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Video recording as an objective assessment tool of health worker performance in neonatal resuscitation at a district hospital in Pemba, Tanzania: a feasibility study

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Abstract

Introduction

Neonatal resuscitation (NR) can save many newborn lives. However, quality of care is not always guaranteed, and quality assessment can be complex. We aimed to assess the feasibility of using video recordings of NR to objectively evaluate the quality of care in a low-resource setting.

Methods

We conducted a prospective observational feasibility study in April and May 2019 at Chake-Chake Hospital, a district hospital in Pemba, Tanzania. All delivering women and their newborns were eligible for participation. Motion-triggered cameras were mounted on resuscitation tables and provided recordings that were analysed for quality of care indicators based on the national NR algorithm. Assessment of feasibility was conducted using Bowen's eight-point framework for feasibility studies.

Results

Ninety-one percent (126/139) of women and 96% (24/26) of health workers were comfortable or very comfortable with the video recordings. Of 139 newborns, eight underwent resuscitation with bag and mask ventilation. In resuscitations, heat loss prevention measures were not performed in half of the cases (4/8), clearing the airway was not performed correctly five out of eight of the cases (5/8), and all newborns were suctioned vigorously and repeatedly, even when not indicated. In a quarter (2/8) the newborn's head was not positioned correctly. Additionally, two of the eight newborns needing ventilation were not ventilated within the first minute of life. In none of the eight cases, ventilation appeared to be performed effectively.

Conclusions

It proved feasible to use video recordings to assess quality of care during NR in a low-resource setting, and the method was considered acceptable for the delivering women and health workers. Adequate recordings of eight resuscitations all demonstrated deviations from NR guidelines.

Data availability statement

Data are available upon reasonable request.

Strengths and limitations of the study

- Prospective study design and large population size for a feasibility study.
- Technical feasible even in a low resource setting with unstable power supply and unstable access to internet.
- Limited enrolment rates due to consenting constrains with missed emergency cases which underestimates resuscitation needs.
- Further research is needed to confirm the practicality and acceptability in other cultural and organisational settings.
- Our results support that there is an urgent need for strategies to improve the quality of neonatal resuscitation in Low- and Middle-Income Countries.

Introduction

Globally, 2.5 million newborns die each year within the first 28 days of life. An additional 2.6 million are stillborn, while half of them were alive at the onset of labour.[1 2] The leading causes of death are infections, intrapartum asphyxia, and preterm birth complications.[3 4] Prioritizing neonatal health is on the global agenda, and United Nations Sustainable Development Goal (SDG) 3.2.2 is to reduce neonatal mortality to at least 12 per 1,000 live births by 2030.[5] Two-thirds of countries at risk of missing this SDG target are in Sub-Saharan Africa.[6] By 2025 it is estimated that 71% of neonatal deaths could be avoided with adequate healthcare coverage and better quality of care.[7]

What happens in the first minutes after birth can influence an entire life, especially given that 5-10% of newborns require assistance to begin breathing with tactile stimulation and 3–6% require bag and mask ventilation.[8-12] In low- and middle-income countries (LMICs), resuscitation guidelines including the American Academy of Paediatrics program - Helping Babies Breathe (HBB) are simplified, and primarily focus on the management of airways and breathing within the first and golden minute; with omission of chest compressions and more advanced resuscitation.[12] Relevant elements of care include the availability of equipment and trained staff to deliver consistent and reliable resuscitation care, which is challenging in many LMICs.[12] Neonatal mortality from intrapartum-related events can be reduced by 30% with basic neonatal resuscitation (NR), and NR training programs for health workers is of highest priority.[8-10 13] However, educational NR programs doesn't necessarily result in improvements in clinical practice in the delivery room, nor expected reductions in neonatal mortality rate[14-16]. Therefore, it is necessary to assess health worker performance during actual clinical NR, so trainings can be targeted to these specific elements and better tailored to local needs and context.

Video recording has been used to evaluate health workers' NR performance in the past and for research purposes in high-resource settings.[17-21] Studies have documented a significant number of deviations from the NR guidelines, also in high resource settings.[17-20] The advantages of video-recorded clinical performance include its low cost, minimal interference with the procedure performed, and collection of real-time, unalterable objective data to assess performance.[17] Furthermore, there is an even stronger argument for using video-recordings instead of direct observations in the delivery room, since the methodology circumvents the ethical paradox of direct observations and could minimize the Hawthorne effect.[22] Video recording as a tool to assess the

quality and performance of NR in LMICs may have great potential, but experiences with it are scarce, with a limited number of studies on the topic and only from larger tertiary or referral hospitals.[23-29]

We aimed to assess the feasibility of using video recordings as an objective tool to assess the quality of care during NR at a secondary level district hospital in a low-resource setting. To our knowledge, this is the first study that used NR video documentation performed in a district hospital in a low-resource setting with a poor and unstable power supply, unstable internet connection, and high neonatal mortality.

METHODOLOGY

Study design

The study was a prospective observational feasibility study. It was designed in preparation for the Newborn Emergency Outcome trial (NCT04093778). The study was conducted over four weeks in April and May 2019 at Chake-Chake District Hospital in Pemba, Zanzibar, Tanzania. The study was approved by the Zanzibar Health Research Institute (NO.ZAREC.02/APR/2019/20).

The feasibility study used Bowen's feasibility study framework with eight wide-ranging areas of attention.[30] The study assessed all of Bowen's eight focus areas; acceptability, demand, implementation, practicality, adaptation, integration, expansion, and limited-efficacy testing (table 1).[30]

Setting

Pemba is an island in the archipelago of Zanzibar with a population of 500,000. The stillbirth rate is estimated at 27.7 per 1,000 live births, and the neonatal mortality rate is approximately 16.0 per 1,000 live births.[31] The island has four district hospitals; this study includes data collected at Chake-Chake district hospital, with approximately 5000 annual deliveries.[32] The main delivery room has three delivery beds and one resuscitation table. In addition, the hospital has a movable table for resuscitation in the operating theatre. The resuscitation tables are also used for the post-delivery observation of healthy newborns not undergoing resuscitation. At Chake-Chake Hospital, midwives are responsible for the postnatal care of all neonates, including resuscitation. The available equipment consists of gloves, bulb suction, a self-inflating bag, and an oxygen source (not always available). A

traditional cloths called kanga brought by the mother is available for wrapping, drying and to prevent heat loss of the newborn after delivery.

Study population

All women delivering at Chake-Chake Hospital and their newborns were eligible for participation. The women in the maternity and delivery ward were enrolled in the study as soon as possible after admission. The women could be enrolled until the expulsion phase of the second stage of labour with written or oral consent using fingerprints, and consent was confirmed post-partum. All health workers at the Chake-Chake Hospital delivery ward gave consent for participation.

Data sources and management equipment

We recorded NR performance using motion-triggered Smart Cam Pro cameras installed above the radiant heater at the resuscitation tables. The cameras provided video recordings with audio, capturing whenever a newborn was placed on the resuscitation tables. The audio was only used to determine if the newborn was crying, gasping or grunting and neither conversations nor background noise were included in the analysis to avoid privacy issues. The camera had a shield around it and the image was zoomed to show only the newborn and the hands of the resuscitation team. The research assistants covered the camera if a non-consent woman gave birth, since all delivery beds shared the resuscitation table. Research assistants were present at the maternity and delivery ward 24 hours a day. The research assistants placed an individually assigned identification card on the resuscitation table just before or after the placement of the newborn. Time stamps and identification numbers were matched with the hospital register for the recorded delivery. The identification number followed the woman and her newborn until discharge. The videos were stored on an encrypted micro-SD card in the camera, and the data were uploaded to a secure database. Only the international research team could access the videos to ensure the individual health workers' anonymity.

Postnatal questionnaire with socio-demographics, obstetric history, pregnancy information, delivery outcome, neonatal characteristics, and acceptability of video recordings were collected by research assistants on paper and entered directly into the secure data collection software RedCap (v5.12.1) on Lenovo version 7 tablets.

Outcomes and variables

We evaluated feasibility using Bowen's framework for feasibility studies[30]. All post-partum women and health workers in the maternity ward answered an acceptability question on a Likert scale. For health workers, the acceptability question was, *"How comfortable did you feel about the neonatal resuscitation being filmed?"* For post-partum women, the acceptability question was, "*How comfortable did you feel about your baby being video filmed?".* Additionally, we conducted 18 semi-structured interviews, nine with post-partum women (one to three days after delivery) and nine with health workers in the maternity ward. The qualitative analysis is beyond the scope of this paper and will be reported in another study.

We logged and described the video recordings' practicality and technicality. A analytical framework for limited efficacy testing of quality of care indicators was developed where resuscitation procedures were scored according to guidelines.[33] The clinical appearance of the newborn was logged as no respiration = 0, gasping = 1, or breathing = 2. The clinical actions performed by the health workers were registered in a thematic template that assesses performance on; heat loss prevention, positioning of the newborn's head, clearing the airway via suction, stimulation, bag and mask ventilation, heart rate assessment, and oxygen management (table 6). Each intervention performance was assessed at three levels: properly performed procedures, inadequate procedures (delayed intervention or inadequate technique for a given procedure), and procedures omitted or performed but not indicated according to NR guidelines.

Data analysis

The video recordings were analysed by two independent researchers (CS and SL). If any doubts arose, the researchers consulted with another member of the study team. A timeline of interventions while the newborn was placed on the resuscitation table and the subsequent events were produced (Figure 1). We transferred data from the video observations from Excel (version 2011, Microsoft Corporation, Washington, United States) and quantitative variables from Redcap to SPSS (version 27.0, IBM, New York, United States) for descriptive statistics. We categorized continuous variables according to common medical standards and newborn risk factors. We expressed the data as number and percentage or median and interquartile range (IQR). The translated semi-structured qualitative interviews were imported to NVivo (version 13) and analysed thematically. The full thematic qualitative analysis of the semi-structured interviews is beyond the scope of this paper and will be reported in a separate paper.

Patient and public involvement

Patients and the public were not involved in developing research questions, designing, conducting, or disseminating the study. During this research patients and staff were interviewed with semi-structured questionnaires as informants to adjust the main study with patient involvement.

Role of funding source

The funders of this study had no role in the study design, data collection, data analysis, data interpretation, or writing of the manuscript. The corresponding author had full access to all the data in the study and was responsible for submitting the manuscript for publication.

Results

Participating women and health workers

During the study period, 274 women were eligible for participation, of which 239 had spontaneous vaginal deliveries and 35 caesarean sections (figure 1). One hundred and thirty-nine women gave consent. Of the 139 enrolled women that gave birth to 139 newborns, 101 (73%) were taken to the resuscitation table and captured by the video camera. Forty-four (44%) of the newborns brought to the resuscitation table were not crying when placed there, and eight underwent resuscitation with bag and mask ventilation. Up to three newborns at a time were placed on the same resuscitation table. Twenty-six health workers were working in the delivery ward and participated in the deliveries during the study period. Demographics of the participating women (table 2) and health workers (table 3) and delivery and birth outcomes of the newborn in (table 4).

We report feasibility according to Bowen et. al. feasibility framework using all eight areas of focus 1) Acceptability, 2) Demand, 3) Implementation, 4) Practicality, 5) Adaptation, 6) Integration, 7) Expansion, 8) Limited-efficacy testing (table 1).[30]

Acceptability of video recordings

Acceptability among the delivering women of the NR video recordings was high, with 89·7% being either very comfortable or comfortable and only one woman felt uncomfortable 0·7%, and 12 women did not answer the question. Twenty-five of the 26 participating health workers (96·0%) responded to the question and 92.3% was either very comfortable or comfortable, only one health worker felt uncomfortable (table 5).

Practicality and technicality

We registered the practical and technical feasibility of capturing NR with motion-triggered cameras during the study period, and although the solution was technically feasible, we made several adjustments (table 1). There were some concerns regarding the camera's angle, and a shield was created around it to make it obvious to everyone that the camera was only capturing the newborn and health worker's hands. We installed a camera on a stand at the portable resuscitation table to capture the table, but this solution was suboptimal and adjusted with a more stable version. The camera ran solely on power banks, since we could not rely on the hospital's power supply. The camera had a secure encrypted SD memory card, and the video material captured was uploaded to a secure database over a Wi-Fi connection. The hospital did not have a stable Wi-Fi connection, so we installed a password-protected 4G Wi-Fi connection that ran on power banks near the resuscitation table.

Limited-efficacy testing

To study limited-efficacy (table 1), the videos were analysed to see if they added value by providing new evidence of gaps in clinical performance (table 6). Of the 139 included newborns, eight were resuscitated with bag and mask ventilation and captured on video. According to the questionnaire, further two newborns were resuscitated, but not captured on video, possibly because the resuscitation took place away from the resuscitation table or an episode occurred when the camera was shielded due to a non-consent woman giving birth simultaneously. Two other newborns were stillborn: the corresponding video showed a baby with a very low birth weight, whereas the other child was not captured on video.

The health workers report was that all newborns had been resuscitated with adequate stimulation, suction, ventilation, and heat loss prevention. The eight videos, however, showed that heat loss prevention measures were not performed in half of the resuscitations. In two cases, the head positioned incorrectly and not in a neutral position. Clearing the airway via suction was not performed correctly in six cases. As none of the cases were born in thick meconium, suction was not recommended according to NR guidelines[33]. Nevertheless, all eight were suctioned vigorously and repeatedly. None of them were stimulated correctly, either. One infant, in need of ventilation, was not ventilated at all, and the remaining were ventilated ineffectively with undue delay, wrong

technique, or in short and interrupted sequences rather than as a sustained effort. In two cases, ventilation efforts were halted before regular breathing. The timeline of events of each resuscitation video showed that while six in need of resuscitation were ventilated within one minute of placement on the resuscitation table, two were not (figure 2). The average time on the resuscitation table before ventilation was 41 s (0–96). Only, one-third of the newborns in need of resuscitation were stimulated within their first minute on the resuscitation table. The average time spent on suction was 35 s (00:00–01:22). All resuscitations deviated from NR guidelines. However, all newborns who underwent resuscitation in the videos survived until discharge.

Discussion

In this study, using video recordings to assess the quality of care during NR in a low-resource setting proved feasible and provided valuable objective measures of performance in the timing of events and adherence to NR guidelines. The application was highly acceptable among the facility's delivering women and health workers, with more than 90% comfortable or very comfortable. We also found video recording practically and technically achievable, albeit operationally challenging. We found a demand from health workers to focus on NR and a need to improve NR based, and our limited efficacy testing on performance gaps supports this. We conclude that the study can be expanded to include all district hospitals in Pemba as planned in the NEO-study. The efficacy testing of video recordings suggested that it may provide added value. In Chake-Chake District Hospital, performance in NR was sub-optimal, as was adherence to NR guidelines.

The need for clinical management assessments during actual NR and related training programs for all healthcare workers involved in the management of newborns is undeniable. Nearly all neonatal deaths attributed to intrapartum-related events occur in LMICs and may constitute of up to 60% of neonatal deaths in primary facilities and secondary level hospitals[34]. Among the survivors of intrapartum-related events, 1 million may develop cerebral palsy or other disabilities each year.[35] NR is an emergency associated with high stress among health workers, resulting in frequent medical errors and lack of adherence to guidelines. The noted deviations from guidelines are in line with studies that also used a video review process to analyse NR in high-income countries[17]. Schilleman et al. found in a study from 2012 that only 21% of recorded resuscitations were performed entirely according to local guidelines, and McCarthy et al. reported in a study from 2013 that the recommended NR timeline is rarely followed in real-life resuscitations[17 19]. Yamada et al. (2015)

similarly classified and quantified the types of errors observed in 250 NR recordings in their institution[36]. They identified a 23% error rate for all tasks determined to be important elements of the NR algorithm. Errors similar to our study included omission of tasks that according to guidelines were indicated or tasks that were performed although not indicated, with incorrect timing or technique. Deviations from guidelines were more common and could consist of tasks that were performed but not indicated, tasks performed at the incorrect time, or tasks performed but following an improper technique.

To our knowledge, the study is the first to use video recordings of NR in a secondary district level hospital in a low-income country. Video has been used as a component of development and assessment of training interventions for health worker performance and was found feasible in tertiary hospitals in Nepal and Mozambique[23 24]. In a study from 2017 from Nepal, Wrammert et al. compared the resuscitation practices of low and normal birthweight infants using video camera recordings, noting crying, stimulation, ventilation, suctioning, and oxygen administration during resuscitation[24]. In as study from 2015 from Mozambique, Trevisanuto et al. similarly used video recordings of 100 resuscitations to assess the effect of an adapted NR program course on healthcare providers' performance, finding a significant improvement in resuscitation scores in all levels of resuscitation from before and after the course[23]. In a study from 2020 from Uganda, Pejovic et al. used video recordings to assess the effect of a specific intervention ventilation with face masks versus laryngeal masks. It concluded that laryngeal mask reduced time to spontaneous breathing compared with face mask during newborn resuscitation in a low-resource setting.[28]

There is not a standardized method or approach analysing NR performance videos. Carabine et al. developed a scoring system used in a high-income setting in a study from 2000, which Trevisanuto et al. adapted to a low-resource setting in 2015[17 23]. We were inspired by these systems but had to further adjust them due to our study occurring in a secondary level facility in a low-resource setting.

The limited efficacy testing in our study was positive. We found the video recordings usable for objective assessments of health worker performance, detail, and timeliness during actual NR resuscitations. In our study, NR performance was sub-optimal, particularly for essential NR interventions such as stimulation, suction, and bag and mask ventilation. Similarly, Lindbäcket et al. identified guideline deviations in over 50% of resuscitations in a tertiary hospital in Nepal in a study

from 2015.[29] We found that bag and mask ventilation in particular was inadequately performed, and suction was excessive and used vigorously even when not medically indicated. These findings are in line with other studies that followed a video review process to analyse NR performance in LMICs[17 20]. Lindbäcket et al. also noted excessive use of oxygen, which we did not, likely because our setting was a secondary level facility with limited access to oxygen therapy due to an insufficient supply chain, and only one oxygen dispenser available for the whole hospital[29]. A further important finding of the present study concerns the timeline of resuscitation, where initiation and the duration of all procedures were inconsistent with the times recommended by guidelines.

Twenty-five percent of newborns in need of resuscitation did not have bag and mask ventilation initiated within the first minute of life. In a study from Mozambique Pietravalle et al. examined tactile stimulation in a study from 2018 and, similar to our findings, found that multiple stimulation techniques were administered in two-thirds of neonates (64.7%), while recommended techniques (rubbing the back or flicking the soles of the feet) occurred in less than 10% (8.8%). The median stimulation duration was 17 s (IQR 9–33)[25], which is much shorter than our study, where the median time was 75 s (IQR 90). Gaertner et al. evaluated video recordings of 75 stimulated infants, including early preterm infants in a study from 2018, and suggested that truncal stimulation (drying, chest rubs, and back rubs) might be more effective than foot flicks[21].

The limited combined experiences indicate that videos of clinical performance during actual NR in LMICs provide valuable objective information to improve quality of care and patient safety and survival. Improving this requires focus. Identifying errors during real-life situations can drive the type of training and guideline adjustments needed, such as an enhanced focus on avoiding excessive and unnecessary suction practices, stimulation techniques, timely and sustained positive pressure, and bag and mask ventilation techniques[23 37-39]. Despite an unstable power connection, the video recordings were technically possible through backup power sources in our setting. Our intervention was low-cost and relatively easy to install. Like other studies, we used cameras that activated automatically, which did not interfere with the resuscitation process and thus took focus from the neonate. Others in more resourceful settings have used multiple cameras for different angles that include the neonate, healthcare professionals delivering care, and equipment being used[40]. Due to ethical, privacy and logistical reasons, this was not feasible in our setting.

