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Simulation and education

Decision making and situational awareness in neonatal resuscitation in low resource settings

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Abstract

Introduction: Data on non-technical skills (i.e. task management, team working, situation awareness and decision-making) of healthcare providers during real-life newborn resuscitation in low-resource settings are lacking. We aimed to assess non-technical skills of trained midwives during real-life newborn resuscitation in a low-resource setting before and after participation in a modified NRP course, and after a low-dose/high-frequency training.

Methods: One-hundred and fifty video-recorded resuscitations (50 before and 50 after participation in a modified NRP course, and 50 after a low-dose/high-frequency training) collected at the Beira Central Hospital (Mozambique) were independently viewed and rated by two neonatologists with expertise in high fidelity simulation. Non-technical skills regarding task management, situation awareness and decision-making were evaluated using the modified Anesthetists' Non-Technical Skills tool.

Results: Overall, most non-technical skills were scored as poor or marginal. Small improvements were observed in task management (planning and preparing $p = 0.02$; providing/maintaining standards $p = 0.03$) after the course. Limited improvements were observed in task management (prioritizing $p = 0.03$; providing/maintaining standards $p = 0.04$; identifying and utilizing resources $p = 0.02$) and decision-making (identifying options $p = 0.04$; balancing risk/selecting options $p = 0.02$) after the low-dose/high-frequency training. No differences were observed in situation awareness, apart from a small improvement in recognizing/understanding ($p = 0.04$) after the low-dose/high-frequency training.

Conclusion: An educational intervention including a modified NRP course and a low-dose/high-frequency training on neonatal resuscitation had a limited impact on non-technical skills of participants. All items remained significantly under the recommended standards. Behavioral skills should be considered in training programs in order to improve the quality of neonatal resuscitation in low resource settings.

Keywords: Education, Low-resource setting, Neonatal resuscitation, Non-technical skills

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Introduction

Neonatal deaths account for a significant proportion of mortality in children less than 5 years.[1] Neonates are at the highest risk of dying around the time of birth, due to intrapartum-related complications that contribute to approximately one-quarter of neonatal deaths.[2] The vast majority of these deaths (98%) occur in low- and middle-resource countries and can be prevented by simple resuscitation and newborn care interventions.[2,3]

Education in neonatal resuscitation is crucial in the prevention of neonatal morbidity and mortality.[4] Appropriate translation of the science of resuscitation into a training programme aims to transfer the knowledge and the skills of resuscitation into improved clinical practice.[5] Educational programs to reduce neonatal deaths include the WHO Essential Newborn Care (ENC), the American Academy of Pediatrics Neonatal Resuscitation Program (NRP) and Helping Babies Breathe (HBB), specifically designed to teach neonatal resuscitation in a low-resource setting.[6–8]

There is a growing literature suggesting that teaching neonatal resuscitation through training based on low-dose, high frequency simulation practices has a positive effect on long-term knowledge and skills of healthcare providers and significantly decreases perinatal mortality rate.[9–13] Although these results seem promising, research aimed on determining and refining components that improve retention of neonatal resuscitation skills and clinical performance is warranted.[14–16]

Video analysis of real-life newborn resuscitations showed limited adherence to NRP and HBB guidelines in both, high and low-resource settings.[17–21] Such findings confirm that further research in educational methods is needed in order to improve acquisition and retention of knowledge and skills related to newborn resuscitation.

Several educational aspects may play an important role in translating the knowledge and skills acquired during a standardized formal neonatal resuscitation training into clinical practice.[5,14] In fact, staff performance depends on individual skills but also on the ability to manage other relevant aspects such as planning and preparing the field, recognizing priorities, providing and maintaining standards, identifying and utilizing resources.[22,23] Crisis resource management (CRM) refers to a set of abilities (so-called "non-technical skills") that are not strictly included in medical knowledge and manual skills, but are required to effectively manage emergency situations.[24] However, neonatal resuscitation programs such as NRP and HBB dedicate no attention on non-technical skills.[7,8] Previous studies evaluated technical skills of healthcare providers during real-life newborn resuscitation in low-resource settings,[9–13,19–21] but very little is known about behavioural and non-technical skills.

