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ORIGINAL RESEARCH

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Healthcare personnel self-assessed competence and knowledge following implementation of a new guideline on maternal resuscitation in Norway. A repeated measure study

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Abstract

Introduction: Cardiac arrest in pregnancy is a rare, yet extremely challenging condition to manage for all healthcare personnel involved. Knowledge deficits and poor resuscitation skills can affect outcomes in cardiac arrest in pregnancy, but research exploring healthcare personnel competence and knowledge about maternal resuscitation is limited.

Aims: The aim of this study was to explore (1) healthcare personnel self-assessed competence and knowledge about cardiopulmonary resuscitation (CPR) in pregnancy as well as perimortem caesarean section, before and after implementation of a new guideline, (2) whether there were any interprofessional differences in knowledge about maternal resuscitation, and (3) potential differences between different implementation strategies.

Research Methodology: The study had a prospective repeated measure implementation design, utilizing a questionnaire before and after implementation of a new guideline on maternal resuscitation after cardiac arrest.

Setting: All healthcare personnel potentially involved in CPR in six hospital wards, were invited to participate (n = 527). The guideline was implemented through either simulation, table-top discussions and/or an electronical learning course.

Results: In total, 251 (48%) participants responded to the pre-questionnaire, and 182 (35%) to the postquestionnaire. The need for education and training/simulation concerning maternal resuscitation were significantly lowered after implementation of the guideline, yet still the majority of respondents reported a high to medium need for education and training/simulation. Participants' self-assessed overall competence in maternal resuscitation increased significantly postimplementation. Regardless of professional background, knowledge about CPR and perimortem caesarean section increased significantly in most items in the questionnaire after implementation. Differences in level of knowledge based on implementation strategy was identified, but varied between items, and was therefore inconclusive.

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Conclusion: This study adds knowledge about healthcare personnel self-assessed competence and knowledge about maternal resuscitation and perimortem caesarean section in pregnancy. Our findings indicate that there is still a need for more education and training in this rare incident.

KEYWORDS

cardiac arrest, knowledge, maternal resuscitation, perimortem cesarean section, pregnancy, self-assessed competence

1 | INTRODUCTION

Cardiac arrest in pregnancy is a rare, yet extremely challenging condition to manage for all healthcare personnel involved. Internationally, incidence rates of cardiac arrest in pregnancy varies from 1.71 per 100,000 pregnant women (out-of hospital cardiac arrests), 2.78 per 100,000 maternities,[1,2] or 8.5 per 100,000 during hospitalization for delivery.[3] Common causes of cardiac arrest in pregnant women are pulmonary embolism, hemorrhage, sepsis, peripartum cardiomyopathy, stroke, pre-eclampsia/eclampsia, and complications related to anesthesia.[2,4] Sudden cardiac arrest in pregnancy affects both the mother and the unborn, and requires a multidisciplinary approach, including anesthesiology, cardiology, obstetrics, neonatology, and sometimes cardiothoracic surgery.[5] Consequently, healthcare personnel responding to maternal cardiac arrest must simultaneously perform maternal and obstetric treatment.[6]

The physiological changes that occur in pregnancy can impact treatment and performance of cardiopulmonary resuscitation (CPR). For example, cardiac output rises 30%–50%, and systemic vascular resistance decreases leading to a decrease in mean arterial pressure.[7] The growing uterus can lead to increased afterload through compression of the aorta, and decreased cardiac return through compression of the inferior vena cava, starting at 12–14 weeks of gestational age.[7] Chest compression on pregnant women is also challenged by flared ribs, raised diaphragm, obesity, and breast hypertrophy.[8,9] Consequently, CPR in pregnant women requires adjustment to basic CPR guidelines. These adjustments include left lateral uterine displacement during chest compressions, an assumption that the patient has a difficult airway, placement of intravenous access above the diaphragm,[5] and appropriate personnel should also prepare to perform perimortem cesarean section (PMCS) to decrease compression on the venous system, and to improve the probability of return of spontaneous circulation (ROSC).[10–12]