There is a need for research in the improvement of the quality of NR in low-resource facilities with local adaptation of clinical guidelines based on the actual clinical reality of health workers, adapted training programs, and scarce resources considered. Challenges in many LMIC are diverse and our study reiterates the need for locally adapted guidelines with the clinical reality in mind as discussed by Maaloe et. Al in a viewpoint from 2021[41]

Few qualitative studies explore health providers' attitudes towards the video recording of NR[17 42 43]. We found that healthcare workers in general adapted quickly to the presence of the camera and their acceptability was high, as was that for delivering women[17]. An extensive qualitative study from 2018 from the Netherlands and United States with 49 semi-structured interviews concluded that recording and reviewing NR is highly beneficial for learning and improving resuscitation skills and is considered acceptable by clinical staff[43]. Parents and health workers have generally accepted that recordings may be created for better patient safety, quality improvement, and education both in studies from Nepal, the Netherlands, and the United States[43 44]. Video recordings during emergencies can create controversy, and therefore privacy concerns, medicolegal consequences, storage, and consent must be discussed before implementation[45]. Some programs in high-income countries include a statement in the general admission consent stating that photography and video recording for patient safety, quality improvement, and professional training purposes may occur in the hospital. However, general consent forms at admission are not a widespread practice in LMIC facilities. Consent in emergency research and consent during labour and childbirth is challenging with many ethical aspects and some true dilemmas. Ideally the woman should be informed in a quiet manner in an antenatal visit, but this method was not possible in our setting, and will disturb many pregnant women unnessarily, and will miss those who do not come for antenatal visits. The consent process was discussed back and forth between the research team and the local ethical committee, and we agreed on consent until the expulsion phase, with an emphasis on confirmation of consent post-partum, while a waiver of consent was not deemed acceptable in the local context.

Strengths and limitations

The study's main strengths are the prospective study design and the large population size for a feasibility study. Our study had some limitations. The observers assessing the same video images may have differences in their assessment of the clinical situation involving NR, this was not the case our study, since the videos were scored in collaboration, but this might not be possible in larger studies

with a greater volume of videos. Other studies have investigated inter-rater reliability and displayed a high (above 90%) reliability for the use of bag and mask ventilation and suctioning, but lower reliability for oxygen administration and stimulation[44]. The most sensitive indicator of resuscitation being successful is an increase in the newborn's heart rate. We did not assess heart rate or oxygenation in our resuscitation study since the equipment is not available in the local context, which could have been valuable when assessing the health workers' resuscitation efforts and outcomes. Due to local ethical committee regulations, our study asked the delivering women for their prospective consent. More than 36% of the women were not approached for consent due to being in too much pain, late presentation at the hospital or an obstetric emergency. Indeed, these newborns have an increased risk of the need for resuscitation, intrapartum stillbirth, and asphyxiation, and hence high-level emergencies may not be included in our feasibility study due to the prospective enrolment process[46]. This is a bias, and the finding in this feasibility study may not necessarily mimic newborns' actual situation and challenges, and the results may underestimate the need for NR. An alternative approach used in other studies is a waiver of consent, where consent is obtained before delivery when possible; otherwise, researchers seek retrospective consent[47].

Conclusion

Video recording of neonatal resuscitation at a district hospital in a resource constraint setting was feasible and provided vital information on the quality and timeliness of provided care.

The unstable power supply and lack of reliable internet connection created practical and technical challenges but were manageable. The efficacy testing was positive in assessments of health worker performance and adherence to NR guidelines. All recorded resuscitations demonstrated deviations from NR guidelines, and although all eight infants were manually ventilated as required and all infants survived to discharge, the ventilation was started too late, stopped too early, or delivered ineffectively. More research is still needed in the use of video recordings to assess and improve the quality of NR.

Data availability statement

Data are available upon reasonable request.

Ethic statement

Patient consent for publication.

Not applicable.

Ethics approval

The study was approved by the Zanzibar Health Research Institute (NO.ZAREC.02/APR/2019/20). Each participant received information about the purpose of the study and informed consent was obtained from all subjects.

Author Contributions

SL, AP, CCHH and GG conceived the idea for the study. CCHH, TBS, ML, MK, SM, SMA collected the data. CCHH and SL wrote the first draft of the manuscript. The data has been verified by CCHH, TM and SL, statistical analysis was performed by CCHH, CS and SL. CS and SL developed the framework and analyzed the resuscitation videos. CCHH, SA and SMA were the principal investigators of the study. All authors read and approved the version final manuscript

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Conflicts of interest

None.

REFERENCES

1. Wang H, Bhutta ZA, Coates MM, et al. Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet* 2016;388(10053):1725-74. doi: 10.1016/s0140-6736(16)31575-6
2. Lawn JE, Blencowe H, Waiswa P, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. *The Lancet* 2016;387(10018):587-603. doi: 10.1016/s0140-6736(15)00837-5

3. Lawn JE, Blencowe H, Oza S, et al. Every Newborn: progress, priorities, and potential beyond survival. *The Lancet* 2014;384(9938):189-205. doi: 10.1016/s0140-6736(14)60496-7
4. Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: When? Where? Why? *The Lancet* 2005;365(9462):891-900. doi: 10.1016/s0140-6736(05)71048-5
5. Economic UNDo, Affairs S. The Sustainable Development Goals Report 2016: United Nations 2016.
6. Hug L, Alexander M, You D, et al. National, regional, and global levels and trends in neonatal mortality between 1990 and 2017, with scenario-based projections to 2030: a systematic analysis. *The Lancet Global Health* 2019;7(6):e710-e20. doi: 10.1016/s2214-109x(19)30163-9
7. Bhutta ZA, Das JK, Bahl R, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? *The Lancet* 2014;384(9940):347-70. doi: 10.1016/s0140-6736(14)60792-3
8. Wall SN, Lee AC, Niermeyer S, et al. Neonatal resuscitation in low-resource settings: what, who, and how to overcome challenges to scale up? *Int J Gynaecol Obstet* 2009;107 Suppl 1(Suppl 1):S47-62, s63-4. doi: 10.1016/j.ijgo.2009.07.013 [published Online First: 2009/10/10]
9. Ades A, Lee HC. Update on simulation for the Neonatal Resuscitation Program. *Semin Perinatol* 2016;40(7):447-54. doi: 10.1053/j.semperi.2016.08.005 [published Online First: 2016/11/09]
10. Sawyer T, Lee HC, Aziz K. Anticipation and preparation for every delivery room resuscitation. *Semin Fetal Neonatal Med* 2018;23(5):312-20. doi: 10.1016/j.siny.2018.06.004 [published Online First: 2018/10/30]
11. Palme-Kilander C. Methods of resuscitatoin in low-Apgar-score newborn infants - a national survey. *Acta Paediatric* 1992;81(10):739-44.
12. Niermeyer S, Little GA, Singhal N, et al. A Short History of Helping Babies Breathe: Why and How, Then and Now. *Pediatrics* 2020;146(Suppl 2):S101-S11. doi: 10.1542/peds.2020-016915C [published Online First: 2020/10/03]
13. Lee AC, Cousens S, Wall SN, et al. Neonatal resuscitation and immediate newborn assessment and stimulation for the prevention of neonatal deaths: a systematic review, meta-analysis and Delphi estimation of mortality effect. *BMC Public Health* 2011;11 Suppl 3(Suppl 3):S12. doi: 10.1186/1471-2458-11-s3-s12 [published Online First: 2011/04/29]
14. Carlo WA, Wright LL, Chomba E, et al. Educational impact of the neonatal resuscitation program in low-risk delivery centers in a developing country. *J Pediatr* 2009;154(4):504-08.e5. doi: 10.1016/j.jpeds.2008.10.005 [published Online First: 2008/12/09]
15. Singhal N, McMillan DD, Savich R, et al. Development and Impact of Helping Babies Breathe Educational Methodology. *Pediatrics* 2020;146(Suppl 2):S123-s33. doi: 10.1542/peds.2020-016915E [published Online First: 2020/10/03]
16. Morris SM, Fratt EM, Rodrigues J, et al. Implementation of the Helping Babies Breathe Training Program: A Systematic Review. *Pediatrics* 2020;146
17. Carbine DN, Finer NN, Knodel E, et al. Video Recordings as a Means of Evaluating Neonatal Resuscitation Performance. *Pediatrics* 2000;106(4)
18. Shivananda S, Twiss J, El-Gouhary E, et al. Video recording of neonatal resuscitation: A feasibility study to inform widespread adoption. *World J Clin Pediatr* 2017;6(1):69-80. doi: 10.5409/wjcp.v6.i1.69 [published Online First: 2017/02/23]

19. Schilleman K, Siew ML, Lopriore E, et al. Auditing resuscitation of preterm infants at birth by recording video and physiological parameters. *Resuscitation* 2012;83(9):1135-9. doi: 10.1016/j.resuscitation.2012.01.036 [published Online First: 2012/02/11]
20. Maya-Enero S, Botet-Mussons F, Figueras-Aloy J, et al. Adherence to the neonatal resuscitation algorithm for preterm infants in a tertiary hospital in Spain. *BMC Pediatr* 2018;18(1):319. doi: 10.1186/s12887-018-1288-3 [published Online First: 2018/10/12]
21. Gaertner VD, Flemmer SA, Lorenz L, et al. Physical stimulation of newborn infants in the delivery room. *Arch Dis Child Fetal Neonatal Ed* 2018;103(2):F132-F36. doi: 10.1136/archdischild-2016-312311 [published Online First: 2017/06/11]
22. Sedgwick P, Greenwood N. Understanding the Hawthorne effect. *BMJ* 2015;351:h4672. doi: 10.1136/bmj.h4672 [published Online First: 2015/09/06]
23. Trevisanuto D, Bertuola F, Lanzoni P, et al. Effect of a Neonatal Resuscitation Course on Healthcare Providers' Performances Assessed by Video Recording in a Low-Resource Setting. *PLoS One* 2015;10(12):e0144443. doi: 10.1371/journal.pone.0144443 [published Online First: 2015/12/15]
24. Wrammert J, Zetterlund C, Kc A, et al. Resuscitation practices of low and normal birth weight infants in Nepal: an observational study using video camera recordings. *Glob Health Action* 2017;10(1):1322372. doi: 10.1080/16549716.2017.1322372 [published Online First: 2017/06/03]
25. Pietravalle A, Cavallin F, Opocher A, et al. Neonatal tactile stimulation at birth in a low-resource setting. *BMC Pediatr* 2018;18(1):306. doi: 10.1186/s12887-018-1279-4 [published Online First: 2018/09/22]
26. Cavicchiolo ME, Cavallin F, Bertuola F, et al. Effect of a Low-Dose/High-Frequency Training on Real-Life Neonatal Resuscitation in a Low-Resource Setting. *Neonatology* 2018;114(4):294-302. doi: 10.1159/000490370 [published Online First: 2018/07/17]
27. Kc A, Wrammert J, Clark RB, et al. Reducing Perinatal Mortality in Nepal Using Helping Babies Breathe. *Pediatrics* 2016;137(6) doi: 10.1542/peds.2015-0117 [published Online First: 2016/05/27]
28. Pejovic NJ, Myrnerts Hook S, Byamugisha J, et al. A Randomized Trial of Laryngeal Mask Airway in Neonatal Resuscitation. *N Engl J Med* 2020;383(22):2138-47. doi: 10.1056/NEJMoa2005333 [published Online First: 2020/12/01]
29. Lindback C, Kc A, Wrammert J, et al. Poor adherence to neonatal resuscitation guidelines exposed; an observational study using camera surveillance at a tertiary hospital in Nepal. *BMC Pediatr* 2014;14:233. doi: 10.1186/1471-2431-14-233 [published Online First: 2014/09/18]
30. Bowen DJ, Kreuter M, Spring B, et al. How we design feasibility studies. *Am J Prev Med* 2009;36(5):452-7. doi: 10.1016/j.amepre.2009.02.002 [published Online First: 2009/04/14]
31. group AfMaNHIAms. Population-based rates, timing, and causes of maternal deaths, stillbirths, and neonatal deaths in south Asia and sub-Saharan Africa: a multi-country prospective cohort study. *Lancet Glob Health* 2018;6(12):e1297-e308. doi: 10.1016/s2214-109x(18)30385-1 [published Online First: 2018/10/27]
32. Health ZMo. The Zanzibar Annual Health Bulletin 2017, 2017.
33. Organization WH. WHO Recommendations on Newborn Health, Guidelines Approved by the WHO Guideliens Review Committee. . 2017

34. Ersdal HL, Mduma E, Svensen E, et al. Birth asphyxia: a major cause of early neonatal mortality in a Tanzanian rural hospital. *Pediatrics* 2012;129(5):e1238-43. doi: 10.1542/peds.2011-3134 [published Online First: 2012/04/18]
35. Liu L, Johnson HL, Cousens S, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet* 2012;379(9832):2151-61. doi: 10.1016/s0140-6736(12)60560-1 [published Online First: 2012/05/15]
36. Yamada NK, Yaeger KA, Halamek LP. Analysis and classification of errors made by teams during neonatal resuscitation. *Resuscitation* 2015;96:109-13. doi: 10.1016/j.resuscitation.2015.07.048 [published Online First: 2015/08/19]
37. Maya-Enero S, Botet-Mussons F, Figueras-Aloy J, et al. Adherence to the neonatal resuscitation algorithm for preterm infants in a tertiary hospital in Spain. *BMC Pediatr* 2018;18(1):319. doi: 10.1186/s12887-018-1288-3 [published Online First: 2018/10/12]
38. Skåre C, Boldingh AM, Kramer-Johansen J, et al. Video performance-debriefings and ventilation-refreshers improve quality of neonatal resuscitation. *Resuscitation* 2018;132:140-46. doi: 10.1016/j.resuscitation.2018.07.013 [published Online First: 2018/07/17]
39. Odongkara B, Tylleskär T, Pejovic N, et al. Adding video-debriefing to Helping-Babies-Breathe training enhanced retention of neonatal resuscitation knowledge and skills among health workers in Uganda: a cluster randomized trial. *Glob Health Action* 2020;13(1):1743496. doi: 10.1080/16549716.2020.1743496 [published Online First: 2020/06/12]
40. Gelbart B, Hiscock R, Barfield C. Assessment of neonatal resuscitation performance using video recording in a perinatal centre. *J Paediatr Child Health* 2010;46(7-8):378-83. doi: 10.1111/j.1440-1754.2010.01747.x [published Online First: 2010/06/16]
41. Maaløe N, Ørtved AMR, Sørensen JB, et al. The injustice of unfit clinical practice guidelines in low-resource realities. *The Lancet Global Health* 2021;9(6):e875-e79. doi: 10.1016/s2214-109x(21)00059-0
42. Carbine DN, Finer NN, Knodel E, et al. Video recording as a means of evaluating neonatal resuscitation performance. *Pediatrics* 2000;106(4):654-8. doi: 10.1542/peds.106.4.654 [published Online First: 2000/10/04]
43. den Boer MC, Houtlosser M, Foglia EE, et al. Benefits of recording and reviewing neonatal resuscitation: the providers' perspective. *Arch Dis Child Fetal Neonatal Ed* 2019;104(5):F528-f34. doi: 10.1136/archdischild-2018-315648 [published Online First: 2018/12/07]
44. Lindbäck C, Kc A, Wrammert J, et al. Poor adherence to neonatal resuscitation guidelines exposed; an observational study using camera surveillance at a tertiary hospital in Nepal. *BMC Pediatr* 2014;14:233. doi: 10.1186/1471-2431-14-233 [published Online First: 2014/09/18]
45. den Boer MC, Houtlosser M, van Zanten HA, et al. Ethical dilemmas of recording and reviewing neonatal resuscitation. *Arch Dis Child Fetal Neonatal Ed* 2018;103(3):F280-f84. doi: 10.1136/archdischild-2017-314191 [published Online First: 2018/01/22]
46. Lawn JE, Blencowe H, Waiswa P, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. *Lancet* 2016;387(10018):587-603. doi: 10.1016/s0140-6736(15)00837-5 [published Online First: 2016/01/23]
47. Health ZMo. The Zanzibar Annual Health Bulletin 2016, 2016.

Figure 1 Flowchart of the study population.

Figure 2 Timeline of interventions in the eight infants who were manually ventilated during resuscitation

Table 1
Bowen acceptability framework adapted

Area of focus	Definitions according to Bowen[30]	**Outcomes of interest from results from the current NEO feasibility study**
1. Acceptability	- To what extent will participants accept the new idea?	- Acceptability of video recordings with a Likert acceptability scale question for all women and health workers - Acceptability interview with mothers and health workers
2. Demand	- Is there a demand? - Is it Fit within the? organizational culture	- Perceived demand for focus on neonatal resuscitation by health workers - Appropriate within the organizational culture - Desperate need for improvement of neonatal resuscitation practice - Exploratory and participatory meetings and workshops with staff before the design of the study - Exploratory meetings with stakeholders, policymakers, and officials from the Ministry of Health -
3. Implementation	- Can the new idea be successfully implemented?	- Recordings of NR can be implemented - There is an ability of the study team to carry out and implement the study at the health facility
4. Practicality	- Implementation with existing means, resources, and circumstances?	- Awareness of technical challenges - The extent where the video recordings are possible in the context - Efficiency, speed, and quality of implementation setting with an unstable power source and unstable internet

5. Adaptation	- To what extent can a new idea perform when changes are made for a new format? - Degree to which similar outcomes are obtained in a new format?	- The extent where video recordings are possible when a non-consent woman is in the delivery room - The extent to video recordings can be implemented without effect on clinical work
6. Integration	- To what extent can it be integrated into the existing system?	- Fit within existing infrastructure. - Video recordings work in a local context with no influence on workflow
7. Expansion	- To what extent can the method be expanded?	- Positive effects on the health system explored - Possible expansion with all practical factors considered - The extent to which video recordings of NR can be scaled up or in more facilities
8. Limited-efficacy testing	- Does the new idea show promise of being successful in the intended populations? - Intended effects on key intermediate variables	- The added value of video recordings to assess the quality of NR. - Small-scale analysis of NR videos and development of a thematic template scoring system

Table 2 Characteristics of the participating women		
Demographics		n = 139 (%)
Age distribution		
	< 20 years	13 (9.4)
	20–29 years	83 (59.7)
	30–39 years	34 (24.5)
	> 40 years	0 (0.0)
	Unknown	9 (6.5)
Civil status		
	Married	138 (99.3)
	Single	0 (0.0)
	Unknown	1 (0.7)
Education		
	None	1 (0.7)
	Primary	19 (13.7)
	Secondary	106 (76.3)
	> Secondary	12 (8.6)
	Unknown	1 (0.7)
Parity		
	Primiparous	34 (24.5)
	Multiparous (2–4)	67 (48.2)
	Grand multiparous (> 5)	37 (26.6)
	Unknown	1 (0.7)
Antenatal care visits		
	Did not attend	0

	1–3	48 (34.5)
	> 4	86 (61.9)
	Unknown	5 (3.6)
Previous Caesarean Section		
	Yes	9 (6.5)
	No	122 (87.8)
	Unknown	7 (5.0)

