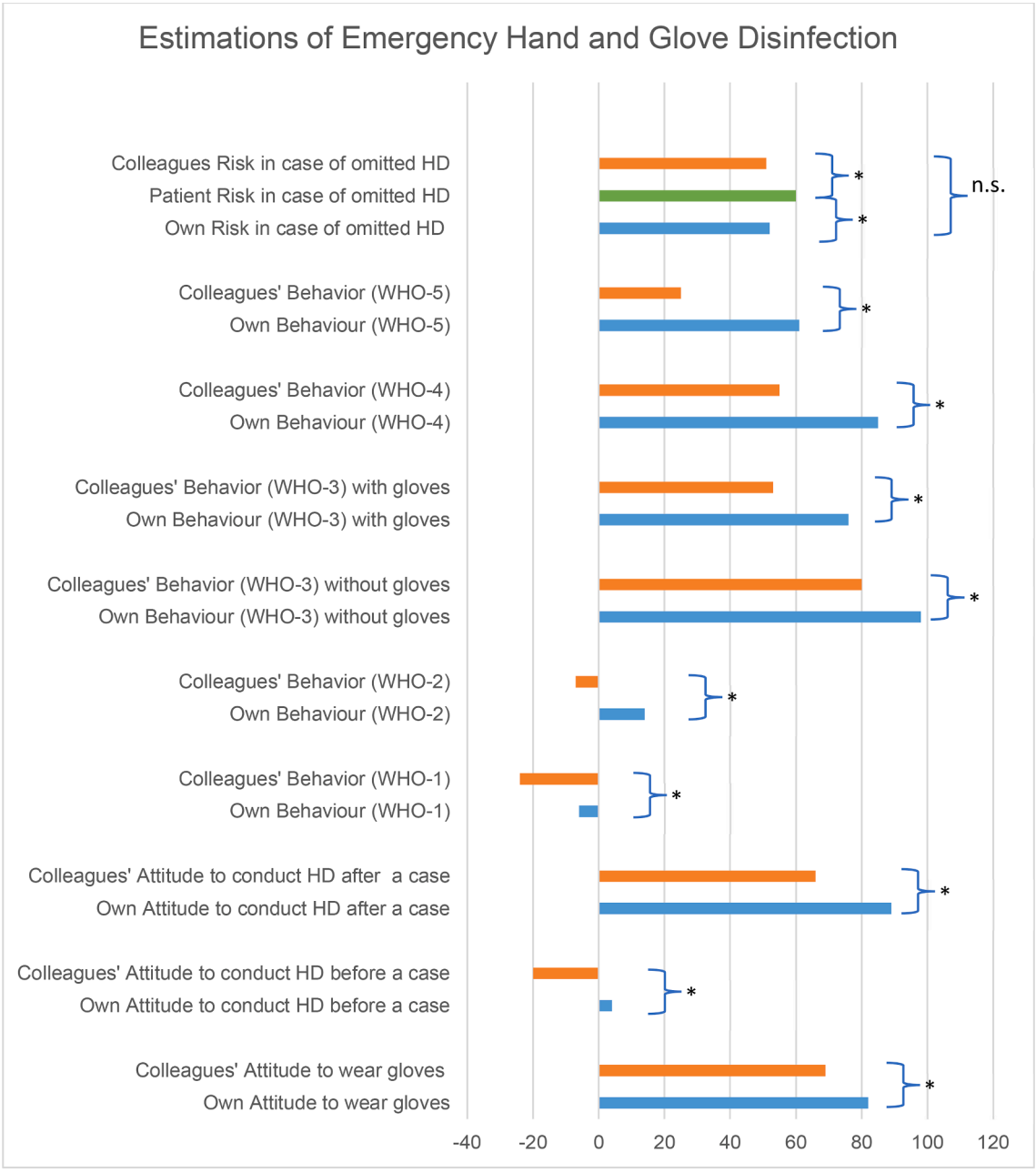

Fig. 1. Estimations of attitudes and behavior concerning hand disinfection in disinfection situations (all respondents). The Y-Axis shows paired questions for priorities and behavior. The last set is a triplet of risk estimation. The X-Axis shows responders' points on the slider questions (ranging from −100 to +100 with "0″ being a neutral option). Asterisks (*) mark for significance ($p < 0.025$ for risk estimations and $p < 0.05$ for other items), "n.s." for not significant.