According to the American Heart Association, knowledge deficits and poor resuscitation skills can affect outcomes in cardiac arrest in pregnancy.[13] To prepare for optimal treatment of cardiac arrest in pregnancy, guidelines recommend that all units likely to deal with cardiac arrest in pregnancy should have plans and equipment in place for resuscitation of both the pregnant woman and the newborn. Also, the units should ensure early involvement of obstetric, anesthetic, critical care, and neonatal teams and ensure regular training in obstetric emergencies.[6,14,15] The rate of survival to hospital discharge after maternal cardiac arrest has been reported to be much higher than in other cardiac arrest populations (58.9%).[16] This justifies appropriate education, training and preparation for such events despite their rarity.

Even though knowledge gaps in maternal resuscitation have been emphasized,[9] research exploring healthcare personnel competence and knowledge about cardiac arrest in pregnancy as well as PMCS is limited. Both Einav et al.[17] and Cohen et al.[18] found that specialist clinicians possess a limited knowledge of the recommendations for treating maternal cardiac arrest. Yet, these were small studies ($n = 30$ and $n = 75$ respectively), utilizing non-validated questionnaires.[17,18] Hence, the aims of this study were (1) to assess healthcare personnel self-assessed competence and knowledge about how to treat cardiac arrest in pregnancy as well as PMCS, before and after implementation of a new guideline on maternal resuscitation, (2) to assess whether there were any Interprofessional differences in knowledge about maternal resuscitation, and (3) to explore possible differences between different implementation strategies.

2 | MATERIALS AND METHODS

This study had a prospective repeated measure implementation design, utilizing a questionnaire before and after implementation of a new guideline on maternal resuscitation.

2.1 | Setting and participants

The study was conducted in a Norwegian regional hospital, with a catchment area of about 322,000 inhabitants. The hospital handles about 2700 births a year. Wards most likely to experience cardiac arrest in pregnancy were purposefully selected to participate in the study, namely the maternity and gynecology ward, emergency department, intensive care unit, postanaesthetic care unit, ward for cardiac monitoring and department of anesthesiology. Participants were initially contacted via e-mail with information about the project and an invitation to participate. All healthcare personnel potentially involved in maternal resuscitation in the six wards, were invited ($n = 527$). Inclusion criteria were personnel with 50% clinical work or more. Personnel groups included medical physicians, anesthesiologists, gynecologists, obstetricians, midwives, nurses, and nurses with

a specialization (anesthesia, critical care, emergency care), and nurse assistants.

2.2 | Implementation of new guidelines

The new guideline in maternal resuscitation consisted of background information about cardiac arrest in pregnancy and specific instructions for CPR, PMCS, and local warning routines. It applies to pregnant women from gestation Week 20.[19] Implementation were planned implemented utilizing different approaches: (1) simulation, (2) table-top discussions and (3) an electronical learning (e-learning) course. Simulations were conducted in teams, including nurse assistants, nurses, midwives and physicians, and followed recommended guidelines.[20] The table-tops involved discussions and decision-making of an imaginary situation of maternal resuscitation. The selection of type of learning activity was pragmatic. The e-learning was made accessible for all personnel. In addition, personnel available at the time of simulation and table-top discussions respectively, participated in this.

Simulations and table-top discussions were conducted in the periode May–June 2019. The e-learning course was launched in May 2019, and is per December 2021 still available in the hospital.

2.3 | Data collection

We utilized "The Competence in Cardiac Arrest in Pregnancy-questionnaire" (ComCA-P), which was developed and validated to assess healthcare personnel knowledge and self-assessed competence in cardiac arrest in pregnancy and PMCS.[21] The questionnaire consists of 37 questions, referred to as "items," distributed in five areas: (1) demographics (2) courses and training (3) self-assessed competence (4) roles/responsibility and (5) theoretical knowledge about CPR and PMCS. Moreover, the postimplementation questionnaire included information about which learning activity the participant had attended: simulation, table-top discussion or e-learning course (or neither) For detailed overview of items, see supporting information 1.