Table 3 Participating health workers

		n = 26 (%)
Gender		
	Female	23 (88.5)
	Male	3 (11.5)
Age		
	< 30 years	11 (42.3)
	30–50 years	13 (50.0)
	> 50 years	2 (7.7)
Education		
	General nurse	8 (30.8)
	Nurse midwife	8 (30.8)
	Medical doctor	3 (11.5)
	Clinical officer	3 (11.5)
	Assistant nurse	4 (15.4)
Years since graduation		
	< 5	19 (73.1)

	5–10	**3 (11.5)**
	> 10	**4 (15.4)**
Number of deliveries one month prior to the study		
	< 5	**3 (11.5)**
	6–20	**8 (30.8)**
	> 20	**15 (57.7)**
Post-graduate Neonatal Resuscitation course		
	Yes	**15 (57.7)**
	No	**11 (42.3)**

Table 4 Delivery and neonate characteristics at birth

		Not resuscitated n = 131 (%)	Resuscitated n=8 (%)
Mode of delivery			
	Spontaneous vaginal delivery	121 (92.4)	**7 (87.5)**
	Assisted vaginal delivery	1 (0.7)	**0 (0)**
	Caesarean section	9 (6.9)	**1 (12.5)**
Presentation			
	Cephalic	123 (93.9)	**5 (62.5)**
	Breech	4 (3.1)	**3 (37.5)**
	Other	1 (0.8)	**0 (0)**
	Unknown	3 (2.3)	**0 (0)**
Born in thick meconium			

	Yes	5 (3.8)	**0 (0)**
	No	108 (82.4)	**8 (100)**
	Unknown	18 (13.7)	**0 (0)**
Foetal heart rate at the admission of the delivering woman			
	Yes	127 (96.9)	**8 (100)**
	No	4 (3.1)	**0 (0)**
Neonate status at birth			
	Alive at birth	127 (96.9)	**8 (100)**
	Stillbirth fresh	2 (1.5)	**0 (0)**
	Stillbirth macerated	2 (1.5)	**0 (0)**
Gender			
	Male	62 (47.3)	**3 (37.5)**
	Female	69 (52.7)	**5 (62.5)**
Birthweight, grams			
	< 1500	1 (0.8)	**0 (0)**
	1500–2500	17 (13.0)	**3 (37.5)**
	2501–4000	108 (82.4)	**5 (62.5)**
	> 4000	4 (3.1)	**0 (0)**
	Data missing	1 (0.8)	**0 (0)**

Table 5 Acceptability of video recordings during neonatal resuscitation		
Women		n = 139 (%)
	Very comfortable	26 (18.7)
	Comfortable	100 (71.9)
	Neither comfortable nor uncomfortable	0 (0.0)
	Uncomfortable	1 (0.7)
	Very uncomfortable	0 (0.0)
	Data missing	12 (8.6)
Health workers		**n = 26 (%)**
	Very comfortable	10 (38.5)
	Comfortable	14 (53.8)
	Neither comfortable nor uncomfortable	0 (0.0)
	Uncomfortable	1 (3.8)
	Very uncomfortable	0 (0.0)
	Missing	1 (3.8)

Table 6 Quality of resuscitation assessed by video recordings in 0–15 min of life		
	n = 8 (%)	Median (IQR)
Heat loss prevention		
Not performed	4 (50)	
Inadequately performed *(Newborn dried with cloth but cloth not replaced by a new one; head not covered)*	2 (25)	
Well performed *(Newborn dried and cloth replaced; wrapped and head covered)*	2 (25)	
Time to first intervention		2 s (14 s)
Number of interventions/newborn		3 (2)
Total time spent on heat loss prevention		31 s (27 s)
Positioning of head		
Not performed	0 (0)	
Inadequately performed *(Head hyperextended or bent to the side)*	2 (25)	
Well performed *(Head in a sniffing position)*	6 (75)	
Time to first intervention		42 s (38 s)
Number of interventions/newborn		5 (4)
Total time spent on positioning of the head		12 s (11 s)
Clearing the airway via suction		
Not performed when indicated (meconium)	0 (0)	
Inadequately performed *(Done after the first minute of life; longer than 5 s; incorrect order (nasal suction before oral); excessive number of times)*	5 (63)	
Well performed (*or not performed when not indicated)*	3 (27)	
Time to first intervention		16 s (15 s)
Number of interventions/newborn		2 (2)
Total time spent on suction		41 s (36 s)

Stimulation		
Not performed *(Indicated when inactive, apnoeic/not spontaneously breathing or gasping)*	1 (22)	
Inadequately performed *(Stimulation performed on other places than the back or soles of the feet; too aggressively; excessive number of times)*	7 (88)	
Well performed	0 (0)	
Time to first intervention		41 s (26 s)
Number of interventions/newborn		7 (10)
Total time spent on stimulation		75 s (90 s)
Bag and mask ventilation		
Not performed	1 (22)	
Inadequately performed *(Initiation after the first minute of life; incorrect mask size; incorrect rate (not 40–60 rpm); incorrect technique (mask turned wrong way); mask leak; not re-evaluated for response after 30 s; undue delay; short interrupted sequences)*	7 (88)	
Well performed	0 (0)	
Time to first intervention		39 s (38 s)
Number of interventions/newborn		8 (11)
Total time spent on bag and mask ventilation		130 s (181 s)
Heart rate assessment		
Not performed	7 (88)	
Inadequately performed *(Performed by feeling the umbilicus)*	1 (22)	
Well performed *(Performed with stethoscope)*	0 (0)	
Time to first intervention		148 s (200 s)
Number of interventions/newborn		1 (0)
Total time spent on heart rate assessment		5 s (7 s)

The number of interventions refers to the number of (separate) episodes of that intervention. s=seconds

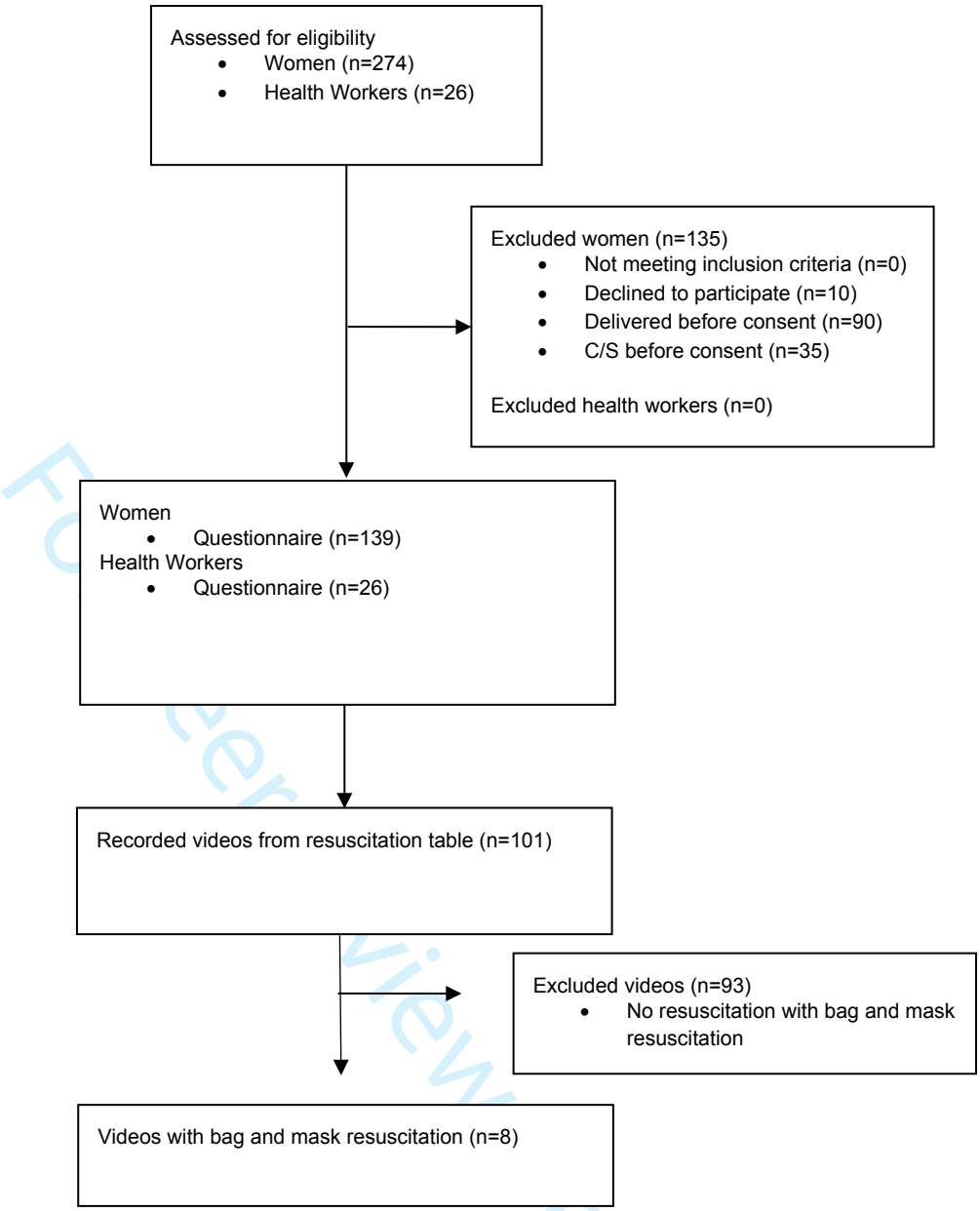
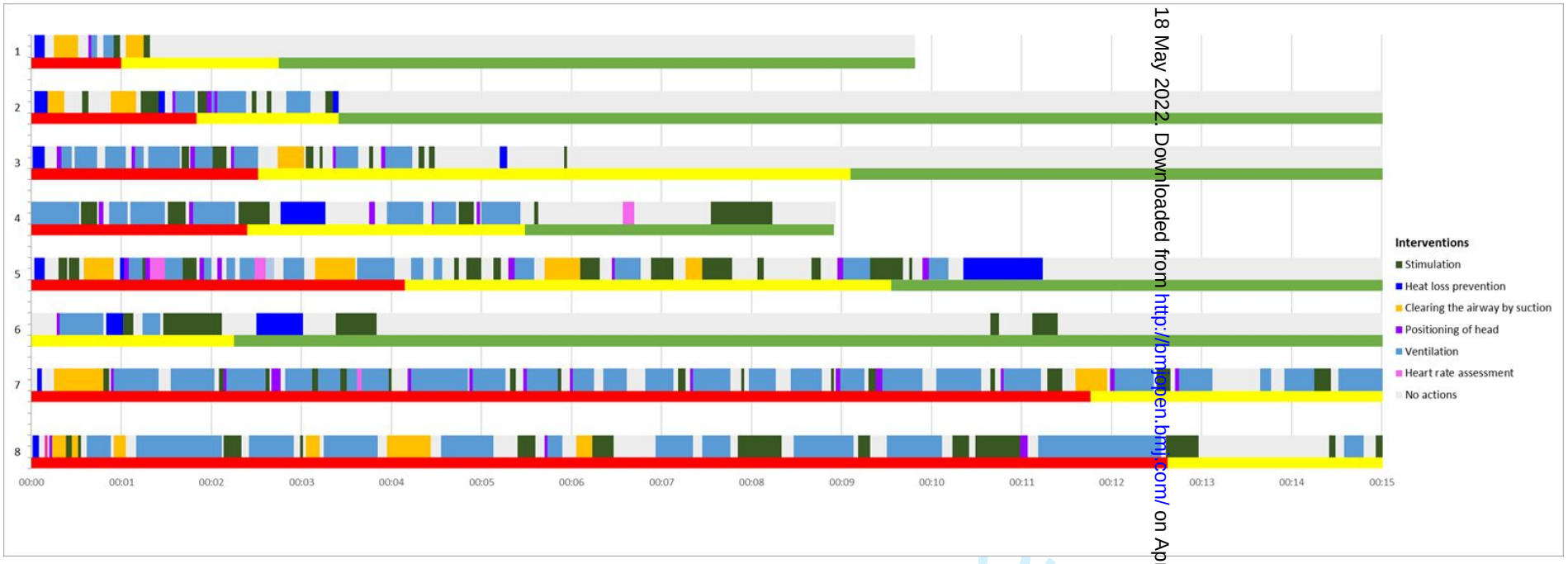


Figure 1 Flowchart of the study population.

Figure 2 Timeline of interventions in the eight infants who were manually ventilated during resuscitation



STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	5
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5 & 6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*6*
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7&8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	Figure 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8 &18
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	19, 24&25
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13 &14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Video recording as an objective assessment tool of health worker performance in neonatal resuscitation at a district hospital in Pemba, Tanzania: a feasibility study

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Primary Subject Heading:	Global health
Secondary Subject Heading:	Health services research, Medical education and training, Obstetrics and gynaecology, Public health
Keywords:	OBSTETRICS, NEONATOLOGY, PUBLIC HEALTH, Paediatric intensive & critical care < ANAESTHETICS, EDUCATION & TRAINING (see Medical Education & Training), Neonatal intensive & critical care < INTENSIVE &

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Video recording as an objective assessment tool of health worker performance in neonatal resuscitation at a district hospital in Pemba, Tanzania: a feasibility study

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Structured Abstract

Objectives

To assess the feasibility of using video recordings of neonatal resuscitation (NR) to evaluate the quality of care in a low-resource district hospital.

Design

Prospective observational feasibility study.

Setting

Chake-Chake Hospital, a district hospital in Pemba, Tanzania, in April and May 2019.

Participants

All delivering women and their newborns were eligible for participation.

Main outcome measures

Motion-triggered cameras were mounted on resuscitation tables and provided recordings that were analysed for quality of care indicators based on the national NR algorithm. Assessment of feasibility was conducted using Bowen's eight-point framework for feasibility studies.

Results

Ninety-one percent (126/139) of women and 96% (24/26) of health workers were comfortable or very comfortable with the video recordings. Of 139 newborns, eight underwent resuscitation with bag and mask ventilation. In resuscitations, heat loss prevention measures were not performed in half of the cases (4/8), clearing the airway was not performed correctly five out of eight cases (5/8), and all newborns were suctioned vigorously and repeatedly, even when not indicated. In a quarter (2/8) the newborn's head was not positioned correctly. Additionally, two of the eight newborns needing ventilation were not ventilated within the first minute of life. In none of the eight cases, ventilation appeared to be performed effectively.

Conclusions

It proved feasible to use video recordings to assess quality of care during NR in a low-resource setting, and the method was considered acceptable for the delivering women and health workers. Recordings of eight resuscitations all demonstrated deviations from NR guidelines.

Strengths and limitations of the study

- This is a prospective study with a large population size for a feasibility study.
- This is the first study using video recordings of neonatal resuscitations at a secondary level district hospital in a resource limited setting.
- Video recordings of neonatal resuscitation instead of direct clinical observations could minimize the Hawthorne effect.
- The study used prospective consent which could cause missed opportunities of including obstetric emergencies and thus potential neonatal emergencies to the study.
- Inter-rater variance is a potential bias when video recordings of clinical performance is assessed, scored, and analyzed.

Introduction

Globally, 2.5 million newborns die each year within the first 28 days of life. An additional 2.6 million are stillborn, while half of them were alive at the onset of labour.[1 2] The leading causes of death are infections, intrapartum asphyxia, and preterm birth complications.[3 4] Prioritizing neonatal health is on the global agenda, and United Nations Sustainable Development Goal (SDG) 3.2.2 is to reduce neonatal mortality to at least 12 per 1,000 live births by 2030.[5] Two-thirds of countries at risk of missing this SDG target are in Sub-Saharan Africa.[6] By 2025 it is estimated that 71% of neonatal deaths could be avoided with adequate healthcare coverage and better quality of care.[7]

What happens in the first minutes after birth can influence an entire life, especially given that 5-10% of newborns require assistance to begin breathing with tactile stimulation and 3–6% require bag and mask ventilation.[8-12] In low- and middle-income countries (LMICs), resuscitation guidelines including the American Academy of Paediatrics program - Helping Babies Breathe (HBB) are simplified, and primarily focus on the management of airways and breathing within the first and golden minute; with omission of chest compressions and more advanced resuscitation.[12] Relevant elements of care include the availability of equipment and trained staff to deliver consistent and reliable resuscitation care, which is challenging in many LMICs.[12] Neonatal mortality from intrapartum-related events can be reduced by 30% with basic neonatal resuscitation (NR), and NR training programs for health workers is of highest priority.[8-10 13] However, educational NR programs doesn't necessarily result in improvements in clinical practice in the delivery room, nor expected reductions in neonatal mortality rate.[14-16] Therefore, it is necessary to assess health worker performance during actual clinical NR, so trainings can be targeted to these specific elements and better tailored to local needs and context.

Video recording has been used to evaluate health workers' NR performance in the past and for research purposes in high-resource settings.[17-21] Studies have documented a significant number of deviations from the NR guidelines, also in high resource settings.[17-20] The advantages of video-recorded clinical performance include its low cost, minimal interference with the procedure performed, and collection of real-time, unalterable objective data to assess performance.[17] Furthermore, there is an even stronger argument for using video-recordings instead of direct observations in the delivery room, since the methodology circumvents the ethical paradox of direct observations and could minimize the Hawthorne effect.[22] Video recording as a tool to assess the

quality and performance of NR in LMICs may have great potential, but experiences with it are scarce, with a limited number of studies on the topic and only from larger tertiary or referral hospitals.[23-29]

Our study utilize the Bowen feasibility framework that was developed to help researchers design feasibility studies that can support and prepare investigators for larger scale testing. The framework is widely adopted and cited more than 2100 times.[30] Feasibility studies are generally used to determine if a programme, intervention or policy are recommended for further testing and could have the intended effect on the outcome as hypothesized.[30]

We aimed to assess the feasibility of using video recordings as an objective tool to assess the quality of care during NR at a secondary level district hospital in a low-resource setting. To our knowledge, this is the first study that used NR video documentation performed in a district hospital in a low-resource setting with a poor and unstable power supply, unstable internet connection, and high neonatal mortality.

METHODOLOGY

Study design

The study was a prospective observational feasibility study. It was designed in preparation for the Newborn Emergency Outcome trial (NCT04093778). The study was conducted over four weeks in April and May 2019 at Chake-Chake District Hospital in Pemba, Zanzibar, Tanzania. The study was approved by the Zanzibar Health Research Institute (NO.ZAREC.02/APR/2019/20).

The feasibility study used Bowen's feasibility study framework with eight wide-ranging areas of attention.[30] The study assessed all of Bowen's eight focus areas; acceptability, demand, implementation, practicality, adaptation, integration, expansion, and limited-efficacy testing (table 1).[30]

Setting

Pemba is an island in the archipelago of Zanzibar with a population of 500,000. The stillbirth rate is estimated at 27.7 per 1,000 live births, and the neonatal mortality rate is approximately 16.0 per 1,000 live births.[31] The island has four district hospitals; this study includes data collected at Chake-Chake district hospital, with approximately 5000 annual deliveries.[32] The main delivery room has three delivery beds and one resuscitation table. In addition, the hospital has a movable table for

resuscitation in the operating theatre. The resuscitation tables are also used for the post-delivery observation of healthy newborns not undergoing resuscitation. At Chake-Chake Hospital, midwives are responsible for the postnatal care of all neonates, including resuscitation. The NR guidelines available in facilities were a Helping Babies Breathe poster, national guidelines provided by the Ministry of Health and WHO guidelines. The available equipment consists of gloves, bulb suction, a self-inflating bag and mask, and an oxygen source (not always available). A traditional cloths called kanga brought by the mother is available for wrapping, drying and to prevent heat loss of the newborn after delivery.