The aim of the present study was to assess non-technical skills of trained midwives during real-life newborn resuscitation in a low-resource setting before and after participation in a modified NRP course, and after a low-dose/high-frequency training.

Methods

Study design

This study evaluated the non-technical skills of trained midwives during an educational intervention at Beira Central Hospital (Mozambique). Three time points of assessment were defined: before the course (BC), after the course (AC) and after a low-dose/high-frequency training (LDHFT). This study is part of a research assessing the impact of an educational intervention in neonatal resuscitation.[19,21] The study protocol was approved by the National Committee of Bioethics (Ref. 315/CNBS/13; November, 1, 2013) and by the Minister of Health of the Republic of Mozambique (Ref. 08/GMS/002/2014; January, 7, 2014). Before delivery, parents gave their consent to obtain video recordings of neonatal delivery room management and to use the data for scientific purpose. In addition, written informed consent to use clinical records in the study was also given by parents and caregivers. All information including informed consent and the material used in the study was written in Portuguese in a clearly understandable form.

Setting

The study was performed at Beira Central Hospital, in the province of Sofala, Mozambique where about 4500 deliveries occur every year. Beira Central Hospital is the referral hospital for a geographical area that covers about 7 million people.[24] At this hospital, midwives are responsible for immediate postnatal care of all neonates, including resuscitation. Available equipment includes gloves, clean towels, wall suction device, suction catheters, bulb suction, a self-inflating bag with two available facemasks (size 0 and 1) and an oxygen source. Neonatal resuscitation program was based on the NRP algorithm (6th edition) apart from use of pulse oximetry, intubation and medications.[25]

Patients

All neonates needing resuscitation at birth were included in the study. Resuscitation was defined as any intervention provided by healthcare providers: initial steps in order to initiate spontaneous breathing, bag mask ventilation, and/or chest compressions. Lack of parental consent was the only exclusion criterion.

Intervention

This study is part of a research assessing the impact of an educational intervention and details of the intervention have already been described elsewhere.[20] On January 31, 2014, all midwives (median age 30 years; median experience in delivery room 7 years) responsible for immediate postnatal management of the newborns at Beira Central Hospital participated in an adapted NRP course held by expatriate instructors in local language. We decided to teach the modified NRP course because the NRP algorithm was already in use and known by midwives involved in neonatal resuscitation at the Beira Central Hospital. About 8 months after the adapted NRP course, we implemented a LDHFT focused on maintaining and improving the skills that were acquired during the course.[20] The LDHFT lasted 6 months and consisted of weekly 3-hour practical sessions on resuscitation held by a local instructor using a manikin (Neonatal Resuscitation Baby, Laerdal, Stavanger, Norway). Each midwife of the unit attended 4–5 sessions during the 6-month training. The content of the sessions consisted of continuous repetition of manual skill stations (initial steps including equipment preparation, prevention of heat loss, airway, stimulation and assessment; bag-mask ventilation; chest compressions) and scenarios guided and supervised by the same expert midwife, who was trained in NRP.[20] During the session, participant performance was not scored, but incorrect procedures and inadequate techniques were appropriately discussed

with and corrected by the instructor. However, the sessions did not include structured debriefing or review of the videos by the learners to underline mistakes. The same group of midwifes participated in the study during all three phases.

Data collection

One-hundred and fifty resuscitations (50 before the modified NRP course, 50 after the modified NRP course and 50 after the LDHFT) were video recorded and analysed by using a predefined composite score.[26] As described in a previous study,[19] video recording was performed by using a webcam for video monitoring (ENXDVR-4C, Encore Electronics. www.encore-usa.com), consisting of one fixed camera installed above the radiant warmers both in the delivery room and in the operating room. The image was zoomed to show only the newborn and the hands of the resuscitation team. Parents, obstetric procedures and faces of the caregivers were not visible. The videos did not include audio-recording. All videos were stored on a hard disk and sent to the coordinator centre (University of Padua). Maternal and neonatal data were also collected. In order to protect the identities of the subjects and the data, all data about resuscitation date and location were removed, and shipment was insured.

