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Original Research

National Implementation of In Situ Simulation-Based Training in Helicopter Emergency Medical Services: A Multicenter Study

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A B S T R A C T

Objective: Medical simulation is used in helicopter emergency services as a tool for training the crew. Using in situ simulation, we aimed to evaluate the degree of implementation, the barriers to completing simulation training, and the crew's attitude toward this form of training.
Methods: This was a 1-year prospective study on simulation at all 14 Norwegian helicopter emergency services bases and 1 search and rescue base. Local facilitators were educated and conducted simulations at their discretion.
Results: All bases agreed to participate initially, but 1 opted out because of technical difficulties. The number of simulations attempted at each base ranged from 1 to 46 (median = 17). Regardless of the base and the number of attempted simulations, participating crews scored self-evaluated satisfaction with this form of training highly. Having 2 local facilitators increased the number of attempted simulations, whereas facilitators' travel distance to work seemed to make no difference on the number of attempted simulations.
Conclusion: Our study reveals considerable differences in the number of attempted simulations between bases despite being given the same prerequisites. The busiest bases completed fewer simulations than the rest of the bases. Our findings suggest that conditions related to the local facilitator are important for the successful implementation of simulation-based training in helicopter emergency services.
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Medical simulation is an integral part of medical education, postgraduate training, and continuous professional development.[1] Several studies have shown that simulation-based training has a positive effect on patient outcomes.[2,3]

In many countries, helicopter emergency medical services (HEMS) are responsible for the management of the most critical patients outside the hospital. Time-critical interventions must be provided and critical decisions made despite clinical uncertainty. The rapidity of transport by air can be beneficial to the patient but also creates a challenging environment with many hazards. Ensuring that care providers in HEMS have the right skills, experience, and training to provide excellent care and take care of the patient's safety may require tailored training and skills maintenance.[4] Many emergency services have incorporated medical simulation as a core element in the training of personnel and crews in critical technical and nontechnical skills.[5-7] However, simulation is resource demanding, both economically and logistically, and implementing effective training programs can be challenging in busy emergency services.

In a previous pilot study, we showed that in situ simulation is a feasible training concept for simulation-based training at the workplace during on-call hours for HEMS crews.[8] In that study, a simulation program was introduced at a busy HEMS base in Norway. The simulation-based training was shown to take up little time for the crews, and the response from the participating crews was generally very positive.[8] To our knowledge, no other program for simulation-based training of on-call HEMS crews has been implemented on a

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national level in other systems. In the present study, we introduced a program of in situ simulation-based training through the entire Norwegian HEMS system.

This prospective study aimed to document the implementation of a national program of in situ on-call simulation-based training for the crews in the national HEMS system in Norway and 1 search and rescue (SAR) base. We also explored possible reasons for not attempting to start a training session or why training was interrupted, along with the participants' and facilitators' satisfaction with the training.

Materials and Methods

Norwegian HEMS System

The Norwegian HEMS is a national service funded by the government. Commercial companies are contracted by the 4 regional health trusts in Norway to manage the flight operations. Medical staffing and medical responsibility for the service lie with the local health trust in which each base is located.

At the time of the project, there were 11 HEMS bases run by 2 commercial companies with medical staffing from 11 local health trusts. Each HEMS base is staffed by a physician, a HEMS crewmember (HCM), and a pilot. One base also includes an anesthetic nurse in the crew. The physicians are all certified anesthesiologists or within 1 year of being certified and have experience in anesthesia, intensive care medicine, emergency medicine, and advanced pain management. The HCMs are trained as emergency medical technicians, paramedics, or nurses and have additional training and experience in rescue techniques, including training in aviation theory, to make them able to act as an assistant to the pilot. All physicians must also regularly perform in-hospital work. The pattern of shifts varies between bases; pilots and HCMs are generally on call 24 hours a day for 1 week, whereas physicians work for 24, 48, 72, or 168 hours depending on local work rotation.

All HEMS bases respond to primary medical and trauma missions and perform interhospital transports and SAR missions. Some bases also perform transfers involving incubators, intra-aortic balloon pumps, and extracorporeal membrane oxygenation. The total number of missions and the type of missions flown vary between the HEMS bases.[9]

SAR bases operated by the Royal Norwegian Air Force are also dispatched for ambulance missions in the national Norwegian HEMS system. The medical staffing and equipment setup of the SAR helicopters are identical to the civilian HEMS, but the HCM is trained by the Air Force and the helicopter is additionally staffed with 2 pilots, a technician, and a systems operator.