3. Results

3.1. Participants

We reached 100 participants in the validation study, of whom 60 accessed the survey (60 %)—of these, 52 completed it (86.7 %). In the open research, we reached 1814 people, of whom 342 (18.9 %) accessed the survey, and 260 completed it (76 %).

Participants needed 4.2 min in the pilot study and 7.46 min in the open research. We excluded two participants as they did not consent to the use of their data ($n = 400$ participants). Of these, 90 responders quit early forming the group of "drop-outs". Additional demographic data is available in Table 1.

4. Descriptive data

4.1. Main results

Regarding the priorities in hand disinfection, the participants felt subjectively that the use of gloves is very important ($M = 82.7$ (SD=32)). In contrast, the need for hand disinfection before patient contact was regarded as unimportant (WHO-1; $M = 4.6$ (SD=61.2)). The glove use was judged markedly more important for self-protection after patient contact (WHO-3; $M = 89.3$ (SD=23.1)).

We detected the same for the estimated behavior: Hand disinfection before patient contact and before aseptic tasks according to WHO-1 were estimated to occur seldomly ($M=-6.4$ (SD=66.0)), WHO-2 moments ($M = 13.9$ (SD=70.1)) showed medium or below medium estimations. These were even lower when estimating colleagues behavior (WHO-1: $M=-24.3$ (SD=59.5) and WHO-2: $M=-7.1$ (SD=64.5), respectively).

For WHO-3 moments, we asked for two scenarios: hand disinfection after contamination of the own bare skin was rated to be performed very commonly ($M = 98.8$ (SD=7.7)), whereas it was significantly less frequently performed whenever gloves were contaminated ($M = 75.8$ (SD=44.7) $p = 0.026$, $D = 0.51$). These ratings were reproducible for colleagues' estimations ($M = 80.31$ (SD=35.0) for skin and $M = 52.7$ (SD=50.3) for glove contamination, $p < 0.001$, $D = 0.63$).

We detected medium to high ratings in WHO-4 ($M = 85.4$ (SD=31.5) for self, $M = 55.8$ (SD=44.4) for colleagues) and WHO-5 moments with $M = 61.21$ (SD=51.8) for self, $M = 25.3$ (SD=55.8) for colleagues).

In all priority and behavior estimations, participants rated themselves significantly higher or better than their collegues ($p < 0.015$ for the priority to wear gloves, $p < 0.001$ for all other item pairs; see Fig. 1 and Table 1). The hedge-corrected effect sizes for comparing self to others in these ratings were of medium size for the priority of glove donning and hand disinfection and for rating hand disinfection behavior (WHO moments 1 to 3) ($D = 0.31$ to 0.58), except for comparing hand disinfection after handover (WHO-4 moment, $D = 0.72$) and after contact with the patients' environment or belongings (WHO-5, $D = 0.7$), both of which had large effect sizes (see Fig. 1 and Table 2).

4.2. Subgroup analysis

Pearson's correlation showed some significant and minor effect for age. Unpaired two-sided Welch tests for the groups "sex" and "hospital/out-of-hospital" with adjusted significance levels for twofold testing showed that females had a positive attitude in hand disinfection before a case, after a case and rated themselves higher in WHO-1, −2 and −4 situations and rated colleagues to have a higher attitude and to conduct hand disinfection more often in WHO-1 and −2 situations (Tables 3 and 4).

Table 2
Comparison of differences between one's and colleagues' attitude, behavior and risks in case of omitted hand disinfection using paired *t*-tests with 95 % confidence intervals (95 % CI). (*) Analyses of risks were corrected for multiple testing. Negative mean differences account for a higher estimation of oneself.