A paper-based questionnaire was distributed before and after implementation of the new guideline by study nurses who also provided reminders to complete the questionnaire to all staff after a short time interval.

2.4 | Statistical analyses

Data were analyzed using the software Statistical Package for the Social Sciences (SPSS).[22] Values are given as numbers with percentages and were analyzed using Pearson chi-squared test. Continuous data are presented as medians (interquartile range) and compared with nonparametric Independent-Samples Mann–Whitney *U* test. $p \leq 0.05$ were considered significant.

2.5 | Ethical approval

The study was based on the principles stated in the Declaration of Helsinki; on anonymity, confidentiality and voluntary, informed consent to participate.[23] A returned, completed questionnaire was assumed as consent to participate. Participants had no opportunity to withdraw, since data were unidentifiable. Data were plotted and kept in the research area of a safe, internal zone (password and user access) at the university college.

The study was approved by the Norwegian Center for Research Data (NSD) (reference number 558373).

3 | RESULTS

Data were collected at two time-points: (1) 3 weeks in March 2019 and (2) 3 weeks in October 2020, approximately 16 months after the implementation. The results are based on comparison at group level.

Of the 527 health care personnel invited to participate in the study, 251 (48%) responded to the prequestionnaire, and 182 (35%) to the postquestionnaire. A smaller number of participants answered the questionnaire in the post-test group, but we found no significant differences in demographic data when comparing pre-test to post-test. Table 1 gives an overview of respondents' descriptives pre and postimplementation.

3.1 | Experienced need for education/training/simulation

To implement the new guideline, 38 (21%) of the respondents in the post-test group had participated in simulation training, 22 (13%) had table top discussions, and 78 (43%) performed the e-learning program. 25 of the respondents participated in two implementation strategies, and three respondents performed all three implementation strategies. In addition, 70 (39%) respondents had not participated in any of the implementation strategies.

Respondents' self-assessed need of more education and training/simulation were considered high in 78% (education) and 82% (training/simulation) of responses before implementation. This was significantly lowered after implementation, but still 56% and 72% reported high need of education and training/simulation after implementation, respectively. For detailed view of self-assessments of needs and competence see Table 2.

3.2 | Self-assessed competence

Self-assessed overall competence in maternal resuscitation improved after implementation of the new guideline. The knowledge questions that had the highest knowledge level in all groups were high both before and after implementation of guidelines; relation compression/ventilations in CPR (82% correct answers pretest vs. 88% post-test,

TABLE 1 Descriptives of respondents pre and postimplementation

Ward	Pre (*N* = 251) *n* (%)	Post (*N* = 182) *n* (%)	*p* Value*
Maternity and gynecology ward	97 (39)	71 (39)	0.50
Emergency department	41 (16)	26 (14)	
Intensive care unit	38 (15)	24 (13)	
Postanaesthetic care unit	12 (5)	6 (3)	
Ward for cardiac monitoring	47 (19)	47 (26)	
Department of anesthesiology	16 (6)	8 (4)	
Professional background	***n* (%)**	***n* (%)**	***p* Value***
Nursing assistant	21 (9)	10 (6)	0.06
Nurse	48 (20)	50 (28)	
Nurse with specialization	123 (50)	96 (53)	
Physician	31 (13)	11 (6)	
Physician with specialization	22 (9)	14 (8)	
Experience	**Median (IQR)**	**Median (IQR)**	***p* Value***
Years of experience since general education	17 (7–24)	16 (7–23)	0.94
Years of experience since specialization	10 (4–17)	9 (4–15)	0.40
Courses	***n* (%)**	***n* (%)**	***p* Value***
Participated in CPR-course	180 (72%)	142 (79%)	0.11
Participated in real-life CPR of pregnant woman	26 (10%)	24 (13%)	0.36

Abbreviations: CPR, cardiopulmonary resuscitation; IQR, interquartile range; *N*, number of respondents; Pre, preimplementation; Post, postimplementation.

