Abstract:

Background

Functional referral system including pre referral care, access to emergency transport and ensuring continuity of care between facilities is critical for improved newborn health outcome. This study assessed the admission clinical status, transportation factors and outcomes of referred neonates at Muhimbili National Hospital (MNH), a tertiary facility in Dar es Salaam, Tanzania.

Methods

A descriptive cross sectional study with a longitudinal follow up was conducted from September 2020 to February 2021, including all neonates received at MNH. A structured questionnaire was used to collect demographic characteristics and transport factors were extracted from the referral documents and by interviewing caregivers or escorting person/nurse. Ambulances were directly observed using a structured checklist on presence, absence and functionality of supportive care during transportation. All enrolled neonates had a clinical assessment at admission and 48 hours post admission to determine 48 hours’ clinical outcome as either survived/died.

Results

Out of the 348 neonates assessed during the study period, the median gestation age was 38 weeks (IQR 32, 39) with the mean birth weight of 2461 ± 936 g. Pre referral documentation showed that temperature was measured in 176 (57.1%), oxygen saturation and random blood glucose in only 143 (46.6%) and 116 (36.2%) neonates respectively. Ambulance was used as a means of transportation among 308 (88.5%) neonates. While no ambulance had an incubator only 7 (2.0%) neonates were kept on a Kangaroo Mother Care (KMC) position. Monitoring enroute was done to only 94 (27%) of the transferred neonates. On arrival, the clinical status of the neonates was as follows; 115 (33%) hypothermic, 74 (21.3%) hypoxic, 30 (8.6%) with poor perfusion and 49 (14.1%) hypoglycemic. Those with hypothermia (< 36.50C), were two times more likely to die compared to those normothermic neonates (OR=2.09, 95% CI (1.05-4.20), p=0.037). Thirty-eight (50.7%) of those who had hypoxia (SPO2 < 90%) at arrival died compared to 37 (49.3%) of those who were not hypoxic (OR=2.88, 95%CI (1.44-5.74), p=0.003). Twenty-one (67.7%) neonates with prolonged capillary refill time (CRT) died compared to ten (32.3%) who survived (OR=4.76, 95%CI (1.80-12.58), p=0.002). Out of forty-nine neonates who arrived with hypoglycemia (RBG < 2.5mmol/l) twenty-one (42.9%) died in the first 48 hours (OR=2.13, 95%CI (0.96-4.74), p=0.064). Additionally, neonates who had hyperglycemia (RBG > 8.3mmol/l) on arrival were three times more likely to die compared to those who were euglycemic [(OR= 3.10, 95% CI (1.19 – 8.09) p=0.021]. Overall mortality was 22.4% within 48 hours of admission and risk of dying increase as the presence of poor clinical status add on.
Conclusion

Neonatal transportation in Dar es Salaam, Tanzania was observed to be challenging. Pre transfer care and monitoring during transportation was inadequate and this contributed to poor clinical status on admission. Hypothermia, hypoglycemia, hyperglycemia, hypoxia and poor perfusion on admission were associated with increased mortality.

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Permission to carry out the study was sought from the Muhimbili University of Health and Allied Sciences (MUHAS) Institutional Review Board (IRB) with an approval number MUHAS-REC-07-2020-306. Written informed consent to participate in the study was sought from both the parent/guardian and health care personnel who escorted the neonate prior to any study procedure. Illiterate parents/guardians were asked for a witness who participated within the discussion prior to obtaining their thumbprints and witness signature. All neonates received appropriate treatment according to the national treatment guidelines of Tanzania regardless of participation.
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Abstract

Background: Functional referral system including pre referral care, access to emergency transport and ensuring continuity of care between facilities is critical for improved newborn health outcome. This study assessed the admission clinical status, transportation factors and outcomes of referred neonates at Muhimbili National Hospital (MNH), a tertiary facility in Dar es Salaam, Tanzania.
Methods: A descriptive cross sectional study with a longitudinal follow up was conducted from September 2020 to February 2021, including all neonates received at MNH. A structured questionnaire was used to collect demographic characteristics and transport factors were extracted from the referral documents and by interviewing caregivers or escorting person/nurse. Ambulances were directly observed using a structured checklist on presence, absence and functionality of supportive care during transportation. All enrolled neonates had a clinical assessment at admission and 48 hours post admission to determine 48 hours’ clinical outcome as either survived/died.