Differences between Self-Estimation and Estimation of Others						
Item	Mean Differences	SD	95 % CI	T	df	Two-sided p-Value
Attitude to wear gloves	14.2	45.0	9.3 ; 19.0	5.8	338	**<0.001**
Attitude to conduct hand disinfection before a case	24.0	54.6	18.1 ; 29.9	8.0	333	**<0.001**
Attitude to conduct hand disinfection after a case	23.3	40.3	19.0 ; 27.6	10.7	341	**<0.001**
Behavior WHO-1	17.9	55.2	11.8 ; 24.0	5.8	320	**<0.001**
Behavior WHO-2	21.0	33.2	15.4 ; 26.7	7.3	300	**<0.001**
Behavior WHO-3 (without gloves)	18.5	33.2	14.9 ; 22.1	10.0	320	**<0.001**
Behavior WHO-3 (with gloves)	23.1	50.0	17.6 ; 28.6	8.3	320	**<0.001**
Behavior WHO-4	29.6	41.2	25.2 ; 34.1	12.9	321	**<0.001**
Behavior WHO-5	35.9	51.1	30.3 ; 41.5	12.5	320	**<0.001**
Comparison of risk in case of omitted disinfection for patients and oneself*	8.1	47.6	2.9 ; 13.3	3.0	319	**0.003**
Comparison of risk in case of omitted disinfection for patients and colleagues*	8.8	48.6	3.4 ; 14.1	3.2	318	**0.001**
Comparison of risk in case of omitted disinfection for oneself and colleagues*	0.9	18.5	- 1.2 ; 2.9	0.8	317	n.s.

Table 3
Comparison of differences between males and females in attitude and behavior in hand disinfection using Welch tests with 95 % confidence intervals (95 % CI). Negative mean differences account for higher estimations by females. Significance was set to $p < 0.025$ due to twofold tests with the in/out-of-hospital subgroup. Risk estimations showed no differences.

	Differences between Males and Females					
	T	df		Mean difference	95 % CI of difference	
			p-value		Lower	Upper
Own attitude to wear Gloves	−0,4	247,5	0,720	−1,3	−8,3	5,7
Own attitude to conduct hand disinfection before a case	−3,0	231,5	**0,003**	−20,2	−33,6	−6,9
Own attitude to conduct hand disinfection after a case	−1,4	259,6	0,165	−3,2	−7,8	1,3
Own behavior WHO-1	−2,6	216,9	**0,011**	−19,4	−34,4	−4,5
Own behavior WHO-2	−2,9	200,3	**0,004**	−23,5	−39,4	−7,6
Own behavior WHO-3 (without gloves)	−1,9	282,9	0,059	−1,1	−2,3	0,0
Own behavior WHO-3 (with gloves)	0,0	209,7	0,973	0,2	−9,8	10,2
Own behavior WHO-4	−2,5	318,5	**0,013**	−7,2	−12,8	−1,6
Own behavior WHO-5	−1,4	247,5	0,166	−7,8	−18,8	3,2
Colleagues attitude to wear gloves	1,4	185,5	0,156	6,3	−2,4	15,0
Colleagues' attitude to conduct hand disinfection before a case	−3,0	195,8	**0,003**	−21,8	−35,9	−7,7
Colleagues' attitude to conduct hand disinfection after a case	−1,0	255,2	0,307	−4,2	−12,4	3,9
Colleagues' behavior WHO-1	−2,2	188,4	0,033	−15,4	−29,6	−1,3
Colleagues' behavior WHO-2	−2,8	201,1	**0,005**	−21,0	−35,8	−6,3
Colleagues' behavior WHO-3 without gloves	−1,0	218,4	0,339	−3,9	−11,9	4,1
Colleagues' behavior WHO-3 with gloves	0,2	220,4	0,873	0,9	−10,5	12,3
Colleagues' behavior WHO-4	−0,6	238,1	0,549	−3,0	−12,7	6,8
Colleagues' behavior WHO-5	−0,5	188,6	0,596	−3,6	−16,9	9,8

Table 4
Comparison of differences between persons working in and out-of-hospital in attitude and behavior in hand disinfection using Welch tests with 95 % confidence intervals (95 % CI). Negative mean differences account for higher ratings in the IN—Hospital group. Significance was set to $p < 0.025$ due to twofold tests with the gender subgroup. Risk estimations showed no differences.