*P-values ≤ 0.05 were considered significant.

TABLE 2 Respondents' experienced need for education and training/simulation

	Need	Pre (*N* = 251) n (%)	Post (*N* = 182) *n* (%)	*p* Value
Need of more education	High	196 (78)	100 (56)	<0.001*
	Medium	50 (20)	68 (38)	
	Low	5 (2)	11 (6)	
Need of more training/ simulation	High	205 (82)	130 (72)	0.04*
	Medium	41 (16)	43 (24)	
	Low	4 (2)	7 (4)	

Abbreviations: High, collated the response alternatives 4 (high) and 5 (very high); Medium, response alternative 3 (average); Low, collated the response alternatives 1 (very low) and 2 (low); Post, postimplementation; Pre, preimplementation.

*$p \leq 0.05$ were considered significant.

$p = 0.087$) and whether a pediatrician should be called during resuscitation (64% correct answers pretest vs. 69% post-test $p = 0.122$). All other themes (except administration of syntocinon after ROSC) were significantly improved after implementation of new guidelines. For details about proportions of correct answers on knowledge questions across all respondents, see Table 3.

3.3 | Knowledge about maternal resuscitation

Knowledge questions about maternal resuscitation were answered correctly more often by physicians than nurses and nursing assistants in all categories, except post-test "relation compressions/ventilations". Physicians and nurses had the highest knowledge level in the same themes; whether to call a pediatrician (physicians 96% vs. nurses 62%), relation compressions/ventilations (physicians 88% vs. nurses 89%) and when the uterus affect circulation (physicians 76% vs. nurses 59%). The lowest knowledge level was regarding how many minutes after PMCS the baby should be delivered (physicians 24% vs. nurses 22%) and whether vaginal delivery was preferred to PMCS (physicians 24% vs. nurses 14%), see Table 4 for details.

3.4 | Interprofessional differences in knowledge

For knowledge questions correct answered after different implementation strategies, see Table 5.

3.5 | Implementation strategies

Table 6 gives an overview of identified differences between different implementation strategies as measured by respondents' knowledge about CPR in pregnancy postimplementation.

4 | DISCUSSION

The main findings of this study showed that self-assessed competence varied in terms of themes and different respondents' backgrounds. Respondents mostly assessed their own competence regarding maternal resuscitation from low to medium, with a few exceptions. There was a high need for more education and training. Implementation of the new guideline for resuscitation improved self-assessed competence and lowered the need for more education and training. Knowledge about maternal resuscitation was in most cases significantly improved after implementation of the new guideline.

TABLE 3 Respondents' self-assessed competence in maternal resuscitation pre and postimplementation

	Self-assessment	Pre (*N* = 251) n (%)	Post (*N* = 182) n (%)	*p* Value
Warning routines	High	178 (72)	120 (66)	0.24
	Medium	50 (20)	46 (25)	
	Low	17 (7)	15 (8)	
	Undecided	3 (1)	0	
Positioning	High	118 (48)	106 (60)	0.03*
	Medium	72 (29)	40 (23)	
	Low	53 (21)	31 (18)	
	Undecided	5 (2)	-	
Airway handling	High	155 (62)	103 (57)	0.38
	Medium	65 (26)	48 (27)	
	Low	28 (11)	29 (16)	
	Undecided	1	-	
Drug administration before delivery	High	39 (16)	24 (13)	0.004*
	Medium	28 (11)	44 (24)	
	Low	176 (71)	109 (61)	
	Undecided	6 (2)	3 (2)	
Drug administration after delivery	High	54 (22)	36 (20)	0.96
	Medium	49 (20)	38 (22)	
	Low	139 (56)	100 (57)	
	Undecided	5 (2)	3 (2)	
Routines for PMCS	High	33 (13)	24 (13)	0.10
	Medium	32 (13)	39 (22)	
	Low	179 (73)	116 (65)	
	Undecided	3 (1)	1 (1)	
Routines for defibrillation	High	105 (45)	68 (39)	0.71
	Medium	69 (29)	55 (32)	
	Low	60 (25)	50 (29)	
	Undecided	-	-	
Overall competence in CPR and PMSC in pregnant women	High	30 (12)	29 (16)	0.03*
	Medium	83 (34)	77 (43)	
	Low	132 (54)	73 (41)	
	Undecided	-	-	