Study population

All women delivering at Chake-Chake Hospital and their newborns were eligible for participation. The women in the maternity and delivery ward were enrolled in the study as soon as possible after admission. The women could be enrolled until the expulsion phase of the second stage of labour with written or oral consent using fingerprints, and consent was confirmed post-partum. All health workers at the Chake-Chake Hospital delivery ward gave consent for participation, no economic incentives were provided. Several meetings, direct observations, informal conversations were held with prior to the study to ensure participatory commitment and equal partnership.

Data sources and management equipment

We recorded NR performance using motion-triggered Smart Cam Pro cameras installed above the radiant heater at the resuscitation tables. The cameras provided video recordings with audio, capturing whenever a newborn was placed on the resuscitation tables. The audio was only used to determine if the newborn was crying, gasping or grunting and neither conversations nor background noise were included in the analysis to avoid privacy issues. The camera had a shield around it and the image was zoomed to show only the newborn and the hands of the resuscitation team. The research assistants covered the camera if a non-consent woman gave birth, since all delivery beds shared the resuscitation table. Research assistants were present at the maternity and delivery ward 24 hours a day. The research assistants placed an individually assigned identification card on the resuscitation table just before or after the placement of the newborn. Time stamps and identification numbers were matched with the hospital register for the recorded delivery. The identification number followed the woman and her newborn until discharge. The videos were stored on an encrypted micro-SD card in the

camera, and the data were uploaded to a secure database. Only the international research team could access the videos to ensure the individual health workers' anonymity.

Postnatal questionnaire with socio-demographics, obstetric history, pregnancy information, delivery outcome, neonatal characteristics, and acceptability of video recordings were collected by research assistants on paper and entered directly into the secure data collection software RedCap (v5.12.1) on Lenovo version 7 tablets.

Outcomes and variables

We evaluated feasibility using Bowen's framework for feasibility studies (table 1).[30] All post-partum women and health workers in the maternity ward answered an acceptability question on a Likert scale. For health workers, the acceptability question was, *"How comfortable did you feel about the neonatal resuscitation being filmed?"* For post-partum women, the acceptability question was, "*How comfortable did you feel about your baby being video filmed?"* (table 2). Additionally, we conducted 18 semi-structured interviews, nine with post-partum women (one to three days after delivery) and nine with health workers in the maternity ward. The qualitative analysis is beyond the scope of this paper and will be reported in another study.

We logged and described the video recordings' practicality and technicality. An analytical framework for limited efficacy testing of quality of care indicators was developed where resuscitation procedures were scored according to guidelines.[33] The clinical appearance of the newborn was logged as no respiration = 0, gasping = 1, or breathing = 2. The clinical actions performed by the health workers were registered in a thematic template that assesses performance on; heat loss prevention, positioning of the newborn's head, clearing the airway via suction, stimulation, bag and mask ventilation, heart rate assessment, and oxygen management. Each intervention performance was assessed at three levels: properly performed procedures, inadequate procedures (delayed intervention or inadequate technique for a given procedure), and procedures omitted or performed but not indicated according to NR guidelines.

Data analysis

Videos where resuscitation with bag and mask was performed were included in the analysis. Video recordings were analysed by two independent researchers (CS and SL). If any doubts arose, the

researchers consulted with another member of the study team. A timeline of interventions while the newborn was placed on the resuscitation table and the subsequent events were produced (Figure 1). We transferred data from the video observations from Excel (version 2011, Microsoft Corporation, Washington, United States) and quantitative variables from Redcap to SPSS (version 27.0, IBM, New York, United States) for descriptive statistics. We categorized continuous variables according to common medical standards and newborn risk factors. We expressed the data as number and percentage or median and interquartile range (IQR). The translated semi-structured qualitative interviews were imported to NVivo (version 13) and analysed thematically. The full thematic qualitative analysis of the semi-structured interviews is beyond the scope of this paper and will be reported in a separate paper.

Patient and public involvement

Patients and the public were not involved in developing research questions, designing, conducting, or disseminating the study. During this research patients and staff were interviewed with semi-structured questionnaires as informants to adjust the main study with patient involvement.

Role of funding source

The funders of this study had no role in the study design, data collection, data analysis, data interpretation, or writing of the manuscript. The corresponding author had full access to all the data in the study and was responsible for submitting the manuscript for publication.

Results

Participating women and health workers

During the study period, 274 women were eligible for participation, of which 239 had spontaneous vaginal deliveries and 35 caesarean sections (figure 1). One hundred and thirty-nine women gave consent. Of the 139 enrolled women that gave birth to 139 newborns, 101 (73%) newborn were taken to the resuscitation table and captured by the video camera, the camera was shielded if a newborn without consent was placed at the table. Forty-four (44%) of the newborns brought to the resuscitation table were not crying when placed there, and eight underwent resuscitation with bag and mask ventilation. Up to three newborns at a time were placed on the same resuscitation table. Twenty-six health workers were working in the delivery ward and participated in the deliveries during the study

period. Demographics of the participating women (table 3) and health workers (table 4) and delivery and birth outcomes of the newborn in (table 5).

We report feasibility according to Bowen et. al. feasibility framework using all eight areas of focus 1) Acceptability, 2) Demand, 3) Implementation, 4) Practicality, 5) Adaptation, 6) Integration, 7) Expansion, 8) Limited-efficacy testing (table 1).[30]

Acceptability of video recordings

Acceptability among the delivering women of the NR video recordings was high, with 89·7% being either very comfortable or comfortable and only one woman felt uncomfortable 0·7%, and 12 women did not answer the question. Twenty-five of the 26 participating health workers (96·0%) responded to the question and 92.3% was either very comfortable or comfortable, only one health worker felt uncomfortable (table 2).

Practicality and technicality

We registered the practical and technical feasibility of capturing NR with motion-triggered cameras during the study period, and although the solution was technically feasible, we made several adjustments (table 1). There were some concerns regarding the camera's angle, and a shield was created around it to make it obvious to everyone that the camera was only capturing the newborn and health worker's hands. We installed a camera on a stand at the portable resuscitation table to capture the table, but this solution was suboptimal and adjusted with a more stable version. The camera ran solely on power banks, since we could not rely on the hospital's power supply. The camera had a secure encrypted SD memory card, and the video material captured was uploaded to a secure database over a Wi-Fi connection. The hospital did not have a stable Wi-Fi connection, so we installed a password-protected 4G Wi-Fi connection that ran on power banks near the resuscitation table.

Limited-efficacy testing

To study limited-efficacy (table 1), the videos were analysed to see if they added value by providing new evidence of gaps in clinical performance (table 6). Of the 139 included newborns, eight were resuscitated with bag and mask ventilation and captured on video. According to the questionnaire, further two newborns were resuscitated, but not captured on video, possibly because the resuscitation took place away from the resuscitation table or an episode occurred when the camera was shielded

due to a non-consent woman giving birth simultaneously. Two other newborns were stillborn: the corresponding video showed a baby with a very low birth weight, whereas the other child was not captured on video.

The health workers report was that all newborns had been resuscitated with adequate stimulation, suction, ventilation, and heat loss prevention. The eight videos, however, showed that heat loss prevention measures were not performed in half of the resuscitations. In two cases, the head positioned incorrectly and not in a neutral position. Clearing the airway via suction was not performed correctly in six cases. As none of the cases were born in thick meconium, suction was not recommended according to NR guidelines.[33] Nevertheless, all eight were suctioned vigorously and repeatedly. None of them were stimulated correctly, either. One infant, in need of ventilation, was not ventilated at all, and the remaining were ventilated ineffectively with undue delay, wrong technique, or in short and interrupted sequences rather than as a sustained effort. In two cases, ventilation efforts were halted before regular breathing. The timeline of events of each resuscitation video showed that while six in need of resuscitation were ventilated within one minute of placement on the resuscitation table, two were not (figure 2). The average time on the resuscitation table before ventilation was 41 s (0–96). Only, one-third of the newborns in need of resuscitation were stimulated within their first minute on the resuscitation table. The average time spent on suction was 35 s (00:00–01:22). All resuscitations deviated from NR guidelines. However, all newborns who underwent resuscitation in the videos survived until discharge.

Discussion

In this study, using video recordings to assess the quality of care during NR in a low-resource setting proved feasible and provided valuable objective measures of performance in the timing of events and adherence to NR guidelines. The application was highly acceptable among the facility's delivering women and health workers, with more than 90% comfortable or very comfortable. We also found video recording practically and technically achievable, albeit operationally challenging. We found a demand from health workers to focus on NR and a need to improve NR based, and our limited efficacy testing on performance gaps supports this. We conclude that the study can be expanded to include all district hospitals in Pemba as planned in the NEO-study. The efficacy testing of video recordings suggested that it may provide added value. In Chake-Chake District Hospital, performance in NR was sub-optimal, as was adherence to NR guidelines.

The need for clinical management assessments during actual NR and related training programs for all healthcare workers involved in the management of newborns is undeniable. Nearly all neonatal deaths attributed to intrapartum-related events occur in LMICs and may constitute of up to 60% of neonatal deaths in primary facilities and secondary level hospitals.[34] Among the survivors of intrapartum-related events, 1 million may develop cerebral palsy or other disabilities each year.[35] NR is an emergency associated with high stress among health workers, resulting in frequent medical errors and lack of adherence to guidelines. The noted deviations from guidelines are in line with studies that also used a video review process to analyse NR in high-income countries.[17] Schilleman et al. found in a study from 2012 that only 21% of recorded resuscitations were performed entirely according to local guidelines, and McCarthy et al. reported in a study from 2013 that the recommended NR timeline is rarely followed in real-life resuscitations.[17 19] Yamada et al. (2015) similarly classified and quantified the types of errors observed in 250 NR recordings in their institution.[36] They identified a 23% error rate for all tasks determined to be important elements of the NR algorithm. Errors similar to our study included omission of tasks that according to guidelines were indicated or tasks that were performed although not indicated, with incorrect timing or technique. Deviations from guidelines were more common and could consist of tasks that were performed but not indicated, tasks performed at the incorrect time, or tasks performed but following an improper technique.

To our knowledge, the study is the first to use video recordings of NR in a secondary district level hospital in a low-income country. Video has been used as a component of development and assessment of training interventions for health worker performance and was found feasible in tertiary hospitals in Nepal and Mozambique.[23 24] In a study from 2017 from Nepal, Wrammert et al. compared the resuscitation practices of low and normal birthweight infants using video camera recordings, noting crying, stimulation, ventilation, suctioning, and oxygen administration during resuscitation.[24] In as study from 2015 from Mozambique, Trevisanuto et al. similarly used video recordings of 100 resuscitations to assess the effect of an adapted NR program course on healthcare providers' performance, finding a significant improvement in resuscitation scores in all levels of resuscitation from before and after the course.[23] In a study from 2020 from Uganda, Pejovic et al. used video recordings to assess the effect of a specific intervention ventilation with face masks versus laryngeal

masks. It concluded that laryngeal mask reduced time to spontaneous breathing compared with face mask during newborn resuscitation in a low-resource setting.[28]

There is not a standardized method or approach analysing NR performance videos. Carabine et al. developed a scoring system used in a high-income setting in a study from 2000, which Trevisanuto et al. adapted to a low-resource setting in 2015.[17 23] We were inspired by these systems but had to further adjust them due to our study occurring in a secondary level facility in a low-resource setting.

The limited efficacy testing in our study was positive. We found the video recordings usable for objective assessments of health worker performance, detail, and timeliness during actual NR resuscitations. In our study, NR performance was sub-optimal, particularly for essential NR interventions such as stimulation, suction, and bag and mask ventilation. Similarly, Lindbäcket et al. identified guideline deviations in over 50% of resuscitations in a tertiary hospital in Nepal in a study from 2015.[29] We found that bag and mask ventilation in particular was inadequately performed, and suction was excessive and used vigorously even when not medically indicated. These findings are in line with other studies that followed a video review process to analyse NR performance in LMICs.[17 20] Lindbäcket et al. also noted excessive use of oxygen, which we did not, likely because our setting was a secondary level facility with limited access to oxygen therapy due to an insufficient supply chain, and only one oxygen dispenser available for the whole hospital.[29] A further important finding of the present study concerns the timeline of resuscitation, where initiation and the duration of all procedures were inconsistent with the times recommended by guidelines.

Twenty-five percent of newborns in need of resuscitation did not have bag and mask ventilation initiated within the first minute of life. In a study from Mozambique Pietravalle et al. examined tactile stimulation in a study from 2018 and, similar to our findings, found that multiple stimulation techniques were administered in two-thirds of neonates (64.7%), while recommended techniques (rubbing the back or flicking the soles of the feet) occurred in less than 10% (8.8%). The median stimulation duration was 17 s (IQR 9–33)[25], which is much shorter than our study, where the median time was 75 s (IQR 90). Gaertner et al. evaluated video recordings of 75 stimulated infants, including early preterm infants in a study from 2018, and suggested that truncal stimulation (drying, chest rubs, and back rubs) might be more effective than foot flicks.[21]

The limited combined experiences indicate that videos of clinical performance during actual NR in LMICs provide valuable objective information to improve quality of care and patient safety and survival. Improving this requires focus. Identifying errors during real-life situations can drive the type of training and guideline adjustments needed, such as an enhanced focus on avoiding excessive and unnecessary suction practices, stimulation techniques, timely and sustained positive pressure, and bag and mask ventilation techniques.[23 37-39] Despite an unstable power connection, the video recordings were technically possible through backup power sources in our setting. Our intervention was low-cost and relatively easy to install. Like other studies, we used cameras that activated automatically, which did not interfere with the resuscitation process and thus took focus from the neonate. Others in more resourceful settings have used multiple cameras for different angles that include the neonate, healthcare professionals delivering care, and equipment being used.[40] Due to ethical, privacy and logistical reasons, this was not feasible in our setting.

There is a need for research in the improvement of the quality of NR in low-resource facilities with local adaptation of clinical guidelines based on the actual clinical reality of health workers, adapted training programs, and scarce resources considered. Challenges in many LMIC are diverse and our study reiterates the need for locally adapted guidelines with the clinical reality in mind as discussed by Maaloe et. Al in a viewpoint from 2021.[41]

Few qualitative studies explore health providers' attitudes towards the video recording of NR.[17 42 43] We found that healthcare workers in general adapted quickly to the presence of the camera and their acceptability was high, as was that for delivering women.[17] An extensive qualitative study from 2018 from the Netherlands and United States with 49 semi-structured interviews concluded that recording and reviewing NR is highly beneficial for learning and improving resuscitation skills and is considered acceptable by clinical staff.[43] Parents and health workers have generally accepted that recordings may be created for better patient safety, quality improvement, and education both in studies from Nepal, the Netherlands, and the United States.[43 44] Video recordings during emergencies can create controversy, and therefore privacy concerns, medicolegal consequences, storage, and consent must be discussed before implementation.[45] Some programs in high-income countries include a statement in the general admission consent stating that photography and video recording for patient safety, quality improvement, and professional training purposes may occur in the hospital. However, general consent forms at admission are not a widespread practice in LMIC facilities. Consent in

emergency research and consent during labour and childbirth is challenging with many ethical aspects and some true dilemmas. Ideally the woman should be informed in a quiet manner in an antenatal visit, but this method was not possible in our setting, and will disturb many pregnant women unnessarily, and will miss those who do not come for antenatal visits. The consent process was discussed back and forth between the research team and the local ethical committee, and we agreed on consent until the expulsion phase, with an emphasis on confirmation of consent post-partum, while a waiver of consent was not deemed acceptable in the local context.

Strengths and limitations

The study's main strengths are the prospective study design and the large population size for a feasibility study. Video recordings of neonatal resuscitation both circumvents the ethical paradox of direct clinical observations and could minimize the Hawthorne effect after an adjustment period.

Our study had some limitations. The observers assessing the same video images may have differences in their assessment of the clinical situation involving NR, this was not the case our study, since the videos were scored in collaboration, but this might not be possible in larger studies with a greater volume of videos. Other studies have investigated inter-rater reliability and displayed a high (above 90%) reliability for the use of bag and mask ventilation and suctioning, but lower reliability for oxygen administration and stimulation.[44] The most sensitive indicator of resuscitation being successful is an increase in the newborn's heart rate. We did not assess heart rate or oxygenation in our resuscitation study since the equipment is not available in the local context, which could have been valuable when assessing the health workers' resuscitation efforts and outcomes. Due to local ethical committee regulations, our study asked the delivering women for their prospective consent. More than 36% of the women were not approached for consent due to being in too much pain, late presentation at the hospital or an obstetric emergency. Indeed, these newborns have an increased risk of the need for resuscitation, intrapartum stillbirth, and asphyxiation, and hence high-level emergencies may not be included in our feasibility study due to the prospective enrolment process.[46] This is a bias, and the finding in this feasibility study may not necessarily mimic newborns' actual situation and challenges, and the results may underestimate the need for NR. An alternative approach used in other studies is a waiver of consent, where consent is obtained before delivery when possible; otherwise, researchers seek retrospective consent.[47]

Conclusion

Video recording of neonatal resuscitation at a district hospital in a resource constraint setting was feasible and provided vital information on the quality and timeliness of provided care.

The unstable power supply and lack of reliable internet connection created practical and technical challenges but were manageable. The efficacy testing was positive in assessments of health worker performance and adherence to NR guidelines. All recorded resuscitations demonstrated deviations from NR guidelines, and although all eight infants were manually ventilated as required and all infants survived to discharge, the ventilation was started too late, stopped too early, or delivered ineffectively. More research is still needed in the use of video recordings to assess and improve the quality of NR.

Data availability statement

Data are available from the corresponding author upon reasonable request.

Ethic statement

Patient consent for publication.

Not applicable.

Ethics approval

The study was approved by the Zanzibar Health Research Institute (NO.ZAREC.02/APR/2019/20). Each participant received information about the purpose of the study and informed consent was obtained from all subjects.

Author Contributions

SL, AP, CCHH and GG conceived the idea for the study. CCHH, TBS, ML, MK, SM, SMA collected the data. CCHH and SL wrote the first draft of the manuscript. The data has been verified by CCHH, TM and SL, statistical analysis was performed by CCHH, CS and SL. CS and SL developed the framework and analyzed the resuscitation videos. CCHH, SA and SMA were the principal investigators of the study. AP, GG, TBS, ML, MK, SM, SMA, JK, CMB reviewed and revised the manuscript. All authors read and approved the version final manuscript

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Conflicts of interest

None.