Differences between IN—Hospital and OUT-of-Hospital						
	T	df		mean difference	95 % CI of difference	
			p-value		Lower	Upper
Own attitude to wear Gloves	0,1	118,6	0,957	0,2	−7,7	8,1
Own attitude to conduct hand disinfection before a case	−2,9	122,3	**0,005**	−22,0	−37,2	−6,8
Own attitude to conduct hand disinfection after a case	−4,5	290,8	**<0,001**	−8,5	−12,3	−4,8
Own behavior WHO-1	−4,7	146,2	**<0,001**	−35,0	−49,6	−20,4
Own behavior WHO-2	−5,8	141,2	**<0,001**	−45,1	−60,3	−29,8
Own behavior WHO-3 without gloves	−0,1	125,2	0,892	−0,1	−2,0	1,7
Own behavior WHO-3 with gloves	−0,1	126,1	0,937	−0,4	−11,1	10,3
Own behavior WHO-4	−1,4	171,1	0,170	−4,6	−11,3	2,0
Own behavior WHO-5	−2,5	187,1	**0,014**	−12,8	−23,0	−2,6
Colleagues attitude to wear gloves	−1,4	123,0	0,167	−6,2	−14,9	2,6
Colleagues' attitude to conduct hand disinfection before a case	−5,5	106,2	**<0,001**	−42,6	−58,0	−27,2
Colleagues' attitude to conduct hand disinfection after a case	−5,0	148,1	**<0,001**	−21,2	−29,5	−12,8
Colleagues' behavior WHO-1	−5,6	102,2	**<0,001**	−41,9	−56,6	−27,1
Colleagues' behavior WHO-2	−6,7	119,5	**<0,001**	−49,3	−63,8	−34,9
Colleagues' behavior WHO-3 without gloves	−1,4	113,3	0,169	−6,2	−15,0	2,7
Colleagues' behavior WHO-3 with gloves	−0,4	100,6	0,663	−2,9	−16,2	10,4
Colleagues' behavior WHO-4	−1,3	106,7	0,192	−7,6	−19,2	3,9
Colleagues' behavior WHO-5	−4,0	135,7	**<0,001**	−25,2	−37,5	−12,9

4.3. Qualitative analysis

We identified four themes in the qualitative analysis (See Table 5). A detailed description of the qualitative analysis is included in Appendix C.

5. Discussion

5.1. Key results

In this project we were able to explore the following perceptions on emergency hand and glove disinfection of well-trained and routinized prehospital and hospital staff and their comparisons to colleagues:

Table 5
Qualitative Analysis. Themes 1 to 4 were derived from the question about feasibility of hand disinfection during CPR, themes 5 to 6 on the question about glove disinfection.

THEMES	CODES	Count
1 - Uncertainty about hand disinfection in emergencies	1) Approval of feasibility	50
	2) Doubt about the feasibility	38
	3) Doubt about the effectiveness	5
	4) Attractivity and	1
	5) Surprise about the possibility.	4
2- Basic conditions for emergency hand and glove disinfection	1) Available resources and logistics	40
	2) Wet hands being problematic	4
	3) Team factors	16
	4) Differences between prehospital and in-hospital settings	2
	5) Ethics.	1
3 - Didactic implementation of emergency hand and glove disinfection in education and life-long learning	1) Education in CPR	28
	2) Implementation in international guidelines	3
	3) Quality management	2
	4) Role models	1
	5) Crypto-normativity	1
4 - Cognitional load in emergencies	1) Distress	6
	2) Awareness	8
5 - Controversy about hand and glove disinfection	1) Rejection of glove disinfection	15
	2) Acceptance of glove disinfection as a second choice	13
	3) Acceptance of glove disinfection with experience in its use	7
6 - Concerns about material compatibility	1) Loss of self-protection	19
	2) Violation of legal and manufacturer recommendations	5