Results: Out of the 348 neonates assessed during the study period, the median gestation age was 38 weeks (IQR 32, 39) with the mean birth weight of 2461 ± 936 g. Pre referral documentation showed that temperature was measured in 176 (57.1%), oxygen saturation and random blood glucose in only 143 (46.6%) and 116 (36.2%) neonates respectively. Ambulance was used as a means of transportation among 308 (88.5%) neonates. While no ambulance had an incubator only 7 (2.0%) neonates were kept on a Kangaroo Mother Care (KMC) position. Monitoring enroute was done to only 94 (27%) of the transferred neonates. On arrival, the clinical status of the neonates was as follows; 115 (33%) hypothermic, 74 (21.3%) hypoxic, 30 (8.6%) with poor perfusion and 49 (14.1%) hypoglycemic. Those with hypothermia (< 36.5°C), were two times more likely to die compared to those normothermic neonates (OR=2.09, 95% CI (1.05-4.20), p=0.037). Thirty-eight (50.7%) of those who had hypoxia (SPO2 < 90%) at arrival died compared to 37 (49.3%) of those who were not hypoxic (OR=2.88, 95%CI (1.44-5.74), p=0.003). Twenty-one (67.7%) neonates with prolonged capillary refill time (CRT) died compared to ten (32.3%) who survived (OR=4.76, 95%CI (1.80-12.58), p=0.002). Out of forty-nine neonates who arrived with hypoglycemia (RBG < 2.5mmol/l) twenty-one (42.9%) died in the first 48 hours (OR=2.13, 95%CI (0.96-4.74), p=0.064). Additionally, neonates who had hyperglycemia (RBG > 8.3mmol/l) on arrival were...
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**Conclusion:** Neonatal transportation in Dar es Salaam, Tanzania was observed to be challenging. Pre transfer care and monitoring during transportation was inadequate and this contributed to poor clinical status on admission. Hypothermia, hypoglycemia, hyperglycemia, hypoxia and poor perfusion on admission were associated with increased mortality.

Effective referral network is needed for improved neonatal health outcomes. Pre referral supportive care, transportation with improved monitoring and clear communication protocol should be invested and effectively utilized. Provision of warmth is critical during neonatal transfer using cost effective measures such as Kangaroo Mother Care.

**Author Summary**

Effective referral network is required between facilities to maintain continuum quality care for improved newborn health outcomes in particular the transportation gaps. This study has investigated pre referral care and transportation gaps in relation to admission clinical status and outcome of the neonates at the receiving facility. We found that pre referral documentation is poor, reflecting quality of care performed. Hypothermia, hypoglycemia, hyperglycemia, hypoxemia and poor perfusion at admission were associated with poor outcomes. All these are preventable conditions which if detected timely, managed and monitored effectively while neonates are being transported would have lesser impact on newborn health outcomes. There is a need to invest on referral network system at all levels and provide timely quality care for the newborn to arrive, survive, thrive and transform with no disability.
Introduction

Neonatal age is the most vulnerable period in human life with neonatal mortality contributing up to 47% of overall under-five deaths. About half of neonates die within the first 24 hours after birth and 75% in the first seven days of life (1). Most of these conditions, up to 75% are preventable through effective equitable measures such as early detection and timely management. Tanzania Demographic Health Survey (TDHS) of 2015-16 documented the current neonatal mortality of 25 deaths per 1000 live births, and it is challenging to reach the targeted Sustainable Development Goals (SDG 3.2) without investing in the continuum of care.

Transfer of the newborn whilst in a mother’s womb is the safest method, but unforeseen complications during pregnancy and delivery cannot always be anticipated resulting in continuous need for transfer of these neonates from one facility to another. A well-established referral system is key to transfer neonates to a tertiary care facility (2–4).

Transportation of a neonate from one facility to another under ideal conditions is still a challenge in many developing countries, Tanzania included. Most of the neonates arrive in poor clinical conditions, which are mostly preventable. Previous studies have shown that hypothermia, hypoglycemia, poor perfusion and hypoxia are associated with increased mortality among transported neonates (5–9).