Note: Pearson χ^2 test.

Abbreviations: CPR, cardio-pulmonary resuscitation; High, collated the response alternatives 4 (high) and 5 (very high); Medium, response alternative 3 (average); Low, collated the response alternatives 1(very low) and 2 (low); Pre, preimplementation; PMCS, perimortem cesarean section; Post, postimplementation.

*$p \leq 0.05$ were considered significant.

Respondents assessed their competence regarding CPR and PMCS in pregnancy both before and after the implementation of a new guideline from medium to high, with a few exceptions. The exceptions were related to drug administration and PMCS, were respondents reported "low" competence more frequent. However, respondents' self-assessed overall competence in CPR and PMCS in pregnancy increased significantly post-implementation. We have not been able to identify any other studies specifically exploring healthcare personnel self-assessed competence in CPR and PMCS in pregnant women. It may be argued that self-assessment is subjective and based on individual interpretation of the concept of competence. However, self-assessed competence is an acknowledged measure indicating quality of healthcare personnel.[3,24–26] Competence has been described as a combination of knowledge, fitness, assessments and attitudes.[27,28] The few studies identified exploring healthcare personnel competence in CPR and PMCS include knowledge questions as well as the provision of practical skills. The most cited studies were conducted in 2008 by Einav et al.[17] and Cohen et al.[18] who both found that specialists have limited knowledge of the recommendations for treating maternal cardiac arrest. Studies conducted by Lipman et al.[29] and Berkenstadt et al.[30] found that a poor level of technical skills was demonstrated in simulations of obstetric crisis. Bartolome' et al.[31] explored four questions related to the management of CA in pregnant women, and found that the mean proportion of correct answers was 54.48%. In our study, respondents had from 11% to 82% (mean 31.9%) correct answers preimplementation, and from 15% to 88% (mean 40.7%) post-implementation. Hence, our study supports earlier research stating that healthcare personnel lack knowledge about CPR and PMSC in pregnancy. More specifically, our study identifies specific areas that need emphasis in planning educational programs. For example, the lowest knowledge was regarding how many minutes after start of PMCS the baby should be delivered and whether vaginal delivery was preferred to PMCS.

Our results indicate that physicians most frequently answered correctly on the knowledge questions. This is most likely due to the differences in educational background between physicians, nurses and nurse assistants. However, the simulation, table-top discussions and e-learning course were similar in all professions. In three items, the knowledge level in nurse assistants decreased. We can not see any logic explanations to this, other than the fact that different individuals responded pre and postimplementation. Einav et al.[17] found that participants with different professional background were divided in their opinions regarding every single choice of action during resuscitation, from patient positioning to medication doses, which is in-line with our findings. CPR and PMCS in pregnancy are based on working in an interprofessional team, were each member has a defined role. Human factors such as teamwork and leadership have been shown to affect adherence to algorithms and hence the outcome of CPR.[32] Zelop et al. claims that simulation and team training enhance institution readiness for maternal cardiac arrest,[9] which our findings also may indicate.