Participants

All 11 HEMS bases in Norway and 1 SAR base were invited to participate in the study. On each base, 1 or 2 experienced senior HEMS physicians were selected by the lead physician at each base to be trained as simulation facilitators. Before the initiation of the study, these facilitators all completed the same standardized EuSim simulation facilitator course together.[10] To ensure knowledge of local operating procedures, all facilitators only acted as facilitators for the simulation-based training at the bases on which they usually worked. All facilitators received remuneration for simulation-based training outside their regular hours of work.

Ethics Approval and Consent to Participate

Crews participated in the simulation-based training voluntarily, and the study was conducted according to relevant local, national, and international ethical guidelines. Responding to the questionnaire was also voluntary and anonymous and only took place after informed consent. Individuals could withdraw their responses to the questionnaire from the study at any time. The project was presented to the Regional Committee for Medical Research (Health Region East), which waived the need for ethical approval given the nature of the study (REK 2014/1425). The Norwegian Social Science Data Services approved the recording of data related to the study (2014/10220, Oslo University Hospital).

Study Design

The study was conducted as a prospective multicenter study from October 31, 2014, to October 31, 2015. Simulation-based training was offered to the HEMS crews on call during the daytime on days selected by the local facilitator on a convenience basis when the facilitator could prepare and conduct the training. There were no requirements or expectations regarding the total number of sessions or their frequency during the study period. The simulation was presented as an optional learning and training opportunity for the crew rather than as a compulsory task because there was no previous tradition of simulation-based training as a crew. Before a training day, the facilitator would inform the on-call crew about upcoming training and at his or her discretion send the on-call crew relevant standard operational procedures. All crewmembers were encouraged to participate in the training, and the scenarios were designed to involve the physician, HCM, and pilot. On the SAR base, the training was designed for the HCM and the physician primarily, but other crewmembers were invited to participate by the nature of SAR operations; the remaining 4 crewmembers of the 6-person SAR crew are less involved in medical care. We emphasized that the training should interfere with normal operations as little as possible.

Scenarios and Equipment

Because of large variations in the mission profiles between the Norwegian HEMS bases, the facilitators were encouraged to develop scenarios tailored to the mission profile of their base. The facilitators were asked to design scenarios to involve all members of the crew. The simulation-based training was designed to be in situ simulation on the base and could take place indoors, outdoors, or both, although they were confined to the vicinity of the HEMS/SAR base to avoid disruption to crew readiness and a delayed response to real missions. The facilitators were encouraged to have specific learning aims for each scenario and to ensure that no participants were exposed to the same scenario more than once. A total time consumption of 1 hour was regarded as optimal, but this could vary.[8] Facilitators were invited to share scenarios between bases, but to what extent this was done was not monitored.

The facilitators were encouraged to create packs of medical equipment specifically for training, similar in layout to those used at their base, and to use the helicopter's medical monitors to increase immersion in the scenarios. The facilitators were free to choose high- or low-fidelity manikins or live actors for the simulations depending on what they regarded as most appropriate for the specific scenario. Real-time physiological parameters were provided by either verbal information or via apps for smartphones and tablets that are commercially available. Additional diagnostic data could be made available if requested by the crews.

All simulation-based training sessions were planned to end with a structured debriefing performed using the PEARLS (Promoting Excellence and Reflective Learning in Simulation) framework for debriefing, which is structured as reaction, description, analysis, and application/summary.[11]

Data Collection

The facilitator in each case recorded the duration of the simulation-based training. The facilitator also noted if the simulation-based training was completed successfully and, if not, the reason for interruption or cancellation. A simulation attempt was regarded as completed if the simulation and debriefing were completed regardless of any interruptions. After each simulation, the participating crew and the facilitator individually and anonymously evaluated the degree of satisfaction with the simulation as a whole on a visual analog scale (VAS) from 0 mm to 100 mm, where 0 mm represented completely unsatisfactory and 100 mm represented maximum satisfaction.[12] The facilitator's previous experience with medical simulation was noted, as was whether the facilitator lived close by or far away from the base (the latter was defined by convenience as a travel distance of more than 30 km). All data were recorded anonymously on a preconceived data collection sheet by the facilitator immediately after each attempted simulation-based training and later entered anonymously into a digital database (Questback Essentials, Oslo, Norway). Data from the collected questionnaires were also entered into the same database. No data involving the identity of participants were entered.