There is enough evidence to support that the transport by a skilled organized team reduces neonatal morbidity and mortality (6,10,11). The goal of all neonatal transport teams should be transporting a well-stabilized neonate. Pre transport stabilization is crucial; this entails securing the patency of the airway, breathing and circulation. Pre-transport procedures such as establishing an intravenous access should be carried out before arrival of the transport team (12)(13). Continuous monitoring need to be maintained on the way to a higher facility.
This study aimed at describing the transport characteristics (i.e. mode of transport, equipment, communication, accompanying personnel and monitoring enroute) used for the referred neonates. Additionally, it sought to assess the clinical status at admission in terms of the presence of hypothermia, hypoxia, prolonged capillary refill time and hypoglycemia for the transported neonates to Muhimbili National Hospital (MNH). Furthermore, it determined 48 hours’ outcome and its associated factors in relation to the admission clinical status of referred neonates.

**Ethics statement**

Permission to carry out the study was sought from the Muhimbili University of Health and Allied Sciences (MUHAS) Institutional Review Board (IRB) with an approval number MUHAS-REC-07-2020-306. Written informed consent to participate in the study was sought from both the parent/guardian and health care personnel who escorted the neonate prior to any study procedure. Illiterate parents/guardians were asked for a witness who participated within the discussion prior to obtaining their thumbprints and witness signature. All neonates received appropriate treatment according to the national treatment guidelines of Tanzania regardless of participation.

**Materials and Methods**

**Study Area**

Muhimbili National Hospital (MNH) is a tertiary referral centre and teaching hospital receiving patients from the five municipalities in Dar es Salaam (Ilala, Kinondoni, Kigamboni, Ubungo and Temke) and other upcountry regions. It has a neonatal unit with a functioning Intensive Care Unit level 2 plus for caring critically ill neonates. The referral annual admissions range between 1440 and 3360 neonates.

**Study Design**
A descriptive cross sectional study with a longitudinal follow up was carried out at Muhimbili National Hospital (MNH), in Dar-es-Salaam region, Tanzania

**Participant recruitment and data collection**

All neonates referred to MNH from September 2020 to February 2021 were eligible for enrollment except for neonates with obvious congenital anomalies. A consecutive sampling was used to recruit referred neonates until the required sample size of 349 neonates was met. Sample size was calculated using the expected proportion of referred neonates transported to the neonatal unit of MNH who died in the first week post admission. This was established using a pilot study conducted at MNH prior to this, and was found to be 35%. A sample size of 349 was achieved using the Kish Leslie formula with 95% confidence level and 5% margin of error.

Data was collected day and night using a pretested structured questionnaire designed for the study (S1). Data on demographic characteristics of the study participants were obtained from the referral documents and by interviewing the caregiver or escorting personnel/nurse. The accompanying personnel was enquired about the transport process including pre transport care and monitoring during transport. All escorts were asked on whether they received a training on essential newborn care. Data on ambulance characteristics was obtained through direct observation of the transport by looking inside the transport for the presence of necessary equipment using WHO neonatal ambulance checklist (14). Clinical status on admission was measured using TOPS Model (15), whereby;

Temperature was recorded in degrees centigrade and Hypothermia - defined as an axillary temperature on admission < 36.5°C measured with a digital thermometer (KONIG HC-DT10 Digital Thermometer, United Kingdom). Fever as axillary temperature on admission > 37.5°C.
Oxygen saturation (SPO2) was measured by using the pulse oximeter (ChoiceMMEd fingertip pulse oximeter, manufacturer: Beijing choice electronic technology Co., Ltd. Fuxing road A36 Beijing, 100039 China). Hypoxia was defined as oxygen saturation less than 90% in room air (16).

Perfusion, Capillary Refill Time was recorded by applying gentle pressure on the sternum for 3-5 seconds to cause blanching then the time taken for color to return was measured.

Sugar, Random Blood Glucose was measured by using a haemoglucometer machine (STANDARD™ GlucoNavii® GDH. Manufacturer: SD Biosensor, Inc. Gyeonggi-do, 16690, Republic of Korea). Hypoglycemia was defined as the blood glucose measurement of less than 2.5 mmol/L and Hyperglycemia as blood glucose measurement greater than 8.3 mmol/L.

All enrolled neonates were assessed at 48 hours post admission to capture the early outcome that was defined as survived or died.