REFERENCES

1. Wang H, Bhutta ZA, Coates MM, et al. Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet* 2016;388(10053):1725-74. doi: 10.1016/s0140-6736(16)31575-6
2. Lawn JE, Blencowe H, Waiswa P, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. *The Lancet* 2016;387(10018):587-603. doi: 10.1016/s0140-6736(15)00837-5
3. Lawn JE, Blencowe H, Oza S, et al. Every Newborn: progress, priorities, and potential beyond survival. *The Lancet* 2014;384(9938):189-205. doi: 10.1016/s0140-6736(14)60496-7
4. Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: When? Where? Why? *The Lancet* 2005;365(9462):891-900. doi: 10.1016/s0140-6736(05)71048-5
5. Economic UNDo, Affairs S. The Sustainable Development Goals Report 2016: United Nations 2016.
6. Hug L, Alexander M, You D, et al. National, regional, and global levels and trends in neonatal mortality between 1990 and 2017, with scenario-based projections to 2030: a systematic analysis. *The Lancet Global Health* 2019;7(6):e710-e20. doi: 10.1016/s2214-109x(19)30163-9
7. Bhutta ZA, Das JK, Bahl R, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? *The Lancet* 2014;384(9940):347-70. doi: 10.1016/s0140-6736(14)60792-3
8. Wall SN, Lee AC, Niermeyer S, et al. Neonatal resuscitation in low-resource settings: what, who, and how to overcome challenges to scale up? *Int J Gynaecol Obstet* 2009;107 Suppl 1(Suppl 1):S47-62, s63-4. doi: 10.1016/j.ijgo.2009.07.013 [published Online First: 2009/10/10]
9. Ades A, Lee HC. Update on simulation for the Neonatal Resuscitation Program. *Semin Perinatol* 2016;40(7):447-54. doi: 10.1053/j.semperi.2016.08.005 [published Online First: 2016/11/09]
10. Sawyer T, Lee HC, Aziz K. Anticipation and preparation for every delivery room resuscitation. *Semin Fetal Neonatal Med* 2018;23(5):312-20. doi: 10.1016/j.siny.2018.06.004 [published Online First: 2018/10/30]
11. Palme-Kilander C. Methods of resuscitatoin in low-Apgar-score newborn infants - a national survey. *Acta Paediatric* 1992;81(10):739-44.

12. Niermeyer S, Little GA, Singhal N, et al. A Short History of Helping Babies Breathe: Why and How, Then and Now. *Pediatrics* 2020;146(Suppl 2):S101-S11. doi: 10.1542/peds.2020-016915C [published Online First: 2020/10/03]
13. Lee AC, Cousens S, Wall SN, et al. Neonatal resuscitation and immediate newborn assessment and stimulation for the prevention of neonatal deaths: a systematic review, meta-analysis and Delphi estimation of mortality effect. *BMC Public Health* 2011;11 Suppl 3(Suppl 3):S12. doi: 10.1186/1471-2458-11-s3-s12 [published Online First: 2011/04/29]
14. Carlo WA, Wright LL, Chomba E, et al. Educational impact of the neonatal resuscitation program in low-risk delivery centers in a developing country. *J Pediatr* 2009;154(4):504-08.e5. doi: 10.1016/j.jpeds.2008.10.005 [published Online First: 2008/12/09]
15. Singhal N, McMillan DD, Savich R, et al. Development and Impact of Helping Babies Breathe Educational Methodology. *Pediatrics* 2020;146(Suppl 2):S123-s33. doi: 10.1542/peds.2020-016915E [published Online First: 2020/10/03]
16. Morris SM, Fratt EM, Rodrigues J, et al. Implementation of the Helping Babies Breathe Training Program: A Systematic Review. *Pediatrics* 2020;146
17. Carbine DN, Finer NN, Knodel E, et al. Video Recordings as a Means of Evaluating Neonatal Resuscitation Performance. *Pediatrics* 2000;106(4)
18. Shivananda S, Twiss J, El-Gouhary E, et al. Video recording of neonatal resuscitation: A feasibility study to inform widespread adoption. *World J Clin Pediatr* 2017;6(1):69-80. doi: 10.5409/wjcp.v6.i1.69 [published Online First: 2017/02/23]
19. Schilleman K, Siew ML, Lopriore E, et al. Auditing resuscitation of preterm infants at birth by recording video and physiological parameters. *Resuscitation* 2012;83(9):1135-9. doi: 10.1016/j.resuscitation.2012.01.036 [published Online First: 2012/02/11]
20. Maya-Enero S, Botet-Mussons F, Figueras-Aloy J, et al. Adherence to the neonatal resuscitation algorithm for preterm infants in a tertiary hospital in Spain. *BMC Pediatr* 2018;18(1):319. doi: 10.1186/s12887-018-1288-3 [published Online First: 2018/10/12]
21. Gaertner VD, Flemmer SA, Lorenz L, et al. Physical stimulation of newborn infants in the delivery room. *Arch Dis Child Fetal Neonatal Ed* 2018;103(2):F132-F36. doi: 10.1136/archdischild-2016-312311 [published Online First: 2017/06/11]
22. Sedgwick P, Greenwood N. Understanding the Hawthorne effect. *BMJ* 2015;351:h4672. doi: 10.1136/bmj.h4672 [published Online First: 2015/09/06]
23. Trevisanuto D, Bertuola F, Lanzoni P, et al. Effect of a Neonatal Resuscitation Course on Healthcare Providers' Performances Assessed by Video Recording in a Low-Resource Setting. *PLoS One* 2015;10(12):e0144443. doi: 10.1371/journal.pone.0144443 [published Online First: 2015/12/15]
24. Wrammert J, Zetterlund C, Kc A, et al. Resuscitation practices of low and normal birth weight infants in Nepal: an observational study using video camera recordings. *Glob Health Action* 2017;10(1):1322372. doi: 10.1080/16549716.2017.1322372 [published Online First: 2017/06/03]
25. Pietravalle A, Cavallin F, Opocher A, et al. Neonatal tactile stimulation at birth in a low-resource setting. *BMC Pediatr* 2018;18(1):306. doi: 10.1186/s12887-018-1279-4 [published Online First: 2018/09/22]
26. Cavicchiolo ME, Cavallin F, Bertuola F, et al. Effect of a Low-Dose/High-Frequency Training on Real-Life Neonatal Resuscitation in a Low-Resource Setting. *Neonatology* 2018;114(4):294-302. doi: 10.1159/000490370 [published Online First: 2018/07/17]

27. Kc A, Wrammert J, Clark RB, et al. Reducing Perinatal Mortality in Nepal Using Helping Babies Breathe. *Pediatrics* 2016;137(6) doi: 10.1542/peds.2015-0117 [published Online First: 2016/05/27]
28. Pejovic NJ, Myrnerts Hook S, Byamugisha J, et al. A Randomized Trial of Laryngeal Mask Airway in Neonatal Resuscitation. *N Engl J Med* 2020;383(22):2138-47. doi: 10.1056/NEJMoa2005333 [published Online First: 2020/12/01]
29. Lindback C, Kc A, Wrammert J, et al. Poor adherence to neonatal resuscitation guidelines exposed; an observational study using camera surveillance at a tertiary hospital in Nepal. *BMC Pediatr* 2014;14:233. doi: 10.1186/1471-2431-14-233 [published Online First: 2014/09/18]
30. Bowen DJ, Kreuter M, Spring B, et al. How we design feasibility studies. *Am J Prev Med* 2009;36(5):452-7. doi: 10.1016/j.amepre.2009.02.002 [published Online First: 2009/04/14]
31. group AfMaNHIAms. Population-based rates, timing, and causes of maternal deaths, stillbirths, and neonatal deaths in south Asia and sub-Saharan Africa: a multi-country prospective cohort study. *Lancet Glob Health* 2018;6(12):e1297-e308. doi: 10.1016/s2214-109x(18)30385-1 [published Online First: 2018/10/27]
32. Health ZMo. The Zanzibar Annual Health Bulletin 2017, 2017.
33. Organization WH. WHO Recommendations on Newborn Health, Guidelines Approved by the WHO Guideliens Review Committee. . 2017
34. Ersdal HL, Mduma E, Svensen E, et al. Birth asphyxia: a major cause of early neonatal mortality in a Tanzanian rural hospital. *Pediatrics* 2012;129(5):e1238-43. doi: 10.1542/peds.2011-3134 [published Online First: 2012/04/18]
35. Liu L, Johnson HL, Cousens S, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet* 2012;379(9832):2151-61. doi: 10.1016/s0140-6736(12)60560-1 [published Online First: 2012/05/15]
36. Yamada NK, Yaeger KA, Halamek LP. Analysis and classification of errors made by teams during neonatal resuscitation. *Resuscitation* 2015;96:109-13. doi: 10.1016/j.resuscitation.2015.07.048 [published Online First: 2015/08/19]
37. Maya-Enero S, Botet-Mussons F, Figueras-Aloy J, et al. Adherence to the neonatal resuscitation algorithm for preterm infants in a tertiary hospital in Spain. *BMC Pediatr* 2018;18(1):319. doi: 10.1186/s12887-018-1288-3 [published Online First: 2018/10/12]
38. Skåre C, Boldingh AM, Kramer-Johansen J, et al. Video performance-debriefings and ventilation-refreshers improve quality of neonatal resuscitation. *Resuscitation* 2018;132:140-46. doi: 10.1016/j.resuscitation.2018.07.013 [published Online First: 2018/07/17]
39. Odongkara B, Tylleskär T, Pejovic N, et al. Adding video-debriefing to Helping-Babies-Breathe training enhanced retention of neonatal resuscitation knowledge and skills among health workers in Uganda: a cluster randomized trial. *Glob Health Action* 2020;13(1):1743496. doi: 10.1080/16549716.2020.1743496 [published Online First: 2020/06/12]
40. Gelbart B, Hiscock R, Barfield C. Assessment of neonatal resuscitation performance using video recording in a perinatal centre. *J Paediatr Child Health* 2010;46(7-8):378-83. doi: 10.1111/j.1440-1754.2010.01747.x [published Online First: 2010/06/16]

41. Maaløe N, Ørtved AMR, Sørensen JB, et al. The injustice of unfit clinical practice guidelines in low-resource realities. *The Lancet Global Health* 2021;9(6):e875-e79. doi: 10.1016/s2214-109x(21)00059-0
42. Carbine DN, Finer NN, Knodel E, et al. Video recording as a means of evaluating neonatal resuscitation performance. *Pediatrics* 2000;106(4):654-8. doi: 10.1542/peds.106.4.654 [published Online First: 2000/10/04]
43. den Boer MC, Houtlosser M, Foglia EE, et al. Benefits of recording and reviewing neonatal resuscitation: the providers' perspective. *Arch Dis Child Fetal Neonatal Ed* 2019;104(5):F528-f34. doi: 10.1136/archdischild-2018-315648 [published Online First: 2018/12/07]
44. Lindbäck C, Kc A, Wrammert J, et al. Poor adherence to neonatal resuscitation guidelines exposed; an observational study using camera surveillance at a tertiary hospital in Nepal. *BMC Pediatr* 2014;14:233. doi: 10.1186/1471-2431-14-233 [published Online First: 2014/09/18]
45. den Boer MC, Houtlosser M, van Zanten HA, et al. Ethical dilemmas of recording and reviewing neonatal resuscitation. *Arch Dis Child Fetal Neonatal Ed* 2018;103(3):F280-f84. doi: 10.1136/archdischild-2017-314191 [published Online First: 2018/01/22]
46. Lawn JE, Blencowe H, Waiswa P, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. *Lancet* 2016;387(10018):587-603. doi: 10.1016/s0140-6736(15)00837-5 [published Online First: 2016/01/23]
47. Health ZMo. The Zanzibar Annual Health Bulletin 2016, 2016.

Table 1
Bowen acceptability framework adapted

Area of focus	Definitions according to Bowen[30]	**Outcomes of interest from results from the current NEO feasibility study**
1. Acceptability	- To what extent will participants accept the new idea?	- Acceptability of video recordings with a Likert acceptability scale question for all women and health workers - Acceptability interview with mothers and health workers
2. Demand	- Is there a demand? - Is it Fit within the? organizational culture	- Perceived demand for focus on neonatal resuscitation by health workers - Appropriate within the organizational culture - Desperate need for improvement of neonatal resuscitation practice - Exploratory and participatory meetings and workshops with staff before the design of the study - Exploratory meetings with stakeholders, policymakers, and officials from the Ministry of Health -
3. Implementation	- Can the new idea be successfully implemented?	- Recordings of NR can be implemented - There is an ability of the study team to carry out and implement the study at the health facility
4. Practicality	- Implementation with existing means, resources, and circumstances?	- Awareness of technical challenges - The extent where the video recordings are possible in the context - Efficiency, speed, and quality of implementation setting with an unstable power source and unstable internet
5. Adaptation	- To what extent can a new idea perform when changes are made for a new format?	- The extent where video recordings are possible when a non-consent woman is in the delivery room

	- Degree to which similar outcomes are obtained in a new format?	- The extent to video recordings can be implemented without effect on clinical work
6. Integration	- To what extent can it be integrated into the existing system?	- Fit within existing infrastructure. - Video recordings work in a local context with no influence on workflow
7. Expansion	- To what extent can the method be expanded?	- Positive effects on the health system explored - Possible expansion with all practical factors considered - The extent to which video recordings of NR can be scaled up or in more facilities
8. Limited-efficacy testing	- Does the new idea show promise of being successful in the intended populations? - Intended effects on key intermediate variables	- The added value of video recordings to assess the quality of NR. - Small-scale analysis of NR videos and development of a thematic template scoring system

Table 2 Acceptability of video recordings during neonatal resuscitation		
Women		n = 139 (%)
	Very comfortable	26 (18.7)
	Comfortable	100 (71.9)
	Neither comfortable nor uncomfortable	0 (0.0)
	Uncomfortable	1 (0.7)
	Very uncomfortable	0 (0.0)
	Data missing	12 (8.6)
Health workers		**n = 26 (%)**
	Very comfortable	10 (38.5)
	Comfortable	14 (53.8)
	Neither comfortable nor uncomfortable	0 (0.0)
	Uncomfortable	1 (3.8)
	Very uncomfortable	0 (0.0)
	Missing	1 (3.8)

Table 3 Characteristics of the participating women		
Demographics		n = 139 (%)
Age distribution		
	< 20 years	13 (9.4)
	20–29 years	83 (59.7)
	30–39 years	34 (24.5)
	> 40 years	0 (0.0)
	Unknown	9 (6.5)
Civil status		
	Married	138 (99.3)
	Single	0 (0.0)
	Unknown	1 (0.7)
Education		
	None	1 (0.7)
	Primary	19 (13.7)
	Secondary	106 (76.3)
	> Secondary	12 (8.6)
	Unknown	1 (0.7)
Parity		
	Primiparous	34 (24.5)
	Multiparous (2–4)	67 (48.2)
	Grand multiparous (> 5)	37 (26.6)
	Unknown	1 (0.7)
Antenatal care visits		

	Did not attend	0
	1–3	48 (34.5)
	> 4	86 (61.9)
	Unknown	5 (3.6)
Previous Caesarean Section		
	Yes	9 (6.5)
	No	122 (87.8)
	Unknown	7 (5.0)

Table 4 Participating health workers

		n = 26 (%)
Gender		
	Female	23 (88.5)
	Male	3 (11.5)
Age		
	< 30 years	11 (42.3)
	30–50 years	13 (50.0)
	> 50 years	2 (7.7)
Education		
	General nurse	8 (30.8)
	Nurse midwife	8 (30.8)
	Medical doctor	3 (11.5)
	Clinical officer	3 (11.5)
	Assistant nurse	4 (15.4)
Years since graduation		

	< 5	19 (73.1)
	5–10	3 (11.5)
	> 10	4 (15.4)
Number of deliveries in the month prior to the study		
	< 5	3 (11.5)
	6–20	8 (30.8)
	> 20	15 (57.7)
Post-graduate Neonatal Resuscitation course		
	Yes	15 (57.7)
	No	11 (42.3)

Table 5 Delivery and neonate characteristics at birth			
		Not resuscitated n = 131 (%)	Resuscitated n=8 (%)
Mode of delivery			
	Spontaneous vaginal delivery	121 (92.4)	**7 (87.5)**
	Assisted vaginal delivery	1 (0.7)	**0 (0)**
	Caesarean section	9 (6.9)	**1 (12.5)**
Presentation			
	Cephalic	123 (93.9)	**5 (62.5)**
	Breech	4 (3.1)	**3 (37.5)**
	Other	1 (0.8)	**0 (0)**
	Unknown	3 (2.3)	**0 (0)**
Born in thick meconium			
	Yes	5 (3.8)	**0 (0)**
	No	108 (82.4)	**8 (100)**
	Unknown	18 (13.7)	**0 (0)**
Foetal heart rate at the admission of the delivering woman			
	Yes	127 (96.9)	**8 (100)**
	No	4 (3.1)	**0 (0)**
Neonate status at birth			
	Alive at birth	127 (96.9)	**8 (100)**
	Stillbirth fresh	2 (1.5)	**0 (0)**
	Stillbirth macerated	2 (1.5)	**0 (0)**
Gender			

	Male	62 (47.3)	**3 (37.5)**
	Female	69 (52.7)	**5 (62.5)**
Birthweight, grams			
	< 1500	1 (0.8)	**0 (0)**
	1500–2500	17 (13.0)	**3 (37.5)**
	2501–4000	108 (82.4)	**5 (62.5)**
	> 4000	4 (3.1)	**0 (0)**
	Data missing	1 (0.8)	**0 (0)**

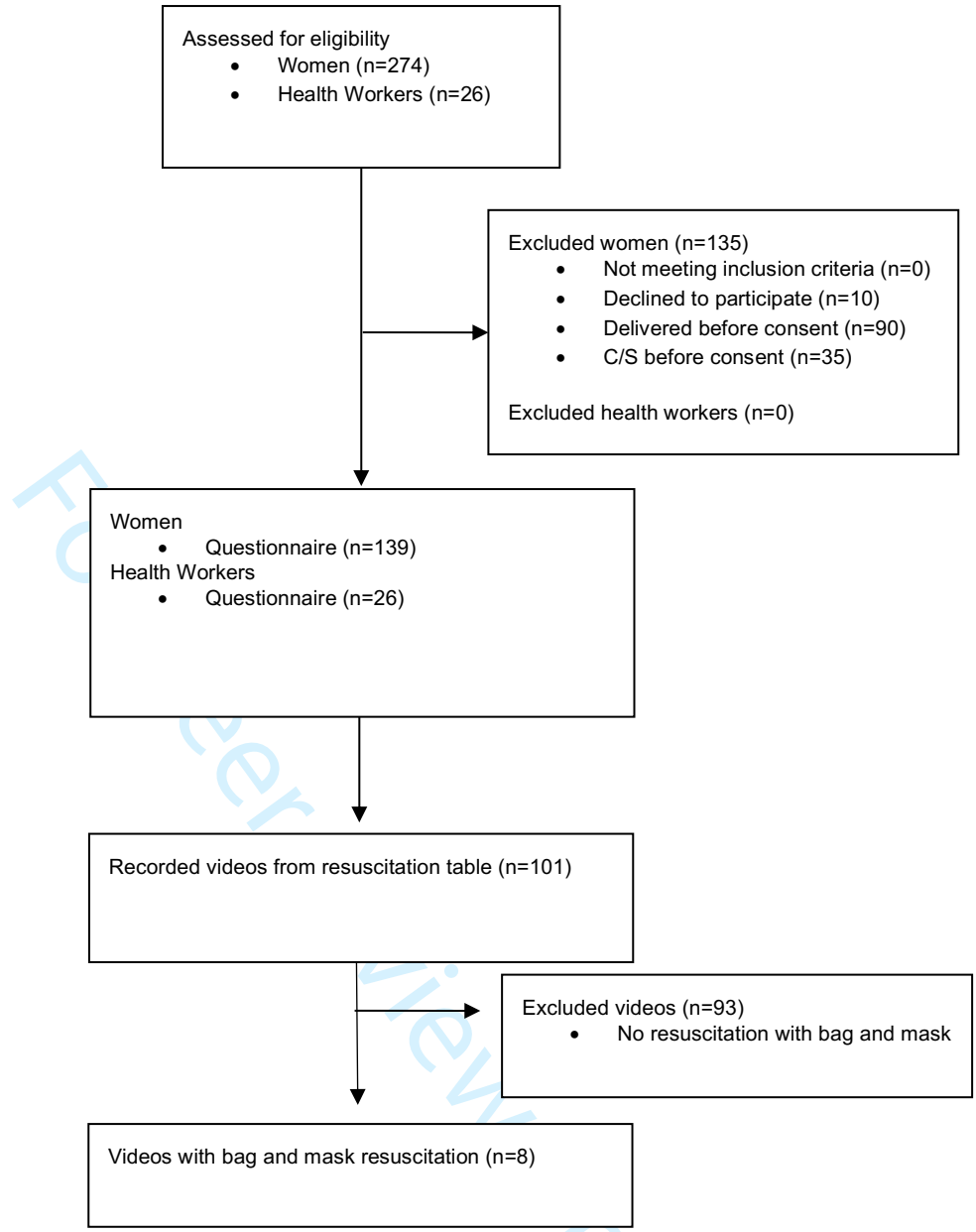
Table 6 Quality of resuscitation assessed by video recordings in 0–15 min of life