Assessment of non-technical skills

Non-technical skills were evaluated using the Anesthetists' Non-Technical Skills (ANTS) tool.[26] This tool is based on four categories (task management, team working, situation awareness and decision-making) that include individual items representing important actions or behaviors (Table 1). Each item was scored using a Likert scale from 1 (poor performance) to 4 (good performance). All video-recordings were viewed and evaluated by two neonatologists (MEC and DT) who were high fidelity simulation instructors. Additional expertise was also received from a CRM expert neonatologist (AS) in case of doubts or disagreement between the two assessors. A descriptive anchor was provided for each item, in order to reduce personal bias in interpreting performance (Table 1).

Statistical analysis

Continuous data were expressed as median and interquartile range (IQR), categorical data as number and percentages. Non-technical skills (scored as poor, marginal, acceptable, good) were compared among the three groups (before the course - BC, after the course - AC and LDHFT) using Fisher's test, followed by pairwise comparisons as appropriate. Pairwise comparisons were performed between BC and AC groups (to evaluate the improvement due to the course), and between AC and LDHFT groups (to evaluate the outcome of the low-dose/high-frequency training). All p-values were adjusted according to Benjamini-Hochberg method for multiple endpoints.[27] A p-value of less than 0.05 was considered statistically significant. Statistical analysis was performed using R 3.3.2 software (R Foundation for Statistical Computing, Vienna, Austria).[28]

Table 1 – Descriptive anchor for each item of Anesthetists' Non-Technical Skills tool, in order to reduce personal bias in interpreting performance. (modified from Fletcher et al. [26]).

Category	Individual items	Descriptive anchor
Task management	-planning and preparing	*1: no equipment available/ 2: very limited equipment available (i.e. suction system) / 3: acceptable equipment available (at least SIB & oxygen) / 4: all equipment available (pre-warmed linen, suction system, SIB, oxygen)*
	-prioritizing	*understand the problem and act 1: only prolonged stimulation and/or suction / 2: PPV after prolonged stimulation and/or suction / 3: PPV within 1 minute after birth/ 4: effective PPV and re-evaluation*
	-providing and maintaining standards	*follow the steps of resuscitation: 1: without order / 2: with order / 3: correct order and timing / 4: correct order and timing and re-evaluation*
	-identifying and utilizing resources	*use the available equipment/material (suction system, SIB, oxygen, etc.): 1: do not use material / 2: wrong use/ 3: use discreetly / 4: adequate use*
Team working	-coordinating activities with team members	*confirm roles and responsibilities of team members; consider requirements of others before acting*
	-exchanging information	*discuss maternal history with team members; mutual feedback during resuscitation among team members*
	-using authorities and assertiveness	*adequate coordination by the team leader and cooperation by team members*
	-assessing capabilities	*adequate assignment of roles among team members (according to individual experience and capabilities)*
	-supporting others	*mutual motivation and cooperation among team members (helping each other when necessary)*
Situation awareness	-gathering information	*collect and interpret the information correctly*
	-recognizing and understanding	*choose correct interventions based on patient's clinical response*
	-anticipating	*anticipate clinical deterioration starting adequate interventions and avoiding wasting time*
Decision-making	-identifying options	*choose the best option when available (i.e. PPV rather than prolonged stimulation and/or suction or oxygen)*
	-balancing risks and selecting options	*avoid prolonged suction and/or stimulation / start PPV immediately and choose corrective options / start CC after effective PPV has been established*
	-re-evaluating	*patient's re-evaluation: HR assessment: 1: never / 2: at least 1 time during resuscitation; 3: before starting and after PPV; 4: at every step of resuscitation (before starting and after PPV, and before and after CC)*

Results

Participants

The resuscitations were performed on 150 newborn (99 males and 51 females) with a median gestational age of 38 weeks (IQR 36–40) and a median birth weight of 2575 g (IQR 2200–3220 g). Median Apgar score was 5 (IQR 2–6) at 1 minute and 6 (IQR 4–7) at 5 minutes. Seventy-two (48%) subjects were born through cesarean section. Mothers had a median age of 23 years (IQR 19–29) and 62 of them were primiparous (41%).