Data Management and Statistical Analysis

Data analysis was done using SPSS version 23.0. Data for social-demographic and clinical characteristics of study participants were described using mean and standard deviations or medians and interquartile range for continuous variables. Proportions were presented in bar graphs. Multiple logistic regressions (odds ratio) was used to determine association with clinical outcome. A p-value ≤ 0.05 was considered statistically significant at 95% confidence interval.

Results

Baseline characteristics of the study participants

A total of 349 referred neonates were screened during the study period, one was excluded from the study due to a congenital anomaly which was incompatible with life (anencephaly). Figure 1 shows the proportion of participants received at Muhimbili National Hospital (MNH) stratified by
referring districts of Dar es Salaam, Tanzania. Out of the 348 neonates, 207 (59.5%) were term babies while 141 (40.5%) were preterm. Majority were male babies 197 (56.6%). 258 (74.1%) were delivered by Spontaneous Vertex Delivery (SVD) while 85 (24.4%) were born via caesarean section. The median gestation age was 38 weeks (IQR; 32 -39) with the mean birth weight of 2461 ± 936 g. Table 1 describes the socio- demographic and clinical characteristics of the study participants.

**Pre Transport Care and documentation At Referring Facility**

Two hundred and forty-six (79.9%) neonates had an intravenous line inserted prior to transfer. Temperature was measured in 176 (57.1%) neonates before transfer. Oxygen saturation and random blood glucose were measured pre transfer in only 143 (46.6%) and 116 (36.2%) neonates respectively.

**Transport Process**

**Communication:** Out of 348 neonates who were transferred to the neonatal unit of MNH, in only 26.7% the notification was given prior to transfer.

**Escorting personnel:** Out of the 340 neonates who were escorted, two hundred and twenty-four (65.9%) were escorted by the registered nurse. Seventy-three (21.5%) were escorted by the nurse attendant while eight (2.4%) were escorted by a doctor and thirty-two (9.4%) were escorted by the family member. Of the health care professional escorting the neonate, one hundred and sixty-nine (54.9%) had no training on essential newborn care.

**Access to ambulance service:** Majority of the neonates were transported by ambulance 308 (88.5%), followed by private car/taxi 30 (8.6%), public service vehicle 9 (2.6%) and tricyclic motor vehicle 1 (0.3%).
Monitoring during transport: Monitoring was done to only 94 (27%) of the transferred neonates. Of those 69 (73.4%) had their temperature measured. Blood circulation was monitored in 37 (39.4%) of the transferred neonates while Random blood glucose was checked in 27 (28.7%). Just 57 (60.6%) had their oxygen monitored during transport.

Warmth during transport: Most of the referred neonates were kept warm using local clothes (Khanga/Kitenge), 233 (67.0%). Only 7 (2.0%) were kept on a Kangaroo Mother Care position, while no neonate was kept in an incubator during transfer as all ambulance were lacking incubators.

Reasons for referral: The main reason for transfer was to seek specialized care 164 (47.1%) followed by a lack of newborn unit 65 (18.7%), referred for further investigation 65 (18.7%), lack of equipment 23 (6.6%) and lack of personnel 7 (2.0%).

Ambulance Characteristics

For those who came with an ambulance 308, 294 (95.5%) had an oxygen supply, but in 42.5% of those the oxygen delivery system was not functioning. Only 201 (65.3%) had resuscitation equipment such as Ambu bag packed in the ambulances. Resuscitation drugs such as adrenaline were included in 200 (64.9%). Monitoring equipment were not available in 104 (33.8%) ambulances. IV fluids were present in 237 (77.0) while only 184 (59.7%) had suction apparatus. No ambulance had an incubator.
Figure 2 summarizes coverage gap during the referral journey of a newborn in Dar es Salaam, Tanzania.