TABLE 4 Respondents' knowledge about CPR in pregnancy pre and postimplementation, defined as number of correct answers

	Pre ($N = 251$) *n* (%)	Post ($N = 182$) *n* (%)	*p* Value
From what gestation week will the uterus probably affect the circulation in patients on their back?	107 (43) Missing: 1	111 (61) Missing: 1	<0.001*
In what relation should compressions/ventilations be conducted?	205 (82) Missing: 2	157 (88) Missing: 3	0.087
What position is optimal during CPR?	67 (27) Missing: 1	104 (58) Missing: 1	<0.001*
How many minutes after cardiac arrest should the procedure start?	68 (27) Missing: 3	78 (45) Missing: 9	<0.001*
How many minutes after start of procedure should the baby be delivered?	30 (12) Missing: 4	36 (21) Missing: 10	<0.001*
Should automated compression machine (LUCAS) be used before the baby has been delivered?	90 (38) Missing: 13	94 (54) Missing: 7	0.006*
Is vaginal delivery preferred to PMCS in women with full opening?	23 (9) Missing: 4	27 (15) Missing: 6	0.002*
Is PMCS performed when the uterus is at umilical level?	39 (16) Missing: 6	57 (34) Missing: 12	<0.001*
Should a pediatrician be called when the gestational age is above 24 weeks?	160 (64) Missing: 2	122 (69) Missing: 5	0.122
After ROSC, is liberal administration of syntocinon recommended?	27 (11) Missing: 7	30 (17) Missing: 8	0.182

Note: Pearson chi-squared test.

Abbreviations: CPR, cardiopulmonary resuscitation; PMCS, perimortem cesarean section; Post, postimplementation; Pre, preimplementation; ROSC, return of spontaneous circulation.

*$p \leq 0.05$ were considered significant. Nonresponding marked as "missing."

Bartolome' et al.[31] also identified deficiencies in the knowledge about CPR in pregnancy, and that personnel perceived a lack of training on this subject. Based on their findings, the authors suggest that an Advanced Cardiac Life Support in Pregnancy course must be created for staff who do not work in a delivery room. A study from the USA indicated that median time for starting CPR decreased under 1 min after introducing a structured educational program.[33] In our study, the implementation increased the knowledge level in most items in all three professional groups, which support the importance of educating personnel.

Our study could not identify any patterns in differences between knowledge level and implementation strategy. Nor could we identify studies comparing such implementation strategies and their effect on learning outcome. Simulation-based education is recognized as an effective interprofessional teaching and learning method.[34] Studies indicate that high-fidelity simulations have a strong educational effect on psychomotoric skills and student performance.[35–37] However, high-fidelity simulations are resource-demanding, both regarding planning, conduction, equipment and locations. Research regarding the effect of table-top discussions is also lacking, even if the literature describes this method as a cost-efficient and effective way to develop the necessary group skills and appropriate group reactions. An integrative review from 2015[38] showed that the individuals' motivation and prior experience with the artifact influence the effectiveness of e-learning. A systematic review from 2017 states that many barriers exist to successful implementation, such as financial disincentives, lack of time or awareness of large evidence resources, limited critical appraisal skills, and difficulties applying evidence in context. Moreover, that there is a paucity of studies evaluating the effectiveness of implementation strategies.[39]

Resuscitation in pregnancy is complicated due to several unique factors in pregnant women with an altered physiological state and the possibility of PMCS. In addition, few healthcare personnel experience such an event during their whole career. This may lead to healthcare personnel repeated reporting of a need for more education and simulation/training, and potential increase in both self-assessed competence and knowledge level. According to the European Resuscitation Council (ERC), there is a lack of high-quality research in resuscitation education to demonstrate whether CPR training improves process quality and patient outcomes.[40] The ERC has developed a life-long-learning strategy enabling all persons educated in resuscitation to maintain their resuscitation competencies as long as they pass recertification modules every 6–12 months. Still this relates to basic CPR, and is not specified to CPR in specific patients or conditions. Guidelines for cardiac arrest under special circumstances emphasize that units likely to deal with cardiac arrest in pregnancy should ensure regular training in obstetric emergencies.[14] Based on our findings, we suggest that the specific adjustments to CPR in

TABLE 5 Interprofessional differences in knowledge about CPR in pregnancy pre and postimplementation, defined as number of correct answers