Firstly, responders reported for themselves and others that disinfection in WHO-1 and WHO-2 moments are not a high priority in emergencies – both in the qualitative and quantitative data. This corresponds with the literature: Haac et al. showed that protocol adherence in Dutch trauma bays was 3 % for WHO-1 and 0 % for WHO-2 respectively (Haac et al., 2017). Zottele et al. detected compliance rates of 20 % for WHO-1 and 7.8 % for WHO-2 in an emergency department (Zottele et al., 2017), and Teter showed a self-estimation of about 34 % for WHO-1 for emergency medical services (Teter et al., 2015). Participants defended the omission of disinfection as an active decision to avoid delaying life-support. In international recommendations, hand disinfection is not forbidden in guidelines, but is simply not mentioned (Wyckoff et al., 2022). Additionally, we detected that WHO-3 moments are a high priority, especially when bare skin is contaminated. WHO-4 and WHO-5 moments are accomplished as well, but not as often as WHO-3, which is prioritized above all others in terms of justified self-protection (AHA 2020). These findings correspond to the literature showing that self-protection is prioritized, however the actual implementation may differ dramatically when tested (Bushuven et al., 2020; Livshiz-Riven et al., 2022; Lamping et al., 2022). Furthermore, the use of gloves bears the risk that gloves are perceived as protective alone and replace hand disinfection. Nevertheless, the narrative that emergency hand and glove disinfection is not feasible or effective needs to be challenged as simulation studies of our group showed that in cardiac arrest, about 50 % of all indications would be achievable in high-performance teams (Bushuven et al., 2022). This was approved by several participants in free text entries.

Next, we detected overplacement effects (the belief to be better than others) (Dunning et al., 2004; Moore and Healy, 2008) in attitude and behavior concerning all WHO moments. We and other working groups had previously demonstrated this effect on hand disinfection in different settings and occupations (Bushuven et al., 2020; Lamping et al., 2022; S. Bushuven et al., 2019; S. Bushuven et al., 2019; Trifunovic-Koenig et al., 2022; Jackson et al., 2014) and in life support (Bushuven et al., 2023). It remains unclear whether or how overconfidence in disinfection interferes with overconfidence in life support. If well-educated staff are overconfident, it may be challenging to convince them about the "sidelight" of hand disinfection they already have an opinion on – resulting in stress and team conflicts (Dunning et al., 2004). Especially in emergencies, different attitudes (e.g., as we detected in gender or workplace) may lead to disruptive team discussions. To avoid this, the implementation of hand disinfection needs careful consideration of feasibility and efficiency, and its institutionalization in guidelines, education, and quality management of life support -as shown in qualitative findings.

Additionally, participants reported that only well-staffed, high-performance teams could regularly integrate disinfection in life support, comparable a Danish study (Vikke et al., 2019). There is no literature on how often it would be indicated and feasible in real-life scenarios in and out-of-hospital with teams of three, four, five, or six members, meaning more work on this topic in realistic scenarios and low- and high-fidelity simulation (Massoth et al., 2019).

Fifth, we detected insecurity about emergency hand and glove disinfection. As mentioned above, the "real" feasibility of hand disinfection in emergencies and resuscitation is unknown. It may differ due to the setting, team composition, and their experience and attitudes, especially concerning the subjective definition of an "emergency." Next, material compatibility was a central issue in glove disinfection as not all material is compatible with hand disinfectants (Scheithauer et al., 2016). Additionally, the accessibility of disinfectants plays a role (Scheithauer et al., 2014).

Sixth, we identified different groups with contradictory perceptions and estimations – as well in the qualitative as the quantitative

data. All groups included well-educated and experienced educators and leaders. With little literature on this topic and group differences, the demand for further research at the interface of infection control and resuscitation science in different settings is apparent.