**Admission clinical status and outcome at the receiving facility, MNH**

Seventy-eight neonates (22.4%) died within 48 hours of admission. On arrival, the clinical status of the neonates was as follows; 115 (33%) hypothermic, 74 (21.3%) hypoxic, 30 (8.6%) with poor perfusion and 49 (14.1%) hypoglycemic. Those with hypothermia (< 36.5°C), were two times more likely to die compared to those who were normothermic (OR=2.09, 95% CI (1.05-4.20), p=0.037). Thirty-eight (50.7%) of those who had hypoxia (SPO2 < 90%) at arrival died compared to 37 (49.3%) of those who were not hypoxic (OR=2.88, 95%CI (1.44-5.74), p=0.003). Twenty-one (67.7%) neonates with prolonged capillary refill time (CRT) died compared to ten (32.3%) who survived (OR=4.76, 95%CI (1.80-12.58), p=0.002). Out of forty-nine neonates who arrived with hypoglycemia (RBG < 2.5mmol/l) twenty-one (42.9%) died in the first 48 hours (OR=2.13, 95%CI (0.96-4.74), p=0.064). Additionally, neonates who had hyperglycemia (RBG > 8.3mmol/l) on arrival were three times more likely to die compared to those who were euglycemic [(OR= 3.10, 95% CI (1.19 – 8.09) p=0.021]. Table 2 summarizes the results of univariate and multivariate analysis of factors associated with mortality.

The combined effect of poor clinical status on admission in terms of hypoglycemia, hyperglycemia, hypoxia, prolonged CRT and hypothermia were associated with increased mortality as shown in Figure 3.

**Discussion**
Despite its importance, neonatal transportation has often been overlooked in resource constrained and poor countries like Tanzania (13)(17,18). Due to lack of organized neonatal transportation system, most of these neonates arrive in poor clinical condition which influence their outcome negatively (2)(5). This study assessed the gaps on neonatal transportation, admission clinical status and outcome of the referred neonates in Dar es Salaam, Tanzania.

In our study, eighteen percent of the neonates were referred due to lack of a newborn unit in their facilities while almost half of others were referred for specialized medical or surgical care. Improving level of care in these referring institutions including establishment of well-equipped neonatal units will reduce a need for transfer. Having a dedicated neonatal transport team is also of paramount importance to ensure smooth transfer for those in need.

Pre transport stabilization and care is pivotal before transfer to a higher facility. It is generally agreeable that for a quality transport and desirable outcome, stabilization prior to transfer is mandatory (19). A study by Narang et al demonstrated an overall decrease in mortality among neonates in whom lifesaving interventions were done pre referral (20). In our study temperature was measured in more than half of the neonates prior to transfer but in the majority there was no documentation of what was done to those who were found to be hypothermic. In more than half of the referred neonates neither oxygen saturation nor Random blood glucose was measured or documented. Twenty percent of the neonates were transferred without a secured intravenous line which is vital for institution of drugs during resuscitation. Poor pre transport care contributed to poor conditions at arrival with subsequent poor outcome.

Three quarters of the referred neonates were brought in without any notification given to the neonatal unit that could give room for preparation and advice. This finding is similar to the study done by Abdulraheem et al whereby there was no communication or documented information
regarding the clinical stability of any of the neonates prior to transfer (13). In Tanzania referral system, the referring institution is tasked with providing the escorting personnel and most of the times they send staff who will render minimal interruption to the hospital running. Quite a number of neonates were escorted by nurse attendants 73 (21.5%) who were not trained to provide that level of care. Furthermore, this study found more than half of the health care personnel lacking training on essential newborn care. A study done in Jamaica reported one in three of the personnel accompanying the neonate were not skilled in neonatal resuscitation (12). Transfer of neonates by trained personnel has shown to reduce morbidity and mortality (21).

The preponderance of neonates who were referred to our facility came with hospital organized ambulances at 308 (88.5%) compared to other modes of transport. This is different from studies done in Ghana and Nigeria whereby majority of neonates were brought in by taxis and private vehicles at 36% and 43.9% respectively (18)(13). The findings are consistent with the study done in the EThekwini health district of KwaZulu-Natal South Africa whereby all the referrals were transported by ambulance (22). In this study despite a large number of neonates being brought in by ambulance, these ambulances were inadequate in equipment. Lack of equipment such as patient monitors impedes actions that could be taken to reverse deterioration during transport. It is not surprising that many neonates arrived at the tertiary hospital in unsteady clinical conditions (cold, hypoxic, hypoglycemic and hypothermic).