Statistical Analysis

Continuous data were summarized using the median (quartiles) and categoric data as numbers (percentages). Comparisons of nonpaired observations were made with the Mann-Whitney *U* test. The facilitators' and crewmembers' satisfaction with the training is presented as median and quartile VAS scores for all successfully conducted simulations for each base. The association between the number of missions and the simulation attempts at the bases was analyzed using robust linear regression. Robust linear regression is a generalization of traditional linear regression that downplays the importance of outliers that might otherwise disproportionately affect regression coefficients. For the association between the number of missions and simulation success, the analysis was weighted with respect to simulation attempts in a weighted robust linear regression. Data were analyzed using SPSS (SPSS Statistics for Windows, Version 25; IBM Corp, Armonk, NY) and R 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

All 11 Norwegian HEMS bases and 1 SAR base were invited to participate in the study. One HEMS base planned to participate with remote facilitated simulation because none of the physicians could act as an on-site facilitator. Because of technical difficulties, this base opted out before the initiation of the simulation-based training. All other invited bases participated, thus providing us data form 10 of the 11 Norwegian HEMS bases.

A total of 176 simulation attempts were registered. Of these, 116 (66%) were completed. The total monthly number of attempted simulations among all participating bases throughout the study period is shown in Figure 1A, and the successful and unsuccessful simulations, respectively, are shown in Figure 1B. Table 1 shows the number of successful and unsuccessful simulations at each base as well as background information about the simulation-based training (ie, the number of facilitators, the time consumption, VAS scores for facilitators, and crews' self-reported satisfaction with the simulation). The number of simulations initiated at each base ranged from 1 to 46 (median = 17). The reasons for the failure to complete simulations are shown in Table 2.

The association between the number of missions and the number of simulations is shown in Figure 2A and B. The number of simulation attempts was not associated with the total number of annual missions at the base, which was used as a proxy for how busy the bases are (Fig. 2A) (−0.002; 95% confidence interval = −0.009 to 0.010; $P = .973$), and there was no statistically significant difference in the number of completed simulations between the bases when related to the number of annual missions (Fig. 2B) (−0.0165; 95% confidence interval, −0.029 to −0.0002; $P = .077$). Figure 2A and B shows the association between the number of missions and the number of simulations. A statistically significant difference ($P = .01$) in the number of simulation attempts was seen between bases with 1 facilitator and those with 2 facilitators; bases with only 1 facilitator had a median of 8 (range, 5-16) simulation attempts compared with 21 (range, 18-28) for bases with 2 or more facilitators. Neither the facilitator's previous experience with simulation-based training did not have a significant influence on the number of attempted simulations nor the travel distance for the facilitator.

Discussion

In this study, we found variations in the success of implementing in situ simulation for on-call crews in the 11 HEMS bases of the Norwegian air ambulance system and 1 SAR base. The workload of the bases, expressed through the total number of yearly missions, had no impact on the number of attempted simulations. However, there was an indication that bases with a low workload did manage to complete the simulations successfully more often. The number of facilitators at each base positively impacted the number of simulations attempted.