All 150 neonates received the initial steps of resuscitation; 103 of them received bag-mask ventilation, and 41 also required chest compressions. The midwives had a median age of 30 years (IQR 28–36) with a median experience in delivery room of 7 years (IQR 4–10).

Non-technical skills

The specific skills of team working (i.e. coordinating activities with team members; exchanging information; using authorities and assertiveness; assessing capabilities; supporting others) were unobserved in most resuscitations (by group: 47 in BC, 47 in AC and 42 in LDHFT) because only one health caregiver was present at birth, and could therefore not be evaluated.

All non-technical skills were scored as poor/marginal in BC and in AC, except from one item in "planning and preparation" in AC (Figs. 1–3). Fourteen resuscitations had at least one item scored as acceptable/good in LDHFT. Numeric results are reported in Supplementary Table 1.

All aspects of task management significantly changed across the three groups (Fig. 1). Planning and preparing improved from BC to AC ($p = 0.02$) but was similar in AC and LDHFT ($p = 0.10$). Prioritizing was similar in BC and AC ($p = 0.99$) but improved from AC to LDHFT ($p = 0.02$). Providing/maintaining standards improved from BC to AC ($p = 0.03$) and from AC to LDHFT ($p = 0.04$). Identifying and utilizing resources was similar in BC and AC ($p = 0.99$) but different between AC and LDHFT ($p = 0.02$).

Regarding situation awareness, no statistically significant differences were observed among the three groups about gathering information and anticipating ($p = 0.61$ and $p = 0.14$, respectively; Fig. 2). Most participants received a poor score about gathering information (88% in BC, 90% in AC and 82% in LDHFT) and anticipating (92% in BC, 90% in AC and 78% in LDHFT). Recognizing/understanding was similar in BC and AC ($p = 0.20$) but improved from AC to LDHFT ($p = 0.04$).

Small improvements were observed in decision-making (Fig. 3). Identifying options and balancing risk / selecting options were similar in BC and AC ($p = 0.45$ and $p = 0.85$, respectively) but improved from AC to LDHFT ($p = 0.04$ and $p = 0.02$, respectively). Re-evaluating was not significantly different among the three groups ($p = 0.06$).

Discussion

The present study evaluated the non-technical skills of trained midwives during an educational intervention including a modified NRP course and a low-dose/high-frequency training. Our findings showed a limited impact of this educational intervention on non-technical skills during real-life newborn resuscitation in a low-resource setting. In addition, all items indicated unsatisfactory performance regarding several aspects, thus suggesting the need for a different educational approach.

Recent studies showed encouraging results of the HBB program in improving the quality of delivery room interventions and perinatal mortality rate in low-resource settings,[9–13] but the transfer of theoretical knowledge and skills into the delivery room remains an important barrier to the success of neonatal resuscitation training programs.[14,15] To better understand this phenomenon, we chose to evaluate the performance of midwives providing neonatal