These differing perceptions highlight that hand disinfection implementations would have to be multi-modal, feasible, scientifically justified and presented in different settings, teams, and education scenarios.

Our results show that hand disinfection in emergencies is perceived as ambiguous, and its implementation faces several barriers: its feasibility depends on team competence and training. Team training relies on the inclusion of hand disinfection in emergency guidelines, learning material, individual and team performance tests, and resuscitation quality management. These materials are developed by evidence justifying the integration of established critical competencies. By now, evidence is limited in the feasibility and effect of hand disinfection in emergencies and transfer from non-emergency medicine is doubted. These issues leave space for further work on different aspects of hand disinfection in emergencies.

5.2. Limitations

First, the selection bias due to interest might have led to an underrepresentation of persons without any interest in the discussion. However, we did not detect differences between the validation group with a 60 % response rate, compared to the open study, with a response rate of 18.9% indicating our findings' robustness. Second, we asked for perceptions that heuristic errors may influence and considering other studies, the accurate compliance rates will likely be lower than the reported ones (Lamping et al., 2022). Third, our findings are limited to Germany with unknown transferability to other systems or countries. Fourth, we only used single item testing in this inductive study. Regarding the complexity of the theme, development and validation of scales is demanded for robust assessments and concise analyses in different populations. Fifth, we did not ask for the perception of emergencies as the definition thereof might differ: in an obstetric ward, a birth is no emergency; in the ambulance, it is. However, we asked primarily about CPR as the prototype of an emergency that involves nurses, physicians and paramedics and a regularly treated by nurses in different occupational settings. Sixth, our survey only includes a small number of nurses indicating for further work on this group. This is especially important, as nurses in German curricula serve as "central" educators for all three professional groups and may set the initial attitude towards hand disinfection.

Consequently, future research should include varying emergency scenarios in their protocols. Lastly, the semi-quantification of the inductive qualitative results may not be representative as they were mentioned voluntarily, consequently asking for these findings for better quantification is warranted for further studies.

6. Conclusion

In this study, we demonstrated different perceptions of the attitudes and performance of emergency hand and glove disinfection and the overconfidence effects. We also found that the WHO-1 and WHO-2 indications with the highest impact on preventing infection in the patient were not prioritized to avoid delaying life support, with feasibility depending on team factors, education, and situation. We further noticed that acceptance and feasibility may depend on the institutionalisation of disinfection in life support protocols and education. Consequently, and with respect to the limitations our first results in an under-investigated field of resuscitation science may provide resuscitation scientists, medical educators in emergency medicine, and experts in infection control with information about possible barriers to implementing infection control in life support programs and emergency medicine – especially for nurses acting as central educators in basic medical skills for many health care professionals.

Ethical approval

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.

Use of artificial intelligence

During the preparation of this work the authors used Grammarly [Grammarly Inc., San Francisco, USA] and DeepL [DeepL SE, Cologne, Germany] in order to optimize spelling and grammar and translation of the surveys. After using this, the authors, including an English native speaker reviewed and edited the content as needed and take full responsibility for the content of the publication.

CRediT authorship contribution statement

Stefan Bushuven: Writing – review & editing, Writing – original draft, Visualization, Conceptualization. **Michael Bentele:** Writing – original draft, Validation, Supervision, Conceptualization. **Stefanie Bentele:** Writing – original draft, Validation. **Milena Trifunovic-Koenig:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Formal analysis, Data curation. **Sven Lederle:** Validation. **Bianka Gerber:** Writing – original draft, Validation. **Joachim Bansbach:** Writing – review & editing, Writing – original draft, Validation, Supervision. **Julian Friebel:** Writing – original draft, Validation. **Julian Ganter:** Writing – original draft, Validation. **Irit Nachtigall:** Writing – original draft, Validation, Supervision. **Simone Scheithauer:** Writing – review & editing, Writing – original draft, Validation, Supervision.

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.

Data availability

Data is available on request.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijnsa.2024.100207.

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