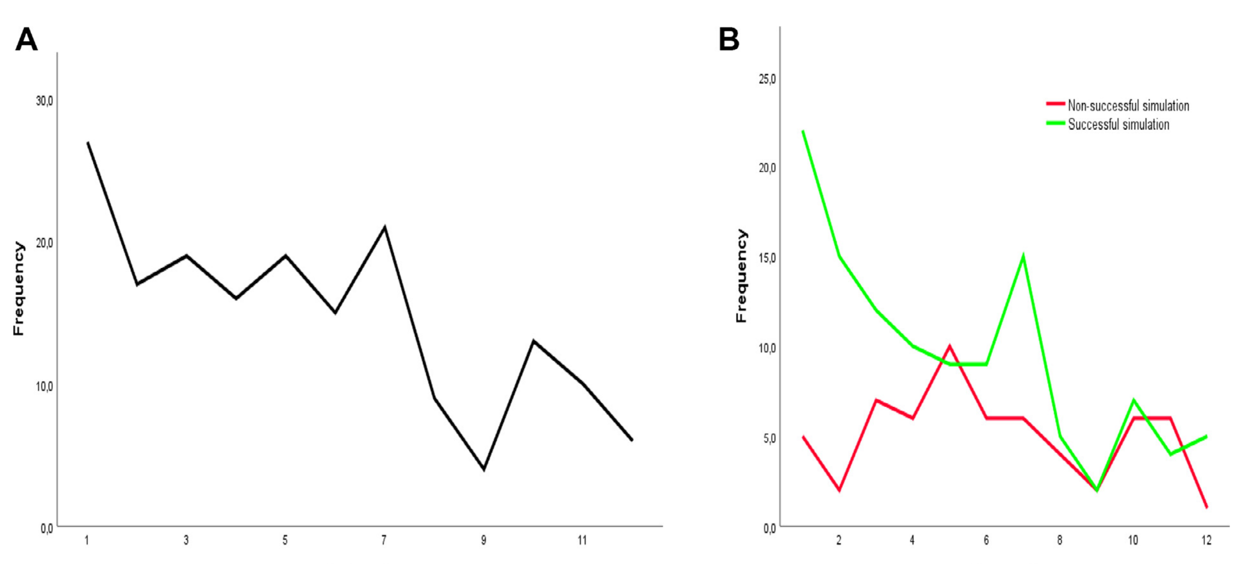

Figure 1. A, The total number of monthly simulations at all bases during the study period. B, The number of monthly successful simulations (green line) and nonsuccessful simulations (red line) during the study period.

Table 1
The Distribution of Background Variables Related to the Simulation Training at Each of the 11 Participating Bases

Base	Missions per Year	Number of Facilitators	Crew Size	Attempted Simulations	Successful Simulations (%)	Time Consumption Mean (SD), Minutes		VAS Score Median (Quartiles)		Facilitator With Previous Experience	Facilitator Living Close to Base
						Facilitator	Crew	Facilitator	Crew		
A	2,997	2	3	17	7 (41)	98 (51)	57 (22)	67 (51-79)	87 (83-90)	Y	Y
B	1,112	2	3	8	5 (63)	166 (47)	86 (18)	80 (54-95)	90 (83-95)	Y	Y
C	628	1	3	5	5 (100)	99 (11)	76 (6)	86 (82-88)	83 (76-98)	Y	N
D	1,783	1	3	5	4 (80)	145 (46)	59 (15)	79 (75-80)	87 (84-96)	Y	Y
E	1,531	1	3	18	9 (50)	101 (20)	90 (18)	86 (71-88)	93 (80-97)	N	Y
F	909	2	3	19	14 (74)	118 (55)	86 (22)	85 (74-90)	85 (79-91)	N	Y
G	1,805	1	3	14	10 (71)	116 (32)	92 (18)	88 (80-92)	90 (86-96)	Y	Y
H	875	1	3	1	0 (0)	90 (–)	60 (–)	86[86-86]	92[92-92]	N	Y
I	833	1	3	20	14 (70)	79 (15)	57 (9)	88[75-92]	88[82-97]	N	N
J	696	2	3	23	18 (78)	118 (41)	62(10)	74[65-83]	89[86-91]	Y	N
K	1,061	2	4	46	31 (67)	177 (64)	95 (28)	90[84-90]	91[87-93]	Y	Y

VAS = visual analog scale.
The VAS score represents the self-reported satisfaction with the training scored after each simulation session.

Table 2
The Number of Successful and Nonsuccessful Simulations and Reasons for Failure to Complete Simulations

Outcome	Details	Percentage (n = Actual Number)	Causes of Noncompleted Simulations (Actual Numbers)
Simulation completed	Completed without interruption	58.0 (n = 102)	
	Started, interrupted, but completed	7.4 (n = 13)	Dispatch for an acute mission: 13
Simulation planned or initiated, but not completed	Started, interrupted, but not completed	28.4 (n = 50)	Dispatch for an acute mission: 42
	Simulation conducted without debrief	3.4 (n = 6)	Crew needs rest: 5
			Crew prioritizes other tasks: 9

Participating crews universally reported high levels of satisfaction with the simulation-based training with little variation between the bases.

More than half (58%) of the simulations were completed without interruption. Most interruptions were due to acute missions. Only a few cancellations of planned simulations were due to crews' lack of motivation or fatigue. This is in agreement with the crews' positive evaluation of the training and our findings in a previous study.[8]

As Figure 2B depicts, there is an indication that the number of successfully completed simulations is related to the workload in terms of the number of yearly missions at the base. Bases with a low workload tended to be able to complete more simulations than bases with a higher workload. However, this relation was not significant ($P = .07$) but would seem natural because a low workload base is less likely to be interrupted once a simulation session has started. We speculate whether this finding could have reached significance with more data (eg, a more extended study period). For implementation purposes, such a finding would be of importance in the planning of simulation training (eg, by offering training on more days in the week to increase the likelihood of completing the training in a quiet period).