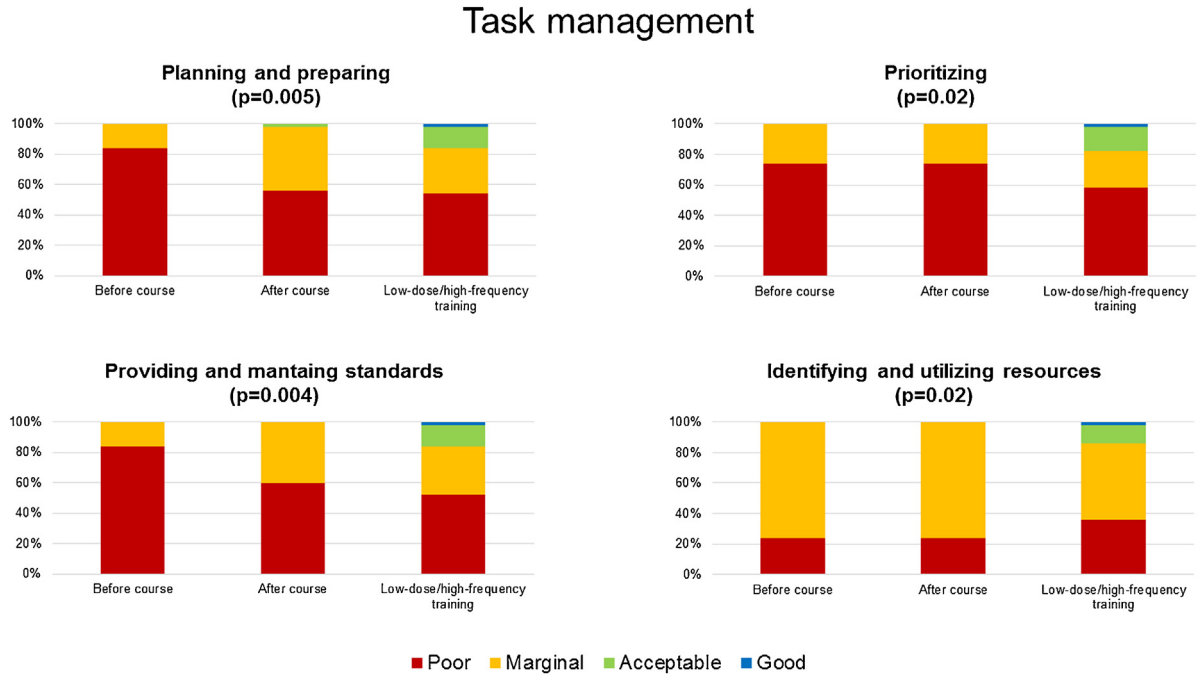

Fig. 1 – Task management.