Most ambulances had oxygen supply similar to a study done in Bangladesh but in only 57.5% was the oxygen delivery system functioning (23). This fact plus lack of monitoring during transport clearly contributed to a number of neonates arriving hypoxic at the facility. A study by Pathak et al done in India using the TOPS score model established that neonates who had hypoglycemia and prolonged capillary refill time on admission had an overall poor outcome compared to their
counterparts (15). This is similar to our study which attested to the same. Additionally, we found a number of neonates who were hyperglycemic, with significant higher odds of mortality. These were the neonates whose blood sugar levels were not monitored and some were given continuous infusion of glucose without any blood glucose check.

Dar es Salaam has a tropical climate located 16m above sea level with an average annual temperature of $26.1^\circ$C. Despite this fact, one third of the neonates were hypothermic on admission which was associated with increased mortality. This finding is similar to studies done in low resource settings in Ghana and India where almost half of the neonates were found to be hypothermic (18)(20). A study which was done on the same setting in 2003 by Manji et al found a threefold increase in mortality and morbidity among hypothermic neonates (8). Hypothermia in our study was contributed by lack of monitoring during transport and inferior means of maintaining warmth as more than two third of the referred neonates were covered by only light local clothes such as Khanga and Kitenge. Most facilities could not afford incubators in their ambulance, nevertheless the practice of Kangaroo Mother Care (KMC) which has been shown to be cheap and effective in preventing hypothermia was observed in only 2% of the transferred neonates. Rathod et al, in their study conducted in southern India had similar findings whereby KMC practice was not observed at all (17).

The overall mortality of neonates 48 hours post admission was 22%. This study demonstrated a correlation between poor clinical status on admission in terms of hypoxia, hypothermia, hyperglycemia and poor perfusion with increased risk of mortality 48 hours post admission. Overall, this study demonstrates inadequate pre transport care, documentation and stabilization, plus lack of monitoring enroute contributing to poor conditions of neonates on admission. Emphasis has to be placed on having well equipped ambulances dedicated to neonatal
transportation. Additionally, ensuring continuous training on health care workers on neonatal resuscitation and essential newborn care is key. Strengthening the referral system network remains a challenge to be tackled.

The study may have been exposed to recall bias as some of the information relied on the escorting health personnel. Hawthorne effect can’t be ignored as the behaviors might have changed on the course of the study including improvement in the areas of referral and transportation of neonates as they become aware they are being observed. Despite the limitations, the findings reflect the gaps of referral system which need to be improved for quality of care of newborns at the primary and secondary levels. Further studies are required to explore and learn on barriers and facilitators of effective referral at all levels of care. All efforts should be done to ensure every small and sick newborn with a condition(s) that cannot be managed effectively with available resources should receive appropriate, timely referral through integrated newborn service pathways with continuity of quality care, including during transportation.

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Supporting Information Legend

Supportive Information 1(S1): Structured questionnaire English version

Figure Legends

Figure 1: Flow of the study participants referred from various districts of Dar es Salaam, Tanzania

Figure 2: Coverage gap during the referral journey of a newborn in Dar es Salaam, Tanzania

Figure 3: Combined effect of exposures on newborns mortality outcome at 48 hours post admission at Muhimbili National Hospital.

Tables
Table 1: Socio-demographic and clinical characteristics of study participants, N=348

| Characteristic                  | Category       | Frequency (n) | Percent (%) |
|--------------------------------|----------------|---------------|-------------|
| Sex                            | Male           | 197           | 56.6        |
|                                | Female         | 151           | 43.4        |
| Gestational age (weeks)        | <28            | 25            | 7.3         |
|                                | 28-32          | 68            | 19.7        |
|                                | 33-36          | 45            | 13.0        |
|                                | >37            | 207           | 60.0        |
| Median gestational age (week) (IQR) |                |               |             |
|                                |                | 38 (32-39)    |             |
| Birth weight (g)               | Less than 1000 | 21            | 6.0         |
|                                | 1000-1499      | 37            | 10.6        |
|                                | 1500-2499      | 96            | 27.6        |
|                                | 2500+          | 194           | 55.8        |
| Mean birth weight (SD) (g)     |                | 2461 (936)    |             |
| Mode of delivery               | SVD            | 258           | 74.1        |
|                                | Breech delivery| 4             | 1.2         |
|                                | Vacuum delivery| 1             | 0.3         |
|                                | Caesarean section | 85       | 24.4        |
| Apgar score 1st and 5 minutes  | 0-3 (low)      | 4             | 1.1         |
|                                | 4-6 (moderately abnormal) | 65 | 18.8 |
|                                | 7-10 (reassuring) | 279 | 80.1 |