One of the bases attempted to run 46 simulations over the 1-year course of the trial, which corresponds to 1 simulation per

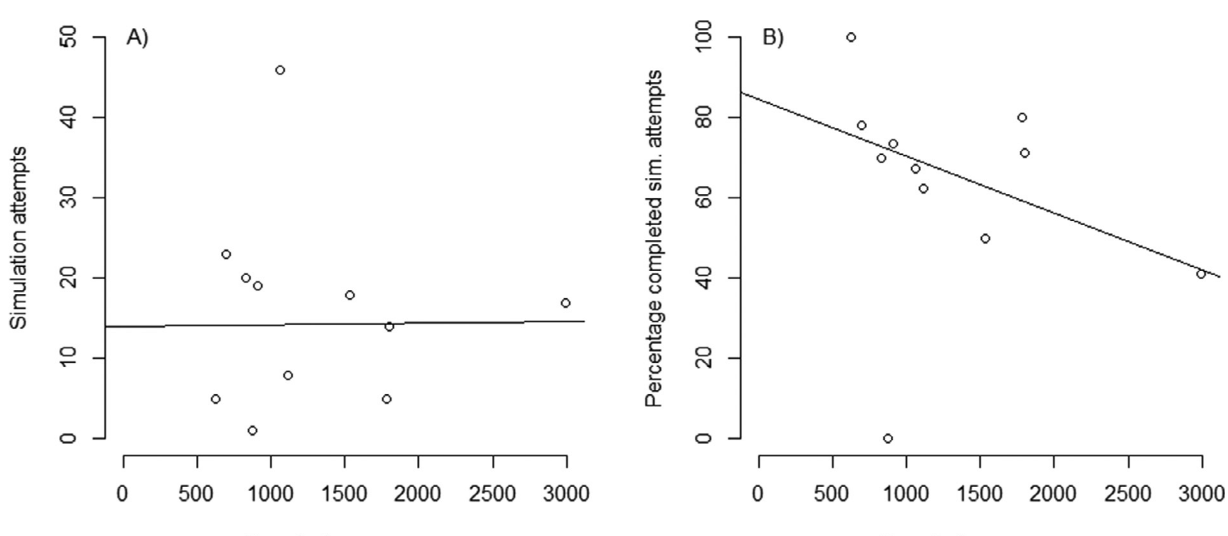

Figure 2. A, The association between the number of missions at a base and the attempted simulations. B, The association between the number of missions at a base and the completed simulations. The corresponding linear regression models are superimposed.

week if training is kept out of the busiest weeks of the year. Thus, arranging for weekly simulations seems feasible. The other bases had a lower number of attempted simulations, mostly less than half of the aforementioned base, which indicates that the implementation was difficult.

Our study did not directly document implementation barriers. One study by Hosny et al[13] on the implementation of simulation training in surgery pointed at costs, practicality, and motivational factors as main barriers to implementing their training concept. Practicality was maintained because training was tailored to the workload of the crews and the facilitator prepared everything before and after the simulation to minimize the additional workload for the crew.

The impact of motivational factors is more difficult to evaluate from our data material.

For example, it might be necessary for leaders to promote and prioritize the simulation. Leadership approved the project but were not involved during the implementation period. We speculate that more support and encouragement of facilitators might have increased the number of attempted simulations. Different levels of support from leaders throughout the project might explain some of the variations between bases.

One base never started simulations because of technical difficulties. This shows the importance of managing logistical and practical issues during the early phase of implementing simulation on a HEMS bases.

Because the attempted simulations are tightly coupled with the facilitators initiating them, the internal motivation and the work capacity of the facilitator may also play a role. Their travel distance to the base did not seem connected to the number of attempted simulations, but this was not tested for significance because of the low number of simulations on some bases.

In our study, we attempted to provide each base with equal resources. The facilitators were given the same training and tools to run the simulation program. We tried to avoid imposing a rigid framework onto the program, which might stifle its adaptation to the local context and learning needs. For example, the facilitators could choose the level of fidelity, the day of the week, and the content of the simulations. Nevertheless, there were significant differences between the bases in how frequently simulation-based training was initiated.

Tariq et al[14] previously described the importance of the follow-up and supervision of facilitators being critical to successful in situ training at London HEMS. They recognized the complexity of the facilitators' role and the need for education and feedback to facilitators. We had no impact on the selection of facilitators on each base and therefore were unaware of their motivations or previous experience.