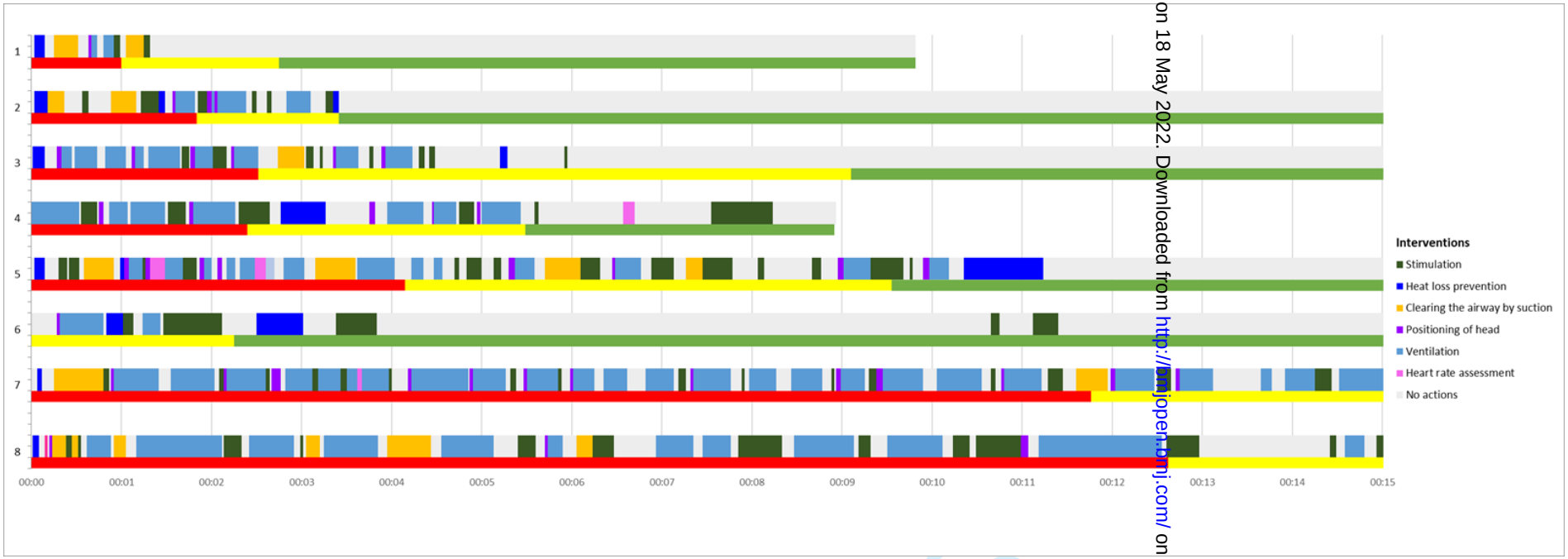
	n = 8 (%)	Median (IQR)
Heat loss prevention		
Not performed	4 (50)	
Inadequately performed *(Newborn dried with cloth but cloth not replaced by a new one; head not covered)*	2 (25)	
Well performed *(Newborn dried and cloth replaced; wrapped and head covered)*	2 (25)	
Time to first intervention		2 s (14 s)
Number of interventions/newborn		3 (2)
Total time spent on heat loss prevention		31 s (27 s)
Positioning of head		
Not performed	0 (0)	
Inadequately performed *(Head hyperextended or bent to the side)*	2 (25)	

Well performed *(Head in a sniffing position)*	6 (75)	
Time to first intervention		42 s (38 s)
Number of interventions/newborn		5 (4)
Total time spent on positioning of the head		12 s (11 s)
Clearing the airway via suction		
Not performed when indicated (meconium)	0 (0)	
Inadequately performed *(Done after the first minute of life; longer than 5 s; incorrect order (nasal suction before oral); excessive number of times)*	5 (63)	
Well performed (*or not performed when not indicated)*	3 (27)	
Time to first intervention		16 s (15 s)
Number of interventions/newborn		2 (2)
Total time spent on suction		41 s (36 s)
Stimulation		
Not performed *(Indicated when inactive, apnoeic/not spontaneously breathing or gasping)*	1 (22)	
Inadequately performed *(Stimulation performed on other places than the back or soles of the feet; too aggressively; excessive number of times)*	7 (88)	
Well performed	0 (0)	
Time to first intervention		41 s (26 s)
Number of interventions/newborn		7 (10)
Total time spent on stimulation		75 s (90 s)
Bag and mask ventilation		
Not performed	1 (22)	
Inadequately performed *(Initiation after the first minute of life; incorrect mask size; incorrect rate (not 40–60 rpm); incorrect technique (mask turned wrong*	7 (88)	

way); mask leak; not re-evaluated for response after 30 s; undue delay; short interrupted sequences)		
Well performed	0 (0)	
Time to first intervention		39 s (38 s)
Number of interventions/newborn		8 (11)
Total time spent on bag and mask ventilation		130 s (181 s)
Heart rate assessment		
Not performed	7 (88)	
Inadequately performed *(Performed by feeling the umbilicus)*	1 (22)	
Well performed *(Performed with stethoscope)*	0 (0)	
Time to first intervention		148 s (200 s)
Number of interventions/newborn		1 (0)
Total time spent on heart rate assessment		5 s (7 s)

The number of interventions refers to the number of (separate) episodes of that intervention. s=seconds





STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	5
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5 & 6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*6*
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7&8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	Figure 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8 &18
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	19, 24&25
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13 &14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Video recording as an objective assessment tool of health worker performance in neonatal resuscitation at a district hospital in Pemba, Tanzania: a feasibility study

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Video recording as an objective assessment tool of health worker performance in neonatal resuscitation at a district hospital in Pemba, Tanzania: a feasibility study

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Abstract

Objectives

To assess the feasibility of using video recordings of neonatal resuscitation (NR) to evaluate the quality of care in a low-resource district hospital.

Design

Prospective observational feasibility study.

Setting

Chake-Chake Hospital, a district hospital in Pemba, Tanzania, in April and May 2019.

Participants

All delivering women and their newborns were eligible for participation.

Main outcome measures

Motion-triggered cameras were mounted on resuscitation tables and provided recordings that were analysed for quality of care indicators based on the national NR algorithm. Assessment of feasibility was conducted using Bowen's eight-point framework for feasibility studies.

Results

91% (126/139) of women and 96% (24/26) of health workers were comfortable or very comfortable with the video recordings. Of 139 newborns, eight underwent resuscitation with bag and mask ventilation. In resuscitations, heat loss prevention measures were not performed in half of the cases (4/8), clearing the airway was not performed correctly five of eight cases, and all newborns were suctioned vigorously and repeatedly, even when not indicated. In a quarter (2/8) of cases, the newborn's head was not positioned correctly. Additionally, two of the eight newborns needing ventilation were not ventilated within the first minute of life. In none of the eight cases did ventilation appear to be performed effectively.

Conclusions

It proved feasible to use video recordings to assess quality of care during NR in a low-resource setting, and the method was considered acceptable for the delivering women and health workers. Recordings of eight resuscitations all demonstrated deviations from NR guidelines.

Strengths and limitations of this study

- This is a prospective study with a large population size for a feasibility study.
- This is the first study using video recordings of neonatal resuscitations at a secondary level district hospital in a resource-limited setting.
- Video recordings of neonatal resuscitation instead of direct clinical observations could minimize the Hawthorne effect.
- The study used prospective consent, which could cause missed opportunities for inclusion of obstetric emergencies and thus potential neonatal emergencies in the study.
- Inter-rater variance is a potential bias when video recordings of clinical performance is assessed, scored, and analysed.

Introduction

Globally, 2.5 million newborns die each year within the first 28 days of life. An additional 2.6 million are stillborn, while half of them were alive at the onset of labour.[1 2] The leading causes of death are infections, intrapartum asphyxia, and preterm birth complications.[3 4] Prioritizing neonatal health is on the global agenda, and United Nations Sustainable Development Goal (SDG) 3.2.2 is to reduce neonatal mortality to at least 12 per 1,000 live births by 2030.[5] Two-thirds of countries at risk of missing this SDG target are in Sub-Saharan Africa.[6] By 2025 it is estimated that 71% of neonatal deaths could be avoided with adequate healthcare coverage and better quality of care.[7]

What happens in the first minutes after birth can influence an entire life, especially given that 5-10% of newborns require assistance to begin breathing with tactile stimulation and 3–6% require bag and mask ventilation.[8-12] In low- and middle-income countries (LMICs), resuscitation guidelines including the American Academy of Paediatrics program - Helping Babies Breathe (HBB) are simplified, and primarily focus on the management of airways and breathing within the first and golden minute; with omission of chest compressions and more advanced resuscitation.[12] Relevant elements of care include the availability of equipment and trained staff to deliver consistent and reliable resuscitation care, which is challenging in many LMICs.[12] Neonatal mortality from intrapartum-related events can be reduced by 30% with basic neonatal resuscitation (NR), and NR training programs for health workers is of highest priority.[8-10 13] However, educational NR programs doesn't necessarily result in improvements in clinical practice in the delivery room, nor expected reductions in neonatal mortality rate.[14-16] Therefore, it is necessary to assess health worker performance during actual clinical NR, so trainings can be targeted to these specific elements and better tailored to local needs and context.

Video recording has been used to evaluate health workers' NR performance in the past and for research purposes in high-resource settings.[17-21] Studies have documented a significant number of deviations from the NR guidelines, also in high-resource settings.[17-20] The advantages of video-recorded clinical performance include its low cost, minimal interference with the procedure performed, and collection of real-time, unalterable objective data to assess performance.[17] Furthermore, there is an even stronger argument for using video-recordings instead of direct observations in the delivery room, since the methodology circumvents the ethical paradox of direct observations and could minimize the Hawthorne effect.[22] Video recording as a tool to assess the

quality and performance of NR in LMICs may have great potential, but experiences with it are scarce, with a limited number of studies on the topic and only from larger tertiary or referral hospitals.[23-29]

Our study utilises the Bowen feasibility framework that was developed to help researchers design feasibility studies that can support and prepare investigators for larger scale testing. The framework is widely adopted and cited more than 2100 times.[30] Feasibility studies are generally used to determine if a programme, intervention or policy are recommended for further testing and could have the intended effect on the outcome as hypothesized.[30]

We aimed to assess the feasibility of using video recordings as an objective tool to assess the quality of care during NR at a secondary level district hospital in a low-resource setting. To our knowledge, this is the first study that used NR video documentation performed in a district hospital in a low-resource setting with a poor and unstable power supply, unstable internet connection, and high neonatal mortality.

METHODS

Study design

The study was a prospective observational feasibility study. It was designed in preparation for the Newborn Emergency Outcome trial (NCT04093778). The study was conducted over 4 weeks in April and May 2019 at Chake-Chake District Hospital in Pemba, Zanzibar, Tanzania. The study was approved by the Zanzibar Health Research Institute (NO.ZAREC.02/APR/2019/20).

The feasibility study used Bowen's feasibility study framework with eight wide-ranging areas of attention.[30] The study assessed all of Bowen's eight focus areas; acceptability, demand, implementation, practicality, adaptation, integration, expansion, and limited-efficacy testing (table 1).[30]

Setting

Pemba is an island in the archipelago of Zanzibar with a population of 500,000. The stillbirth rate is estimated at 27.7 per 1,000 live births, and the neonatal mortality rate is approximately 16.0 per 1,000 live births.[31] The island has four district hospitals; this study includes data collected at Chake-Chake district hospital, with approximately 5000 annual deliveries.[32] The main delivery room has three

delivery beds and one resuscitation table. In addition, the hospital has a movable table for resuscitation in the operating theatre. The resuscitation tables are also used for the post-delivery observation of healthy newborns not undergoing resuscitation. At Chake-Chake Hospital, midwives are responsible for the postnatal care of all neonates, including resuscitation. The NR guidelines available in facilities were a Helping Babies Breathe poster, national guidelines provided by the Ministry of Health and WHO guidelines. The available equipment consists of gloves, bulb suction, a self-inflating bag and mask, and an oxygen source (not always available). A traditional cloths called kanga brought by the mother is available for wrapping, drying and to prevent heat loss of the newborn after delivery.

Study population

All women delivering at Chake-Chake Hospital and their newborns were eligible for participation. The women in the maternity and delivery ward were enrolled in the study as soon as possible after admission. The women could be enrolled until the expulsion phase of the second stage of labour with written or oral consent using fingerprints, and consent was confirmed post-partum. All health workers at the Chake-Chake Hospital delivery ward gave consent for participation, no economic incentives were provided. Several meetings, direct observations, informal conversations were held with prior to the study to ensure participatory commitment and equal partnership.

Data sources and management equipment

We recorded NR performance using motion-triggered Smart Cam Pro cameras installed above the radiant heater at the resuscitation tables. The cameras provided video recordings with audio, capturing whenever a newborn was placed on the resuscitation tables. The audio was only used to determine if the newborn was crying, gasping or grunting and neither conversations nor background noise were included in the analysis to avoid privacy issues. The camera had a shield around it and the image was zoomed to show only the newborn and the hands of the resuscitation team. The research assistants covered the camera if a non-consent woman gave birth, since all delivery beds shared the resuscitation table. Research assistants were present at the maternity and delivery ward 24 hours a day. The research assistants placed an individually assigned identification card on the resuscitation table just before or after the placement of the newborn. Time stamps and identification numbers were matched with the hospital register for the recorded delivery. The identification number followed the woman and her newborn until discharge. The videos were stored on an encrypted micro-SD card in the

camera, and the data were uploaded to a secure database. Only the international research team could access the videos to ensure the individual health workers' anonymity.

Postnatal questionnaire with socio-demographics, obstetric history, pregnancy information, delivery outcome, neonatal characteristics, and acceptability of video recordings were collected by research assistants on paper and entered directly into the secure data collection software RedCap (v5.12.1) on Lenovo version 7 tablets.

Outcomes and variables

We evaluated feasibility using Bowen's framework for feasibility studies (table 1).[30] All post-partum women and health workers in the maternity ward answered an acceptability question on a Likert scale. For health workers, the acceptability question was, *"How comfortable did you feel about the neonatal resuscitation being filmed?"* For post-partum women, the acceptability question was, "*How comfortable did you feel about your baby being video filmed?"* (table 2). Additionally, we conducted 18 semi-structured interviews, nine with post-partum women (one to three days after delivery) and nine with health workers in the maternity ward. The qualitative analysis is beyond the scope of this paper and will be reported in another study.

We logged and described the video recordings' practicality and technicality. An analytical framework for limited efficacy testing of quality of care indicators was developed where resuscitation procedures were scored according to guidelines.[33] The clinical appearance of the newborn was logged as no respiration = 0, gasping = 1, or breathing = 2. The clinical actions performed by the health workers were registered in a thematic template that assesses performance on; heat loss prevention, positioning of the newborn's head, clearing the airway via suction, stimulation, bag and mask ventilation, heart rate assessment, and oxygen management. Each intervention performance was assessed at three levels: properly performed procedures, inadequate procedures (delayed intervention or inadequate technique for a given procedure), and procedures omitted or performed but not indicated according to NR guidelines.

Data analysis

Videos where resuscitation with bag and mask was performed were included in the analysis. Video recordings were analysed by two independent researchers (CS and SL). If any doubts arose, the

researchers consulted with another member of the study team. A timeline of interventions while the newborn was placed on the resuscitation table and the subsequent events were produced (Figure 1). We transferred data from the video observations from Excel (version 2011, Microsoft Corporation, Washington, United States) and quantitative variables from Redcap to SPSS (version 27.0, IBM, New York, United States) for descriptive statistics. We categorized continuous variables according to common medical standards and newborn risk factors. We expressed the data as number and percentage or median and interquartile range (IQR). The translated semi-structured qualitative interviews were imported to NVivo (version 13) and analysed thematically. The full thematic qualitative analysis of the semi-structured interviews is beyond the scope of this paper and will be reported in a separate paper.

Patient and public involvement

Patients and the public were not involved in developing research questions, designing, conducting, or disseminating the study. During this research patients and staff were interviewed with semi-structured questionnaires as informants to adjust the main study with patient involvement.

Results

Participating women and health workers

During the study period, 274 women were eligible for participation, of whom 239 had spontaneous vaginal deliveries and 35 had caesarean sections (figure 1). 139 women gave consent. Of the 139 enrolled women that gave birth to 139 newborns, 101 (73%) newborns were taken to the resuscitation table and captured by the video camera, the camera was shielded if a newborn without consent was placed at the table. 44 (44%) of the newborns brought to the resuscitation table were not crying when placed there, and eight underwent resuscitation with bag and mask ventilation. Up to three newborns at a time were placed on the same resuscitation table. 26 health workers were working in the delivery ward and participated in the deliveries during the study period. Demographics of the participating women (table 3) and health workers (table 4) and delivery and birth outcomes of the newborn in (table 5).

We report feasibility according to Bowen et. al. feasibility framework using all eight areas of focus 1) Acceptability, 2) Demand, 3) Implementation, 4) Practicality, 5) Adaptation, 6) Integration, 7) Expansion, 8) Limited-efficacy testing (table 1).[30]

Acceptability of video recordings

Acceptability among the delivering women of the NR video recordings was high, with 89·7% being either very comfortable or comfortable and only one woman felt uncomfortable 0·7%, and 12 women did not answer the question. 25 of the 26 participating health workers (96·0%) responded to the question and 92.3% was either very comfortable or comfortable, only one health worker felt uncomfortable (table 2).

Practicality and technicality

We registered the practical and technical feasibility of capturing NR with motion-triggered cameras during the study period, and although the solution was technically feasible, we made several adjustments (table 1). There were some concerns regarding the camera's angle, and a shield was created around it to make it obvious to everyone that the camera was only capturing the newborn and health worker's hands. We installed a camera on a stand at the portable resuscitation table to capture the table, but this solution was suboptimal and adjusted with a more stable version. The camera ran solely on power banks, since we could not rely on the hospital's power supply. The camera had a secure encrypted SD memory card, and the video material captured was uploaded to a secure database over a Wi-Fi connection. The hospital did not have a stable Wi-Fi connection, so we installed a password-protected 4G Wi-Fi connection that ran on power banks near the resuscitation table.