	Professional background	Prenursing assistant (*N* = 21) Nurse (*N* = 171) Physician (*N* = 53) *n* (%)	Postnursing assistant (*N* = 10) Nurse (*N* = 146) Physician (*N* = 25) *n* (%)
From what gestation week will the uterus probably affect the circulation in patients on their back?	Nursing assistant	5 (25) Missing: 1	5 (50)
	Nurse	64 (37)	86 (59) Missing: 1
	Physician	37 (70)	19 (76)
In what relation should compressions/ventilations be conducted?	Nursing assistant	16 (76)	7 (70)
	Nurse	141 (83) Missing: 2	128 (89) Missing: 2
	Physician	46 (87)	21 (88)
What position is optimal during CPR?	Nursing assistant	-	5 (50)
	Nurse	44 (26) Missing: 1	81 (56) Missing: 1
	Physician	23 (43)	17 (68)
How many minutes after cardiac arrest should the procedure start?	Nursing assistant	3 (15) Missing: 1	1 (13) Missing: 2
	Nurse	39 (23) Missing: 2	61 (44) Missing: 7
	Physician	25 (47)	15 (60)
How many minutes after start of procedure should the baby be delivered?	Nursing assistant	1 (5) Missing: 1	-
	Nurse	22 (13) Missing: 3	30 (22) Missing: 8
	Physician	7 (13)	6 (24)
Should Automated compression machine (LUCAS) be used before the baby has been delivered?	Nursing assistant	3 (38) Missing: 2	2 (20)
	Nurse	58 (36) Missing: 9	74 (53) Missing: 7
	Physician	27 (53) Missing: 2	17 (68)
Is vaginal delivery preferred to PMCS in women with full opening?	Nursing assistant	5 (24)	2 (22) Missing: 1
	Nurse	13 (8) Missing: 3	19 (14) Missing: 5
	Physician	5 (9)	6 (24)
Is PMCS performed when the uterus is at umilical level?	Nursing assistant	-	2 (25) Missing: 2
	Nurse	18 (11) Missing: 3	38 (28) Missing: 10
	Physician	21 (40) Missing: 1	16 (64)
Should a pediatrician be called when the gestational age is above 24 weeks?	Nursing assistant	17 (81)	10 (100)
	Nurse	101 (60) Missing: 2	88 (62) Missing: 5
	Physician	39 (74)	24 (96)
After ROSC, is liberal administration of syntocinon recommended?	Nursing assistant	-	1 (11) Missing: 1
	Nurse	16 (10) Missing: 5	17 (12) Missing: 7
	Physician	11 (21)	11 (44)

Abbreviations: CPR, cardiopulmonary resuscitation; PMCS, perimortem cesarean section; Post, postimplementation; Pre, preimplementation; ROSC, return of spontaneous circulation.

pregnant women are included in advanced CPR courses as well as in resertification programs for healthcare personnel.

Several limitations of this study need to be addressed. The study was conducted in one hospital only, and this may limit the external validity (reliability) and generalizability of the study. In addition, the response rate was quite low, and decreased from pre- to post intervention; 48% to 35%. This might influence the result. Nevertheless, six different wards as well as healthcare personnel with different professional background and experience were included. Table 1 show no significant differences in demographic background in the pre- and post-test groups, respectively. In addition, our findings adhere to findings in similar studies.

A limitation is that we did not compare results pre and post-implementation at an individual level. Nevertheless, there were no significant differences in descriptives of respondents beyond professional background between the pre and postimplementation groups.

Some of the participants did not participate in any of the implementation strategies. However, the new guideline as well as the e-learning course were made accessible to all staff and discussed in staff meetings, so it is unlikely that any of the respondents were completely unaware of the new guidelines.

Participants had the opportunity to discuss with colleagues before responding to the theoretical questions. Practical tests, observation of simulated cases or theoretical exams may have given a more accurate picture of the participants' actual competence.