Although cautious in our interpretation, we accept that the training of facilitators, the concept of the training, and the follow-up of the facilitators throughout the project may have influenced the overall number of attempted simulations. We are less convinced that this also explains the variance in the number of simulations attempted at different bases; in this context, it seems more likely that other external factors (eg, general workload and competing commitments) or internal factors (eg, local enthusiasm for the simulation-based training and interpersonal dynamics) played a role. However, this remains only speculation because our data did not record the motivations of the facilitator. Furthermore, it is unclear whether the decreasing number of attempted simulations is related to facilitator fatigue. Another explanation could be that the facilitators sensed a fatigue among the crews and therefore did not initiate simulation attempts as frequent as in the beginning of the study period. During the study period, there was no follow-up of the facilitators or the achieved numbers of simulations on each base. Others have shown that the motivation and encouragement of the facilitator are essential factors for the successful implementation of in situ simulation in emergency departments.[15] It is plausible that a monthly follow-up from the project coordinator might have motivated some facilitators to run more simulations. The decreasing number of total simulations per month on all bases throughout the study period suggests that maintaining a program of simulation-based training over some time is likely to require ongoing support (Fig. 1A) and encouragement. Therefore, future and similar projects should focus on removing barriers to the successful completion of training and keeping the spirit alive among the facilitators.

The facilitators were free to deliver training as often as they wanted. However, we speculate that it might have been helpful for the facilitators to have regular and frequent contact with either other facilitators or the leaders of the project. In this way, encouragement and support could be given.

In our study, we allowed each base to have 1 or 2 facilitators, and we know that bases with 2 facilitators were able to attempt more simulations than bases with only 1 facilitator. The redundancy of having 2 facilitators may improve the ability to initiate simulations, and the facilitators may be able to motivate and support one another. After the completion of the study, we became aware that some facilitators were unable to conduct simulation-based training because of long-term sick leave. This was not recorded during the study, so we cannot know how this influenced the frequency of simulations, but it emphasizes the central role of the facilitator in the simulation program. We pragmatically suggest that making at least 2 facilitators available at each base reduces the vulnerability of a simulation program and increases its chances of success. The participating crews at all bases reported high satisfaction scores in their evaluations of the simulation-based training (Table 1). This is in accordance with findings in a previous pilot study.[8]

Discussion of Methods Used

In this study, participation was voluntary; if weekly training were compulsory, more simulations might have occurred. After the group training course, facilitators operated as individuals with no formal follow-up or collaboration between the bases. To our knowledge, facilitators did not share any scenarios or experiences between bases. Potentially, such collaboration might have improved the simulations and supported the facilitators, enabling them to collaborate on solving problems that they encountered. All facilitators were encouraged to adapt the training to their local standard operational procedures and to create training packs that mimicked the actual equipment setup on the base to increase the realism and appropriateness of the training. However, this did create more work for the individual facilitator, especially in the initial setup phase.

By leaving the responsibility to record data during the simulations to the facilitators, we may have introduced a potential reporting bias. Although facilitators were instructed to record the exact time used for the simulations, they may have ended up estimating the time due to the workload with the consequence of potentially under- or overestimating the time used. The same applies to the coding of reasons for nonsuccessful simulations where there is a potential for miscoding.

The participating crews evaluated the simulation-based training immediately after the simulation on a questionnaire. Such immediate self-reporting may introduce a positive bias in the reporting (eg, participants entering overly positive attitudes in order to please the facilitator). Future similar projects could include the assessment of the learning outcome or behavioral changes over time.

Future Perspectives

Often simulation-based training was not completed because of interfering missions for the on-call HEMS crews. It is a waste of human resources for a facilitator to prepare the training and attend the base without being able to complete the simulation. Also, this experience might demotivate the facilitator. As an alternative, it might be better for the facilitator to join the on-call crew and observe the live mission and then conduct a structured debrief upon completion. Such observed practice is described positively by others.[16] Our study did not identify all barriers to the implementation of our simulation-based training program or the reasons why the implementation was so different between the bases in the study. This knowledge could be useful for future programs of this kind and should be explored in future studies.

Conclusion

We found that it is possible to implement in situ simulation-based training for on-call crews on some HEMS bases with a high degree of satisfaction among the participating crews. However, at a national level, implementation was challenging. Although all participating HEMS bases were offered the same prerequisites for an identical training and compensation for facilitators, we found a large spread in the number of attempted simulations. The deliberate lack of a rigid framework and follow-up may have been a contributing factor. There were indications that the proportion of simulations that were conducted successfully were related to the number of missions on each base.

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