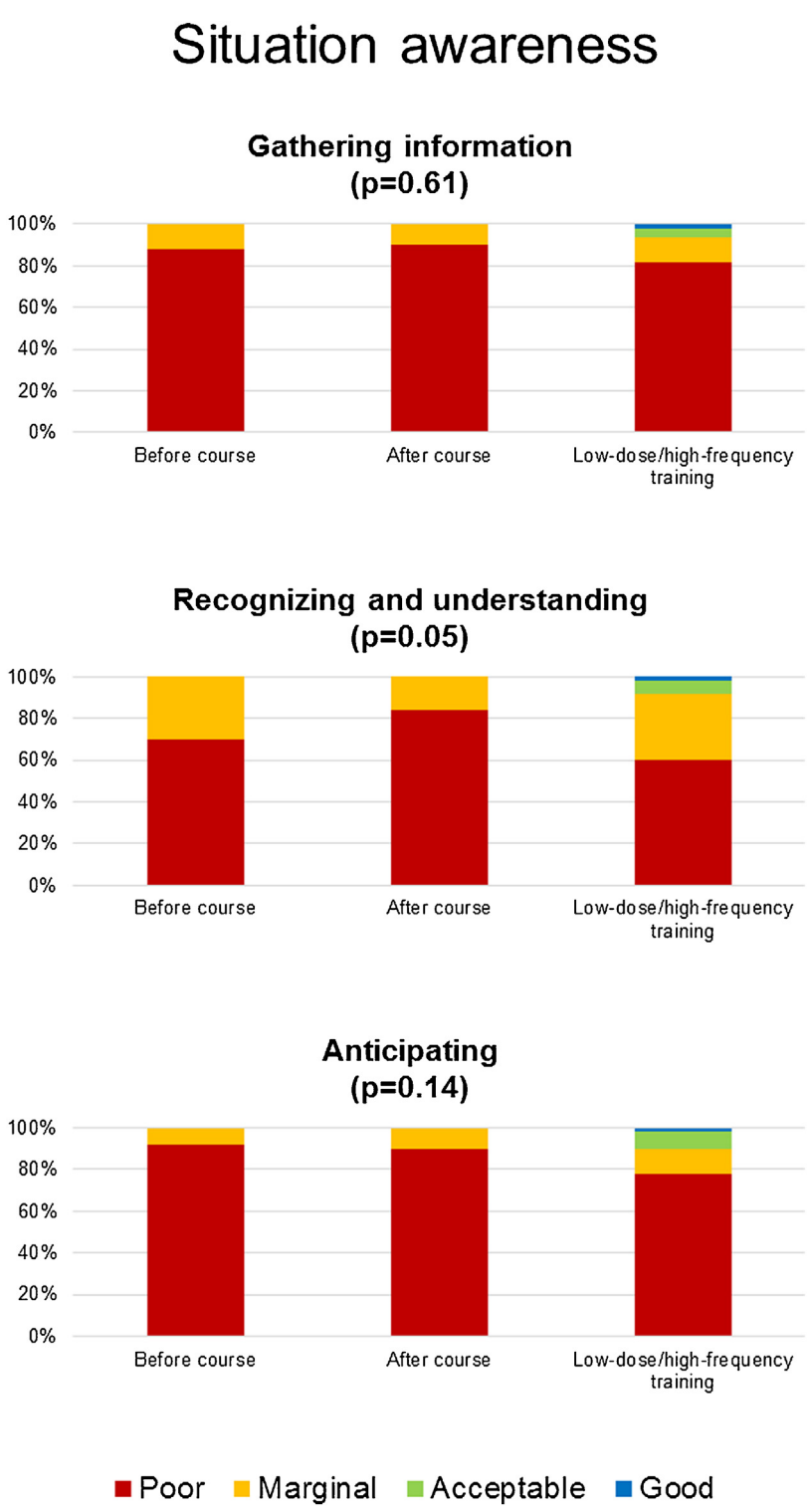

Fig. 2 – Situation awareness.

resuscitation in a low-resource setting from a different point of view. As previous studies in high-resource settings clearly showed that non-technical skills had the most relevant role in effectively managing emergency situations,[22,23] we evaluated the behavioral skills of healthcare providers during real-life neonatal resuscitation in a low-resource context.

Non-technical skills related to task management showed some improvements during the training. These results could be explained by the aspects included in the task management category (i.e. planning and preparing, prioritizing, providing/maintaining standards and identifying/utilizing resources), which mostly reflected the knowledge and the skills taught during the NRP course and the