More extensive statistical analyses, such as regression models, could have been conducted to assess potential associations, for example, between professional background and self-assessments. However, we chose to give a more descriptive presentation of our findings.

TABLE 6 Identified differences between the implementation strategies on respondents' knowledge about CPR in pregnancy pre and postimplementation (defined as number of correct answers)

	Simulation (*N* = 38) *n* (%)	Table-top (*N* = 22) *n* (%)	E-learning (*N* = 78) *n* (%)	None (*N* = 70) *n* (%)	Two strategies (*N* = 24) *n* (%)	All strategies (*N* = 3) *n* (%)
From what gestation week will the uterus probably affect the circulation in patients on their back?	26 (69)	16 (76) Missing: 1	57 (73)	31 (44)	17 (71)	3 (100)
In what relation should compressions/ventilations be conducted?	35 (95) Missing: 1	19 (91) Missing: 1	73 (94)	54 (78) Missing: 1	22 (92)	3 (100)
What position is optimal during CPR?	26 (68)	15 (71) Missing: 1	49 (62)	32 (46)	15 (63)	3 (100)
How many minutes after cardiac arrest should the procedure start?	14 (39)	8 (40) Missing: 2	43 (57) Missing: 2	21 (32) Missing: 4	9 (39) Missing: 1	-
How many minutes after start of procedure should the baby be delivered?	8 (23) Missing: 3	4 (20) Missing: 2	21 (28) Missing: 2	7 (11) Missing: 4	2 (9) Missing: 1	1 (33)
Should Automated compression machine (LUCAS) be used before the baby has been delivered?	19 (51) Missing: 1	14 (67) Missing: 1	43 (57) Missing: 2	34 (51) Missing: 3	14 (58)	2 (67)
Is vaginal delivery preferred to PMCS in women with full opening?	7 (18)	5 (24) Missing: 1	12 (16) Missing: 2	8 (12) Missing: 3	5 (21)	-
Is PMCS performed when the uterus is at umilical level?	14 (39) Missing: 2	14 (70) Missing. 2	29 (38) Missing: 3	13 (20) Missing: 3	9 (38)	3 (100)
Should a pediatrician be called when the gestational age is above 24 weeks?	33 (89) Missing: 1	20 (95) Missing: 2	52 (68) Missing: 1	41 (60) Missing: 2	21 (88)	3 (100)
After ROSC, is liberal administration of syntocinon recommended?	5 (14) Missing: 1	5 (24) Missing: 1	16 (21) Missing: 2	9 (14) Missing: 4	4 (17)	1 (33)

Abbreviations: CPR, cardiopulmonary resuscitation; E, electronical; PMCS, perimortem cesarean section; Post, postimplementation; Pre, preimplementation; ROSC, return of spontaneous circulation.

This study assesses participants' self-assessed competence and knowledge about maternal resuscitation. Hence, we can not conclude whether implementation of a new guideline improved personnel actual competence in performing maternal resuscitation.

5 | CONCLUSIONS

This study adds knowledge about healthcare personnel self-assessed competence and knowledge about maternal resuscitation after cardiac arrest. Our findings indicate that there is a need for repetitive education and training in this rare incident. Based on our results we can not conclude whether simulation, table-top discussions or e-learning are more efficient when aiming to implement new guidelines in the resuscitation team.

AUTHOR CONTRIBUTIONS

Camilla Hardeland: Conceptualization; data curation; formal analysis; methodology; validation; writing – original draft; writing – review and editing. **Edel Jannecke Svendsen**: Conceptualization; data curation; formal analysis; methodology; writing – review and editing. **Grethe Berger Heitmann**: Conceptualization; data curation; methodology; resources; writing – review and editing. **Ann-Chatrin Leonardsen**: Conceptualization; data curation; methodology; project administration; validation; writing – original draft; writing – review and editing.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

TRANSPARENCY DECLARATION

The lead author (Camilla Hardeland) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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