Limited-efficacy testing

To study limited-efficacy (table 1), the videos were analysed to see if they added value by providing new evidence of gaps in clinical performance (table 6). Of the 139 included newborns, eight were resuscitated with bag and mask ventilation and captured on video. According to the questionnaire, further two newborns were resuscitated, but not captured on video, possibly because the resuscitation took place away from the resuscitation table or an episode occurred when the camera was shielded due to a non-consent woman giving birth simultaneously. Two other newborns were stillborn: the corresponding video showed a baby with a very low birth weight, whereas the other child was not captured on video.

The health workers report was that all newborns had been resuscitated with adequate stimulation, suction, ventilation, and heat loss prevention. The eight videos, however, showed that heat loss prevention measures were not performed in half of the resuscitations. In two cases, the head positioned incorrectly and not in a neutral position. Clearing the airway via suction was not performed correctly in six cases. As none of the cases were born in thick meconium, suction was not recommended according to NR guidelines.[33] Nevertheless, all eight were suctioned vigorously and repeatedly. None of them were stimulated correctly, either. One infant in need of ventilation was not ventilated at all, and the others were ventilated ineffectively with undue delay, wrong technique, or in short and interrupted sequences rather than as a sustained effort. In two cases, ventilation efforts were halted before regular breathing. The timeline of events of each resuscitation video showed that while six in need of resuscitation were ventilated within one minute of placement on the resuscitation table, two were not (figure 2). The average time on the resuscitation table before ventilation was 41 s (0–96). Only, one-third of the newborns in need of resuscitation were stimulated within their first minute on the resuscitation table. The average time spent on suction was 35 s (00:00–01:22). All resuscitations deviated from NR guidelines. However, all newborns who underwent resuscitation in the videos survived until discharge.

Discussion

In this study, using video recordings to assess the quality of care during NR in a low-resource setting proved feasible and provided valuable objective measures of performance in the timing of events and adherence to NR guidelines. The application was highly acceptable among the facility's delivering women and health workers, with more than 90% comfortable or very comfortable. We also found video recording practically and technically achievable, albeit operationally challenging. We found a demand from health workers to focus on NR and a need to improve NR based, and our limited efficacy testing on performance gaps supports this. We conclude that the study can be expanded to include all district hospitals in Pemba as planned in the NEO-study. The efficacy testing of video recordings suggested that it may provide added value. In Chake-Chake District Hospital, performance in NR was sub-optimal, as was adherence to NR guidelines.

The need for clinical management assessments during actual NR and related training programs for all healthcare workers involved in the management of newborns is undeniable. Nearly all neonatal

deaths attributed to intrapartum-related events occur in LMICs and may constitute of up to 60% of neonatal deaths in primary facilities and secondary level hospitals.[34] Among the survivors of intrapartum-related events, 1 million may develop cerebral palsy or other disabilities each year.[35] NR is an emergency associated with high stress among health workers, resulting in frequent medical errors and lack of adherence to guidelines. The noted deviations from guidelines are in line with studies that also used a video review process to analyse NR in high-income countries.[17] Schilleman et al. found in a study from 2012 that only 21% of recorded resuscitations were performed entirely according to local guidelines, and McCarthy et al. reported in a study from 2013 that the recommended NR timeline is rarely followed in real-life resuscitations.[17 19] Yamada et al. (2015) similarly classified and quantified the types of errors observed in 250 NR recordings in their institution.[36] They identified a 23% error rate for all tasks determined to be important elements of the NR algorithm. Errors similar to our study included omission of tasks that according to guidelines were indicated or tasks that were performed although not indicated, with incorrect timing or technique. Deviations from guidelines were more common and could consist of tasks that were performed but not indicated, tasks performed at the incorrect time, or tasks performed but following an improper technique.

To our knowledge, the study is the first to use video recordings of NR in a secondary district level hospital in a low-income country. Video has been used as a component of development and assessment of training interventions for health worker performance and was found feasible in tertiary hospitals in Nepal and Mozambique.[23 24] In a study from 2017 from Nepal, Wrammert et al. compared the resuscitation practices of low and normal birthweight infants using video camera recordings, noting crying, stimulation, ventilation, suctioning, and oxygen administration during resuscitation.[24] In as study from 2015 from Mozambique, Trevisanuto et al. similarly used video recordings of 100 resuscitations to assess the effect of an adapted NR program course on healthcare providers' performance, finding a significant improvement in resuscitation scores in all levels of resuscitation from before and after the course.[23] In a study from 2020 from Uganda, Pejovic et al. used video recordings to assess the effect of a specific intervention ventilation with face masks versus laryngeal masks. It concluded that laryngeal mask reduced time to spontaneous breathing compared with face mask during newborn resuscitation in a low-resource setting.[28]

There is not a standardized method or approach analysing NR performance videos. Carabine et al. developed a scoring system used in a high-income setting in a study from 2000, which Trevisanuto et al. adapted to a low-resource setting in 2015.[17 23] We were inspired by these systems but had to further adjust them due to our study occurring in a secondary level facility in a low-resource setting.

The limited-efficacy testing in our study was positive. We found the video recordings usable for objective assessments of health worker performance, detail, and timeliness during actual NR resuscitations. In our study, NR performance was sub-optimal, particularly for essential NR interventions such as stimulation, suction, and bag and mask ventilation. Similarly, Lindbäcket et al. identified guideline deviations in over 50% of resuscitations in a tertiary hospital in Nepal in a study from 2015.[29] We found that bag and mask ventilation in particular was inadequately performed, and suction was excessive and used vigorously even when not medically indicated. These findings are in line with other studies that followed a video review process to analyse NR performance in LMICs.[17 20] Lindbäcket et al. also noted excessive use of oxygen, which we did not, likely because our setting was a secondary level facility with limited access to oxygen therapy due to an insufficient supply chain, and only one oxygen dispenser available for the whole hospital.[29] A further important finding of the present study concerns the timeline of resuscitation, where initiation and the duration of all procedures were inconsistent with the times recommended by guidelines.

25% of newborns in need of resuscitation did not have bag and mask ventilation initiated within the first minute of life. In a study from Mozambique Pietravalle et al. examined tactile stimulation in a study from 2018 and, similar to our findings, found that multiple stimulation techniques were administered in two-thirds of neonates (64.7%), while recommended techniques (rubbing the back or flicking the soles of the feet) occurred in less than 10% (8.8%). The median stimulation duration was 17 s (IQR 9–33)[25], which is much shorter than our study, where the median time was 75 s (IQR 90). Gaertner et al. evaluated video recordings of 75 stimulated infants, including early preterm infants in a study from 2018, and suggested that truncal stimulation (drying, chest rubs, and back rubs) might be more effective than foot flicks.[21]

The limited combined experiences indicate that videos of clinical performance during actual NR in LMICs provide valuable objective information to improve quality of care and patient safety and survival. Improving this requires focus. Identifying errors during real-life situations can drive the type of training and guideline adjustments needed, such as an enhanced focus on avoiding excessive and

unnecessary suction practices, stimulation techniques, timely and sustained positive pressure, and bag and mask ventilation techniques.[23 37-39] Despite an unstable power connection, the video recordings were technically possible through backup power sources in our setting. Our intervention was low-cost and relatively easy to install. Like other studies, we used cameras that activated automatically, which did not interfere with the resuscitation process and thus took focus from the neonate. Others in more resourceful settings have used multiple cameras for different angles that include the neonate, healthcare professionals delivering care, and equipment being used.[40] Due to ethical, privacy and logistical reasons, this was not feasible in our setting.

There is a need for research in the improvement of the quality of NR in low-resource facilities with local adaptation of clinical guidelines based on the actual clinical reality of health workers, adapted training programs, and scarce resources considered. Challenges in many LMIC are diverse and our study reiterates the need for locally adapted guidelines with the clinical reality in mind as discussed by Maaloe et. Al in a viewpoint from 2021.[41]

Few qualitative studies explore health providers' attitudes towards the video recording of NR.[17 42 43] We found that healthcare workers in general adapted quickly to the presence of the camera and their acceptability was high, as was that for delivering women.[17] An extensive qualitative study from 2018 from the Netherlands and United States with 49 semi-structured interviews concluded that recording and reviewing NR is highly beneficial for learning and improving resuscitation skills and is considered acceptable by clinical staff.[43] Parents and health workers have generally accepted that recordings may be created for better patient safety, quality improvement, and education both in studies from Nepal, the Netherlands, and the United States.[43 44] Video recordings during emergencies can create controversy, and therefore privacy concerns, medicolegal consequences, storage, and consent must be discussed before implementation.[45] Some programs in high-income countries include a statement in the general admission consent stating that photography and video recording for patient safety, quality improvement, and professional training purposes may occur in the hospital. However, general consent forms at admission are not a widespread practice in LMIC facilities. Consent in emergency research and consent during labour and childbirth is challenging with many ethical aspects and some true dilemmas. Ideally the woman should be informed in a quiet manner in an antenatal visit, but this method was not possible in our setting, and will disturb many pregnant women unnecessarily, and will miss those who do not come for antenatal visits. The consent process was

discussed back and forth between the research team and the local ethical committee, and we agreed on consent until the expulsion phase, with an emphasis on confirmation of consent post-partum, while a waiver of consent was not deemed acceptable in the local context.

Strengths and limitations

The study's main strengths are the prospective study design and the large population size for a feasibility study. Video recordings of neonatal resuscitation both circumvents the ethical paradox of direct clinical observations and could minimize the Hawthorne effect after an adjustment period.

Our study had some limitations. The observers assessing the same video images may have differences in their assessment of the clinical situation involving NR, this was not the case our study, since the videos were scored in collaboration, but this might not be possible in larger studies with a greater volume of videos. Other studies have investigated inter-rater reliability and displayed a high (above 90%) reliability for the use of bag and mask ventilation and suctioning, but lower reliability for oxygen administration and stimulation.[44] The most sensitive indicator of resuscitation being successful is an increase in the newborn's heart rate. We did not assess heart rate or oxygenation in our resuscitation study since the equipment is not available in the local context, which could have been valuable when assessing the health workers' resuscitation efforts and outcomes. Due to local ethical committee regulations, our study asked the delivering women for their prospective consent. More than 36% of the women were not approached for consent due to being in too much pain, late presentation at the hospital or an obstetric emergency. Indeed, these newborns have an increased risk of the need for resuscitation, intrapartum stillbirth, and asphyxiation, and hence high-level emergencies may not be included in our feasibility study due to the prospective enrolment process.[46] This is a bias, and the finding in this feasibility study may not necessarily mimic newborns' actual situation and challenges, and the results may underestimate the need for NR. An alternative approach used in other studies is a waiver of consent, where consent is obtained before delivery when possible; otherwise, researchers seek retrospective consent.[47]

Conclusion

Video recording of neonatal resuscitation at a district hospital in a resource-limited setting was feasible and provided vital information on the quality and timeliness of provided care.

The unstable power supply and lack of reliable internet connection created practical and technical challenges but were manageable. The efficacy testing was positive in assessments of health worker

performance and adherence to NR guidelines. All recorded resuscitations demonstrated deviations from NR guidelines, and although all eight infants were manually ventilated as required and all infants survived to discharge, the ventilation was started too late, stopped too early, or delivered ineffectively. More research is still needed in the use of video recordings to assess and improve the quality of NR.

Data availability statement

Data are available from the corresponding author upon reasonable request.

Ethics approval and participant consent

The study was approved by the Zanzibar Health Research Institute (NO.ZAREC.02/APR/2019/20). Each participant received information about the purpose of the study and informed consent was obtained from all participants.

Patient consent for publication

Not applicable.

Contributors

SL, AP, CCHH and GG conceived the idea for the study. CCHH, TBS, ML, MK, SM, SMA collected the data. CCHH and SL wrote the first draft of the manuscript. The data has been verified by CCHH, TM and SL, statistical analysis was performed by CCHH, CS and SL. CS and SL developed the framework and analysed the resuscitation videos. CCHH, SA and SMA were the principal investigators of the study. AP, GG, TBS, ML, MK, SM, SMA, JK, CMB reviewed and revised the manuscript. All authors read and approved the version final manuscript

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Competing interests

None.

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REFERENCES

1. Wang H, Bhutta ZA, Coates MM, et al. Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet* 2016;388(10053):1725-74. doi: 10.1016/s0140-6736(16)31575-6
2. Lawn JE, Blencowe H, Waiswa P, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. *The Lancet* 2016;387(10018):587-603. doi: 10.1016/s0140-6736(15)00837-5
3. Lawn JE, Blencowe H, Oza S, et al. Every Newborn: progress, priorities, and potential beyond survival. *The Lancet* 2014;384(9938):189-205. doi: 10.1016/s0140-6736(14)60496-7
4. Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: When? Where? Why? *The Lancet* 2005;365(9462):891-900. doi: 10.1016/s0140-6736(05)71048-5
5. Economic UNDo, Affairs S. The Sustainable Development Goals Report 2016: United Nations 2016.
6. Hug L, Alexander M, You D, et al. National, regional, and global levels and trends in neonatal mortality between 1990 and 2017, with scenario-based projections to 2030: a systematic analysis. *The Lancet Global Health* 2019;7(6):e710-e20. doi: 10.1016/s2214-109x(19)30163-9
7. Bhutta ZA, Das JK, Bahl R, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? *The Lancet* 2014;384(9940):347-70. doi: 10.1016/s0140-6736(14)60792-3
8. Wall SN, Lee AC, Niermeyer S, et al. Neonatal resuscitation in low-resource settings: what, who, and how to overcome challenges to scale up? *Int J Gynaecol Obstet* 2009;107 Suppl 1(Suppl 1):S47-62, s63-4. doi: 10.1016/j.ijgo.2009.07.013 [published Online First: 2009/10/10]
9. Ades A, Lee HC. Update on simulation for the Neonatal Resuscitation Program. *Semin Perinatol* 2016;40(7):447-54. doi: 10.1053/j.semperi.2016.08.005 [published Online First: 2016/11/09]
10. Sawyer T, Lee HC, Aziz K. Anticipation and preparation for every delivery room resuscitation. *Semin Fetal Neonatal Med* 2018;23(5):312-20. doi: 10.1016/j.siny.2018.06.004 [published Online First: 2018/10/30]
11. Palme-Kilander C. Methods of resuscitatoin in low-Apgar-score newborn infants - a national survey. *Acta Paediatric* 1992;81(10):739-44.
12. Niermeyer S, Little GA, Singhal N, et al. A Short History of Helping Babies Breathe: Why and How, Then and Now. *Pediatrics* 2020;146(Suppl 2):S101-S11. doi: 10.1542/peds.2020-016915C [published Online First: 2020/10/03]

13. Lee AC, Cousens S, Wall SN, et al. Neonatal resuscitation and immediate newborn assessment and stimulation for the prevention of neonatal deaths: a systematic review, meta-analysis and Delphi estimation of mortality effect. *BMC Public Health* 2011;11 Suppl 3(Suppl 3):S12. doi: 10.1186/1471-2458-11-s3-s12 [published Online First: 2011/04/29]
14. Carlo WA, Wright LL, Chomba E, et al. Educational impact of the neonatal resuscitation program in low-risk delivery centers in a developing country. *J Pediatr* 2009;154(4):504-08.e5. doi: 10.1016/j.jpeds.2008.10.005 [published Online First: 2008/12/09]
15. Singhal N, McMillan DD, Savich R, et al. Development and Impact of Helping Babies Breathe Educational Methodology. *Pediatrics* 2020;146(Suppl 2):S123-s33. doi: 10.1542/peds.2020-016915E [published Online First: 2020/10/03]
16. Morris SM, Fratt EM, Rodrigues J, et al. Implementation of the Helping Babies Breathe Training Program: A Systematic Review. *Pediatrics* 2020;146
17. Carbine DN, Finer NN, Knodel E, et al. Video Recordings as a Means of Evaluating Neonatal Resuscitation Performance. *Pediatrics* 2000;106(4)
18. Shivananda S, Twiss J, El-Gouhary E, et al. Video recording of neonatal resuscitation: A feasibility study to inform widespread adoption. *World J Clin Pediatr* 2017;6(1):69-80. doi: 10.5409/wjcp.v6.i1.69 [published Online First: 2017/02/23]
19. Schilleman K, Siew ML, Lopriore E, et al. Auditing resuscitation of preterm infants at birth by recording video and physiological parameters. *Resuscitation* 2012;83(9):1135-9. doi: 10.1016/j.resuscitation.2012.01.036 [published Online First: 2012/02/11]
20. Maya-Enero S, Botet-Mussons F, Figueras-Aloy J, et al. Adherence to the neonatal resuscitation algorithm for preterm infants in a tertiary hospital in Spain. *BMC Pediatr* 2018;18(1):319. doi: 10.1186/s12887-018-1288-3 [published Online First: 2018/10/12]
21. Gaertner VD, Flemmer SA, Lorenz L, et al. Physical stimulation of newborn infants in the delivery room. *Arch Dis Child Fetal Neonatal Ed* 2018;103(2):F132-F36. doi: 10.1136/archdischild-2016-312311 [published Online First: 2017/06/11]
22. Sedgwick P, Greenwood N. Understanding the Hawthorne effect. *BMJ* 2015;351:h4672. doi: 10.1136/bmj.h4672 [published Online First: 2015/09/06]
23. Trevisanuto D, Bertuola F, Lanzoni P, et al. Effect of a Neonatal Resuscitation Course on Healthcare Providers' Performances Assessed by Video Recording in a Low-Resource Setting. *PLoS One* 2015;10(12):e0144443. doi: 10.1371/journal.pone.0144443 [published Online First: 2015/12/15]
24. Wrammert J, Zetterlund C, Kc A, et al. Resuscitation practices of low and normal birth weight infants in Nepal: an observational study using video camera recordings. *Glob Health Action* 2017;10(1):1322372. doi: 10.1080/16549716.2017.1322372 [published Online First: 2017/06/03]
25. Pietravalle A, Cavallin F, Opocher A, et al. Neonatal tactile stimulation at birth in a low-resource setting. *BMC Pediatr* 2018;18(1):306. doi: 10.1186/s12887-018-1279-4 [published Online First: 2018/09/22]
26. Cavicchiolo ME, Cavallin F, Bertuola F, et al. Effect of a Low-Dose/High-Frequency Training on Real-Life Neonatal Resuscitation in a Low-Resource Setting. *Neonatology* 2018;114(4):294-302. doi: 10.1159/000490370 [published Online First: 2018/07/17]
27. Kc A, Wrammert J, Clark RB, et al. Reducing Perinatal Mortality in Nepal Using Helping Babies Breathe. *Pediatrics* 2016;137(6) doi: 10.1542/peds.2015-0117 [published Online First: 2016/05/27]