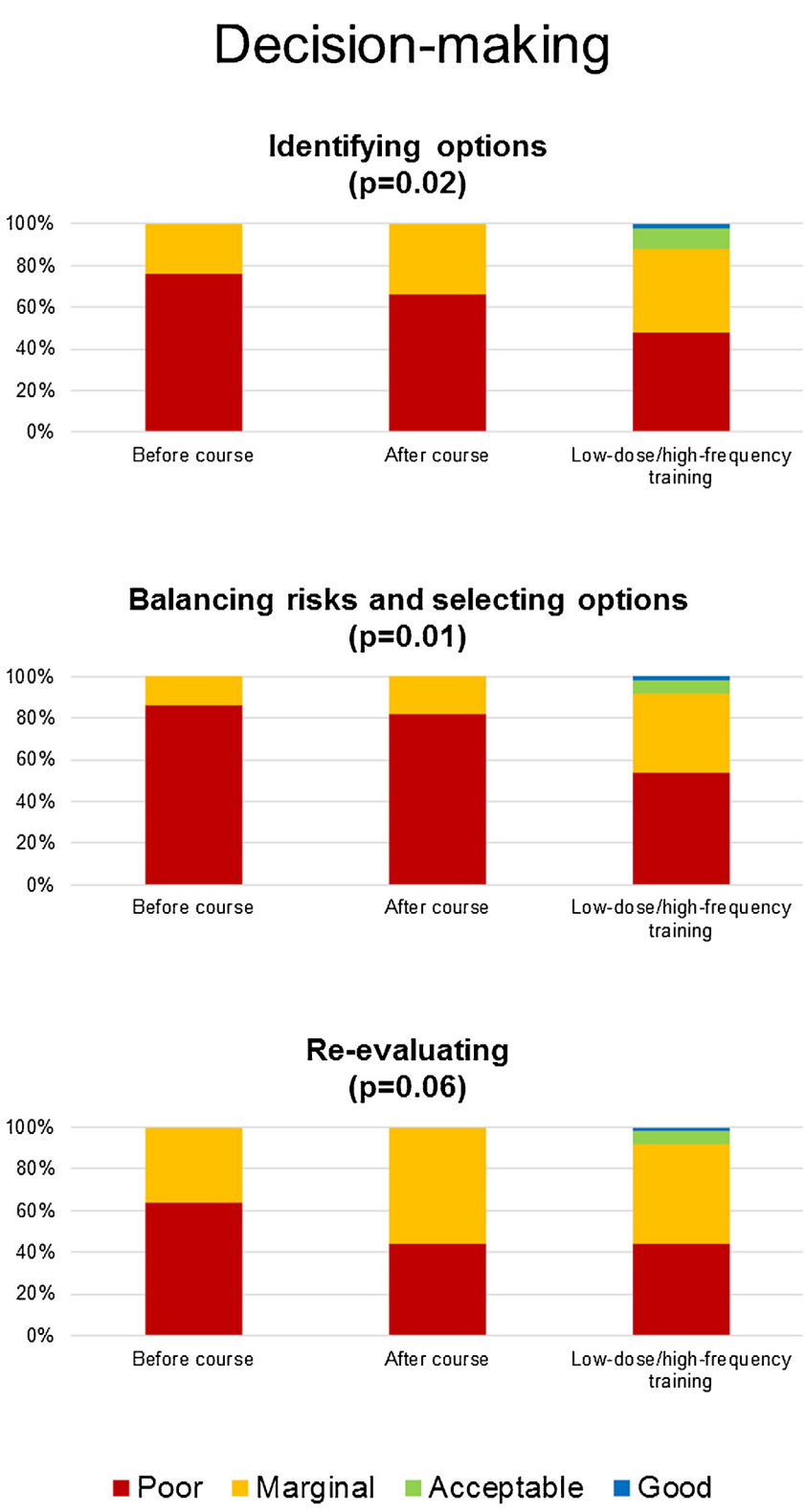

Fig. 3 – Decision-making.

LDHFT. However, the improvement was heterogeneous, with some items improving after the course while other skills were developed only after the LDHFT. These findings were in broad agreement with previous studies that evaluated the impact of newborn resuscitation training on technical skills of healthcare providers in resource-limited settings.[15,16,19–21]

Overall, the non-technical skills related to situation awareness were poor, with no relevant effect of the educational intervention. It is noteworthy that items in this category mostly mirror "cultural" approach to the problem, thus limiting the effect of a resuscitation training. In fact, a previous survey showed that "the fate of the baby is independent from my intervention" was one of the most common

opinions to interpret the scarce application in real life of knowledge and skills acquired during a modified NRP course.[29] In our study, only recognizing/understanding showed a little improvement after the LDHFT, thus suggesting that such training could help in overcoming some cultural fatalistic behavior.[9,13–15] These findings clearly indicate that further initiatives on this field should take into account additional aspects such as the lack of motivation and/or the fatalist approach of healthcare providers involved in the care of the newborns at birth.[30] An approach focused on the evidence-based clinical practice and Quality Improvement initiatives at facility level could also contribute to ameliorate this gap.[14,15,31]

The LDHFT led to small improvements in two aspects of decision-making (i.e. identifying options and balancing risk/selecting options), which overall remained unsatisfactory. These results could be explained by the educational training (modified NRP course) that was adopted. A different educational program, such as HBB that focuses on ventilation and omits chest compressions, could help participants in identifying and selecting the right options in a resource-limited setting.[8–15]