Table 2: Univariate and Multivariate analysis of factors associated with mortality
| Variable                      | Univariate analysis | Multivariate analysis |
|-------------------------------|---------------------|-----------------------|
|                               | cOR  95% CI    | P-value | aOR  95% CI    | P-value |
| Gestational age (weeks)       |                     |          |                     |          |
| < 28                          | 7.95 3.19 – 19.83 | < 0.001 | 3.16 0.77 – 12.99 | 0.111   |
| 28 - 33                       | 1.10 0.57 – 2.15  | 0.769   | 0.61 0.22 – 1.74  | 0.357   |
| 34 - 36                       | 0.49 0.18 – 1.30  | 0.151   | 0.35 0.11 – 1.17  | 0.089   |
| ≥ 37                          | Ref                |          | Ref                |          |
| Weight (Kg)                   |                     |          |                     |          |
| < 1.0                         | 4.65 1.86 – 11.59  | < 0.001 | 1.99 0.45 – 8.74  | 0.362   |
| 1.0 – 1.4                     | 3.03 1.43 – 6.41   | 0.004   | 2.54 0.70 – 9.24  | 0.158   |
| 1.5 – 2.4                     | 1.07 0.57 – 2.02   | 0.829   | 1.56 0.68 – 3.60  | 0.293   |
| ≥ 2.5                         | Ref                |          | Ref                |          |
| Temperature (°C)              |                     |          |                     |          |
| Hypothermia (< 36.5)          | 3.65 2.04 – 6.53   | < 0.001 | 2.09 1.05 – 4.20  | 0.037   |
| Fever (> 37.5)                | 1.62 0.76 – 3.43   | 0.209   | 1.25 0.53 – 2.96  | 0.612   |
| Normal (36.5 – 37.5)          | Ref                |          | Ref                |          |
| Capillary Refill Time         |                     |          |                     |          |
| Prolonged (> 3 seconds)       | 9.58 4.28 – 21.44  | < 0.001 | 4.76 1.80 – 12.58 | 0.002   |
| Normal (< 3 second)           | Ref                |          | Ref                |          |
| Oxygen saturation             |                     |          |                     |          |
| Hypoxia (< 90%)               | 5.98 3.41 – 10.51  | < 0.001 | 2.88 1.44 – 5.74  | 0.003   |
| Normal (≥ 90%)                | Ref                |          | Ref                |          |
| Random blood glucose (mmol/L) |                     |          |                     |          |
| Hypoglycemia (< 2.5)          | 4.19 2.17 – 8.07   | < 0.001 | 2.13 0.96 – 4.74  | 0.064   |
| Hyperglycemia (> 8.3)         | 6.87 3.08 – 15.36  | < 0.001 | 3.10 1.19 – 8.09  | 0.021   |
| Normal (2.5 – 8.3)            | Ref                |          | Ref                |          |

Key: cOR: crude odds ratio, aOR: adjusted odds ratio, Ref: Reference category
349 neonates screened

One ineligible with Congenital anomaly incompatible with life (anencephaly)

Neonates N=348

Dar es Salaam n=292 (83.9%)
Outside Dar es Salaam n=56 (16.1%)

Ilala n=121 (41.4%)
Kinondoni n=75 (25.7%)
Temeke n=59 (20.2%)
Kigamboni n=29 (9.9%)
Ubungo n=8 (2.7%)

The % contribution were as follows:
Public hospital 89.4%
Private hospital 9.2%
Home 1.4%

Figure 1: Flow of the study participants referred from various districts of Dar es salaam,
Newborn referral journey begins

Figure 2. Coverage gap during the referral journey of a newborn in Dar es Salaam, Tanzania
Combined effect of clinical status on admission

0 – Neonates without any poor clinical status on admission
1 – Neonates with one of the poor clinical status on admission
2 – Neonates with two of the poor clinical status on admission combined
3 – Neonates with three of the poor clinical status on admission combined
4 – Neonates with all four poor clinical status on admission combined

NOTE: Clinical status defined as presence or absence of Hypothermia, Hypoxia, Poor Perfusion, Hypoglycemia

Figure 3. Combined effect on newborns mortality outcome at 48 hours post admission at Muhimbili National Hospital
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