28. Pejovic NJ, Myrnerts Hook S, Byamugisha J, et al. A Randomized Trial of Laryngeal Mask Airway in Neonatal Resuscitation. *N Engl J Med* 2020;383(22):2138-47. doi: 10.1056/NEJMoa2005333 [published Online First: 2020/12/01]
29. Lindback C, Kc A, Wrammert J, et al. Poor adherence to neonatal resuscitation guidelines exposed; an observational study using camera surveillance at a tertiary hospital in Nepal. *BMC Pediatr* 2014;14:233. doi: 10.1186/1471-2431-14-233 [published Online First: 2014/09/18]
30. Bowen DJ, Kreuter M, Spring B, et al. How we design feasibility studies. *Am J Prev Med* 2009;36(5):452-7. doi: 10.1016/j.amepre.2009.02.002 [published Online First: 2009/04/14]
31. group AfMaNHIAms. Population-based rates, timing, and causes of maternal deaths, stillbirths, and neonatal deaths in south Asia and sub-Saharan Africa: a multi-country prospective cohort study. *Lancet Glob Health* 2018;6(12):e1297-e308. doi: 10.1016/s2214-109x(18)30385-1 [published Online First: 2018/10/27]
32. Health ZMo. The Zanzibar Annual Health Bulletin 2017, 2017.
33. Organization WH. WHO Recommendations on Newborn Health, Guidelines Approved by the WHO Guideliens Review Committee. . 2017
34. Ersdal HL, Mduma E, Svensen E, et al. Birth asphyxia: a major cause of early neonatal mortality in a Tanzanian rural hospital. *Pediatrics* 2012;129(5):e1238-43. doi: 10.1542/peds.2011-3134 [published Online First: 2012/04/18]
35. Liu L, Johnson HL, Cousens S, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet* 2012;379(9832):2151-61. doi: 10.1016/s0140-6736(12)60560-1 [published Online First: 2012/05/15]
36. Yamada NK, Yaeger KA, Halamek LP. Analysis and classification of errors made by teams during neonatal resuscitation. *Resuscitation* 2015;96:109-13. doi: 10.1016/j.resuscitation.2015.07.048 [published Online First: 2015/08/19]
37. Maya-Enero S, Botet-Mussons F, Figueras-Aloy J, et al. Adherence to the neonatal resuscitation algorithm for preterm infants in a tertiary hospital in Spain. *BMC Pediatr* 2018;18(1):319. doi: 10.1186/s12887-018-1288-3 [published Online First: 2018/10/12]
38. Skåre C, Boldingh AM, Kramer-Johansen J, et al. Video performance-debriefings and ventilation-refreshers improve quality of neonatal resuscitation. *Resuscitation* 2018;132:140-46. doi: 10.1016/j.resuscitation.2018.07.013 [published Online First: 2018/07/17]
39. Odongkara B, Tylleskär T, Pejovic N, et al. Adding video-debriefing to Helping-Babies-Breathe training enhanced retention of neonatal resuscitation knowledge and skills among health workers in Uganda: a cluster randomized trial. *Glob Health Action* 2020;13(1):1743496. doi: 10.1080/16549716.2020.1743496 [published Online First: 2020/06/12]
40. Gelbart B, Hiscock R, Barfield C. Assessment of neonatal resuscitation performance using video recording in a perinatal centre. *J Paediatr Child Health* 2010;46(7-8):378-83. doi: 10.1111/j.1440-1754.2010.01747.x [published Online First: 2010/06/16]
41. Maaløe N, Ørtved AMR, Sørensen JB, et al. The injustice of unfit clinical practice guidelines in low-resource realities. *The Lancet Global Health* 2021;9(6):e875-e79. doi: 10.1016/s2214-109x(21)00059-0

42. Carbine DN, Finer NN, Knodel E, et al. Video recording as a means of evaluating neonatal resuscitation performance. *Pediatrics* 2000;106(4):654-8. doi: 10.1542/peds.106.4.654 [published Online First: 2000/10/04]
43. den Boer MC, Houtlosser M, Foglia EE, et al. Benefits of recording and reviewing neonatal resuscitation: the providers' perspective. *Arch Dis Child Fetal Neonatal Ed* 2019;104(5):F528-f34. doi: 10.1136/archdischild-2018-315648 [published Online First: 2018/12/07]
44. Lindbäck C, Kc A, Wrammert J, et al. Poor adherence to neonatal resuscitation guidelines exposed; an observational study using camera surveillance at a tertiary hospital in Nepal. *BMC Pediatr* 2014;14:233. doi: 10.1186/1471-2431-14-233 [published Online First: 2014/09/18]
45. den Boer MC, Houtlosser M, van Zanten HA, et al. Ethical dilemmas of recording and reviewing neonatal resuscitation. *Arch Dis Child Fetal Neonatal Ed* 2018;103(3):F280-f84. doi: 10.1136/archdischild-2017-314191 [published Online First: 2018/01/22]
46. Lawn JE, Blencowe H, Waiswa P, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. *Lancet* 2016;387(10018):587-603. doi: 10.1016/s0140-6736(15)00837-5 [published Online First: 2016/01/23]
47. Health ZMo. The Zanzibar Annual Health Bulletin 2016, 2016.

Figure 1. Flowchart of the study population

Figure 2. Timeline of interventions in the eight infants who were manually ventilated during resuscitation
The first line per case is the interventions performed. The second line represents a breathing score where red = 0 (no breathing), yellow = 1 (gasping), green = 2 (breathing).

Table 1. Bowen acceptability framework (adapted)

Area of focus	Definitions according to Bowen[30]	**Outcomes of interest from results from the current NEO feasibility study**
1. Acceptability	- To what extent will participants accept the new idea?	- Acceptability of video recordings with a Likert acceptability scale question for all women and health workers - Acceptability interview with mothers and health workers
2. Demand	- Is there a demand? - Is it Fit within the? organizational culture	- Perceived demand for focus on neonatal resuscitation by health workers - Appropriate within the organizational culture - Desperate need for improvement of neonatal resuscitation practice - Exploratory and participatory meetings and workshops with staff before the design of the study - Exploratory meetings with stakeholders, policymakers, and officials from the Ministry of Health -
3. Implementation	- Can the new idea be successfully implemented?	- Recordings of NR can be implemented - There is an ability of the study team to carry out and implement the study at the health facility
4. Practicality	- Implementation with existing means, resources, and circumstances?	- Awareness of technical challenges - The extent where the video recordings are possible in the context - Efficiency, speed, and quality of implementation setting with an unstable power source and unstable internet

5. Adaptation	- To what extent can a new idea perform when changes are made for a new format? - Degree to which similar outcomes are obtained in a new format?	- The extent where video recordings are possible when a non-consent woman is in the delivery room - The extent to video recordings can be implemented without effect on clinical work
6. Integration	- To what extent can it be integrated into the existing system?	- Fit within existing infrastructure. - Video recordings work in a local context with no influence on workflow
7. Expansion	- To what extent can the method be expanded?	- Positive effects on the health system explored - Possible expansion with all practical factors considered - The extent to which video recordings of NR can be scaled up or in more facilities
8. Limited-efficacy testing	- Does the new idea show promise of being successful in the intended populations? - Intended effects on key intermediate variables	- The added value of video recordings to assess the quality of NR. - Small-scale analysis of NR videos and development of a thematic template scoring system

Table 2. Acceptability of video recordings during neonatal resuscitation		
Women		n = 139 (%)
	Very comfortable	26 (18.7)
	Comfortable	100 (71.9)
	Neither comfortable nor uncomfortable	0 (0.0)
	Uncomfortable	1 (0.7)
	Very uncomfortable	0 (0.0)
	Data missing	12 (8.6)
Health workers		**n = 26 (%)**
	Very comfortable	10 (38.5)
	Comfortable	14 (53.8)
	Neither comfortable nor uncomfortable	0 (0.0)
	Uncomfortable	1 (3.8)
	Very uncomfortable	0 (0.0)
	Missing	1 (3.8)

Table 3. Characteristics of the participating women		
Demographics		n = 139 (%)
Age distribution		
	< 20 years	13 (9.4)
	20–29 years	83 (59.7)
	30–39 years	34 (24.5)
	> 40 years	0 (0.0)
	Unknown	9 (6.5)
Civil status		
	Married	138 (99.3)
	Single	0 (0.0)
	Unknown	1 (0.7)
Education		
	None	1 (0.7)
	Primary	19 (13.7)
	Secondary	106 (76.3)
	> Secondary	12 (8.6)
	Unknown	1 (0.7)
Parity		
	Primiparous	34 (24.5)
	Multiparous (2–4)	67 (48.2)
	Grand multiparous (> 5)	37 (26.6)
	Unknown	1 (0.7)
Antenatal care visits		

	Did not attend	0
	1–3	48 (34.5)
	> 4	86 (61.9)
	Unknown	5 (3.6)
Previous Caesarean Section		
	Yes	9 (6.5)
	No	122 (87.8)
	Unknown	7 (5.0)

Table 4. Participating health workers

		n = 26 (%)
Gender		
	Female	23 (88.5)
	Male	3 (11.5)
Age		
	< 30 years	11 (42.3)
	30–50 years	13 (50.0)
	> 50 years	2 (7.7)
Education		
	General nurse	8 (30.8)
	Nurse midwife	8 (30.8)
	Medical doctor	3 (11.5)
	Clinical officer	3 (11.5)
	Assistant nurse	4 (15.4)
Years since graduation		

	< 5	19 (73.1)
	5–10	3 (11.5)
	> 10	4 (15.4)
Number of deliveries in the month prior to the study		
	< 5	3 (11.5)
	6–20	8 (30.8)
	> 20	15 (57.7)
Post-graduate Neonatal Resuscitation course		
	Yes	15 (57.7)
	No	11 (42.3)

Table 5. Delivery and neonate characteristics at birth			
		Not resuscitated n = 131 (%)	Resuscitated n=8 (%)
Mode of delivery			
	Spontaneous vaginal delivery	121 (92.4)	**7 (87.5)**
	Assisted vaginal delivery	1 (0.7)	**0 (0)**
	Caesarean section	9 (6.9)	**1 (12.5)**
Presentation			
	Cephalic	123 (93.9)	**5 (62.5)**
	Breech	4 (3.1)	**3 (37.5)**
	Other	1 (0.8)	**0 (0)**
	Unknown	3 (2.3)	**0 (0)**
Born in thick meconium			
	Yes	5 (3.8)	**0 (0)**
	No	108 (82.4)	**8 (100)**
	Unknown	18 (13.7)	**0 (0)**
Foetal heart rate at the admission of the delivering woman			
	Yes	127 (96.9)	**8 (100)**
	No	4 (3.1)	**0 (0)**
Neonate status at birth			
	Alive at birth	127 (96.9)	**8 (100)**
	Stillbirth fresh	2 (1.5)	**0 (0)**
	Stillbirth macerated	2 (1.5)	**0 (0)**
Gender			

	Male	62 (47.3)	**3 (37.5)**
	Female	69 (52.7)	**5 (62.5)**
Birthweight, grams			
	< 1500	1 (0.8)	**0 (0)**
	1500–2500	17 (13.0)	**3 (37.5)**
	2501–4000	108 (82.4)	**5 (62.5)**
	> 4000	4 (3.1)	**0 (0)**
	Data missing	1 (0.8)	**0 (0)**

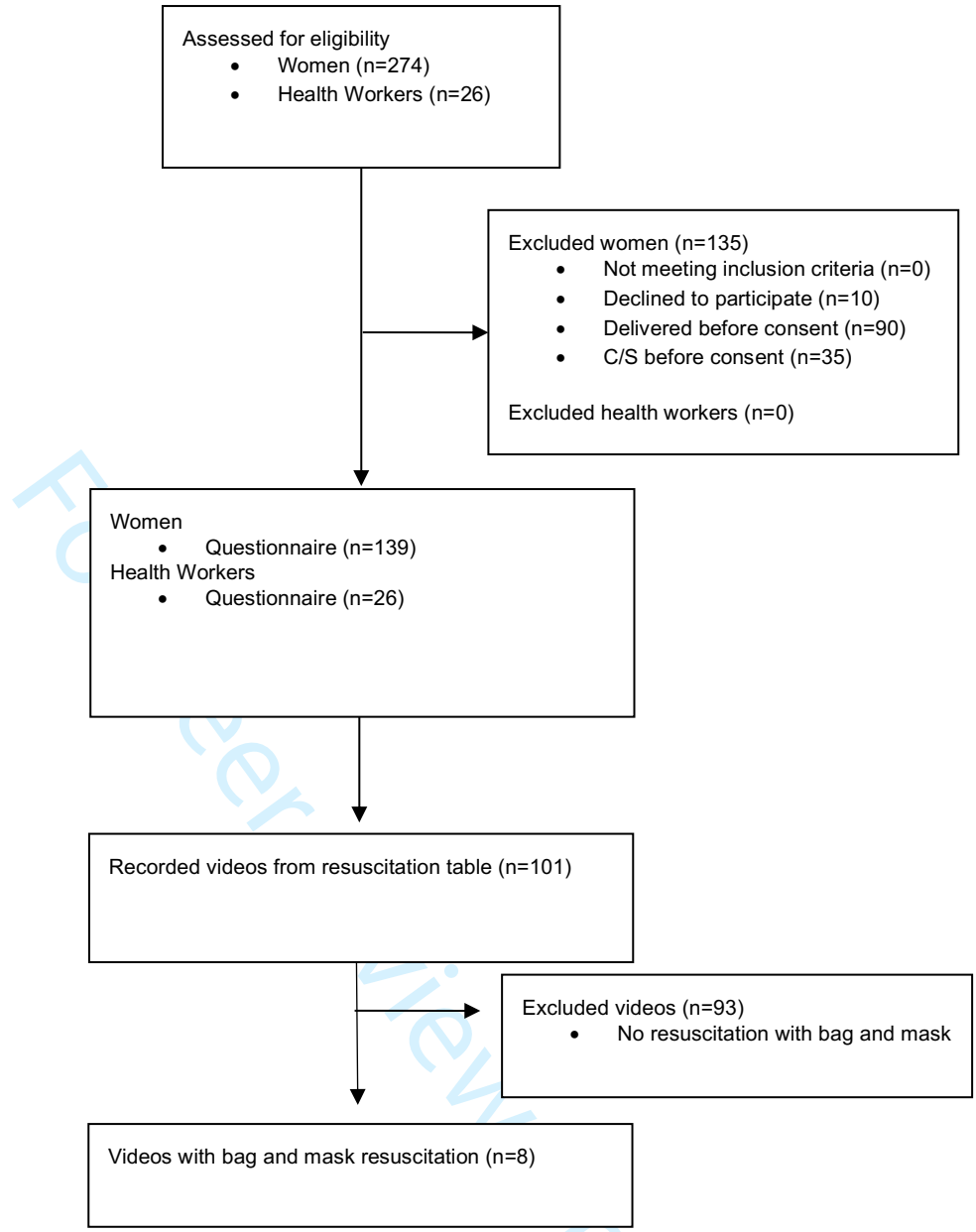
Table 6. Quality of resuscitation assessed by video recordings in 0–15 min of life

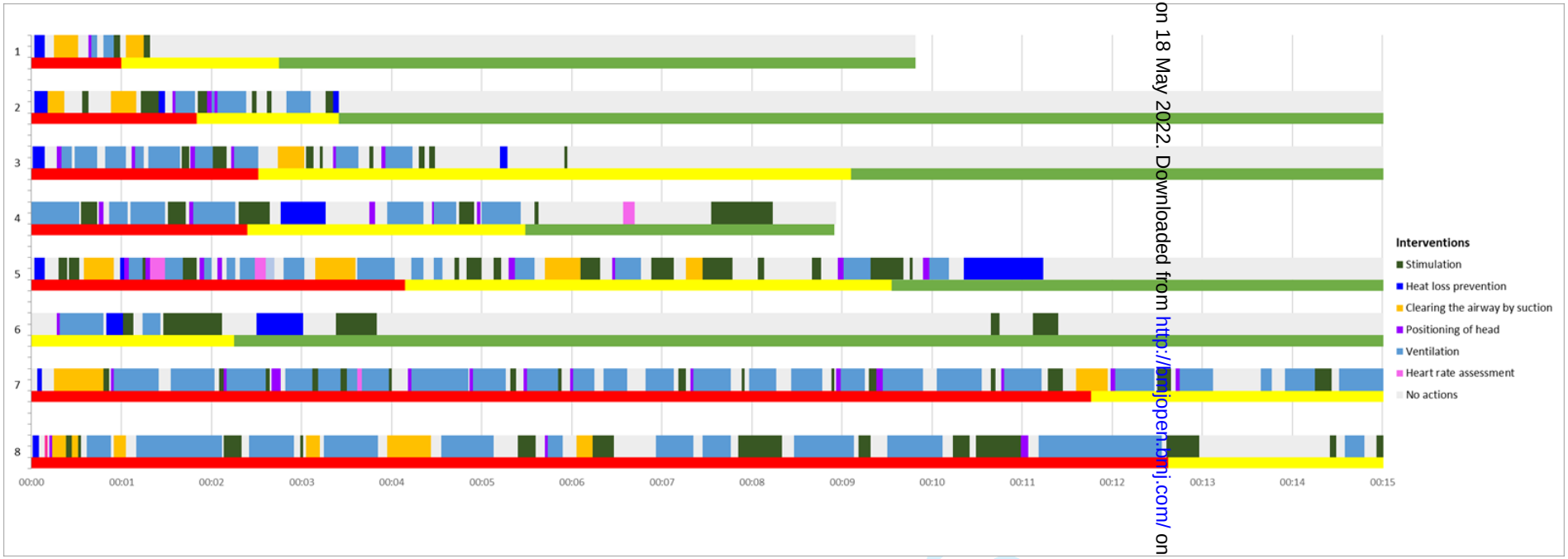
	n = 8 (%)	Median (IQR)
Heat loss prevention		
Not performed	4 (50)	
Inadequately performed *(Newborn dried with cloth but cloth not replaced by a new one; head not covered)*	2 (25)	
Well performed *(Newborn dried and cloth replaced; wrapped and head covered)*	2 (25)	
Time to first intervention		2 s (14 s)
Number of interventions/newborn		3 (2)
Total time spent on heat loss prevention		31 s (27 s)
Positioning of head		
Not performed	0 (0)	
Inadequately performed *(Head hyperextended or bent to the side)*	2 (25)	

Well performed *(Head in a sniffing position)*	6 (75)	
Time to first intervention		42 s (38 s)
Number of interventions/newborn		5 (4)
Total time spent on positioning of the head		12 s (11 s)
Clearing the airway via suction		
Not performed when indicated (meconium)	0 (0)	
Inadequately performed *(Done after the first minute of life; longer than 5 s; incorrect order (nasal suction before oral); excessive number of times)*	5 (63)	
Well performed (*or not performed when not indicated)*	3 (27)	
Time to first intervention		16 s (15 s)
Number of interventions/newborn		2 (2)
Total time spent on suction		41 s (36 s)
Stimulation		
Not performed *(Indicated when inactive, apnoeic/not spontaneously breathing or gasping)*	1 (22)	
Inadequately performed *(Stimulation performed on other places than the back or soles of the feet; too aggressively; excessive number of times)*	7 (88)	
Well performed	0 (0)	
Time to first intervention		41 s (26 s)
Number of interventions/newborn		7 (10)
Total time spent on stimulation		75 s (90 s)
Bag and mask ventilation		
Not performed	1 (22)	
Inadequately performed *(Initiation after the first minute of life; incorrect mask size; incorrect rate (not 40–60 rpm); incorrect technique (mask turned wrong*	7 (88)	

way); mask leak; not re-evaluated for response after 30 s; undue delay; short interrupted sequences)		
Well performed	0 (0)	
Time to first intervention		39 s (38 s)
Number of interventions/newborn		8 (11)
Total time spent on bag and mask ventilation		130 s (181 s)
Heart rate assessment		
Not performed	7 (88)	
Inadequately performed *(Performed by feeling the umbilicus)*	1 (22)	
Well performed *(Performed with stethoscope)*	0 (0)	
Time to first intervention		148 s (200 s)
Number of interventions/newborn		1 (0)
Total time spent on heart rate assessment		5 s (7 s)

The number of interventions refers to the number of (separate) episodes of that intervention. s=seconds





STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	5
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5 & 6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*6*
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7&8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	Figure 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8 &18
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	19, 24&25
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13 &14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.