A further explanation for the limited scores obtained by the midwives in this study could be the lack of a simulation training based on CRM principles.[22,23,29] In high-resource settings, simulation training in an immersive environment replicating a real clinical scenario could facilitate the training in behavioral and communication skills.[25,26] Simulation has been used as an educational methodology to teach cognitive, technical, and behavioral skills also in neonatal resuscitation, but its superiority on "traditional" training in improving delivery of care remains to be confirmed.[32–35] Additional educational challenges in low-resource settings include lack of dedicated education time, sustainability challenges of LDHF practices and lack of focus on critical thinking skills (opposed to text book learning).

It is noteworthy that the majority of our deliveries (91%) only had one single provider, thus we could not focus on teamwork or use other assessment tools (such as TEAM scale[36]). This situation represents a common challenge of neonatal resuscitation in low-resource settings, where usually there is only one provider for caring mother and baby.

Teamwork represent an urgent need in order to improve neonatal and maternal morbidity/mortality in low-resource settings. At least one health-care worker focused on the mother postpartum and one on the newborn asphyxiated baby should be available in each delivery setting.

The strengths of the study include the evaluation of staff performance based on video-recording, the recording of actual resuscitations rather than a video of a skill and the evaluation of staff performance based on video-recording by two high fidelity simulation experts using a predefined tool.

The present study has also some limitations. First, the evaluation of non-technical skills was based on the modified Anesthetists' Non-Technical Skills tool,[26] thus some aspects regarding behavioral skills could not be taken into account. Using high-resource assessment measures represents a challenge in low-resource settings. However, the assessment was performed by two neonatologists with expertise in high fidelity simulation and a descriptive anchor (Table 1) was provided for each item, in order to reduce personal bias. Second, inter-rater variability was not assessed since the two neonatologists viewed and evaluated the video-recordings simultaneously, then achieved a shared decision on the score. Third, the training was based on a modified NRP course because the NRP algorithm was already in use and known by participants at the Beira Central Hospital. Further studies may investigate the effect of different training programs, such as the HBB package,[8] on behavioral skills of health care providers.

Conclusion

An educational intervention including a modified NRP course and a low-dose/high-frequency training had a limited impact on the non-technical skills of trained midwives during real-life newborn resuscitation in a low-resource setting. All items remained significantly under the recommended standards. Behavioral skills should be considered in training programs to improve the quality of neonatal resuscitation in low-resource settings. Challenges of this topic include educational disparities in low-resource settings (i.e. focus on textbook opposed to hands-on learning, lack of previous exposure to simulation, cultural differences) and the lack of a validated tool to evaluate non-technical skills in neonatal resuscitation. Further studies should evaluate the impact of training including non-technical skills on relevant clinical outcomes.

Contributors' Statement

Dr Cavicchiolo wrote the initial draft of the manuscript, contributed to data collection, assessed the videos and made a substantial contribution to the interpretation of the data.

Dr Cavallin participated in the conception of the study, performed the data analysis, redrafted the manuscript, and gave a substantial contribution to the design and interpretation of the data.

Dr. Staffler assessed the videos, participated in the conception and design of the study and made a substantial contribution to the analysis and interpretation of the data.

Drs Pizzol, Matediana and Wingi Manzungu contributed to data collection, strictly followed all the local phases of the study and made a substantial contribution to the interpretation of the data.

Dr. Da Dalt supervised all the phases of study and made a substantial contribution to the interpretation of the data.

Dr. Putoto participated in the conception and design of the study and made a substantial contribution to the analysis and interpretation of the data.

Dr. Trevisanuto conceived and designed the study; made substantial contribution to the analysis and interpretation of the data; redrafted the manuscript and revised it for important intellectual content.

All authors critically revised the manuscript for important intellectual content; and approved this version of the manuscript.

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Conflict of interest

The authors have no potential conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2018.10.034.

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