Transfer of newborns to neonatal care unit: a registry based study in Northern Tanzania

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Abstract

Background: Reduction in neonatal mortality has been slower than anticipated in many low income countries including Tanzania. Adequate neonatal care may contribute to reduced mortality. We studied factors associated with transfer of babies to a neonatal care unit (NCU) in data from a birth registry at Kilimanjaro Christian Medical Centre (KCMC) in Tanzania.

Methods: A total of 21,206 singleton live births registered from 2000 to 2008 were included. Multivariable analysis was carried out to study neonatal transfer to NCU by socio-demographic factors, pregnancy complications and measures of the condition of the newborn.

Results: A total of 3,190 (15%) newborn singletons were transferred to the NCU. As expected, neonatal transfer was strongly associated with specific conditions of the baby including birth weight above 4000 g (relative risk (RR) = 7.2; 95% confidence interval (CI) 6.5-8.0) or below 1500 g (RR = 3.0; 95% CI: 2.3-4.0), five minutes Apgar score less than 7 (RR = 4.0; 95% CI: 3.4-4.6), and preterm birth before 34 weeks of gestation (RR = 1.8; 95% CI: 1.5-2.1). However, pregnancy- and delivery-related conditions like premature rupture of membrane (RR = 2.3; 95% CI: 1.9-2.7), preeclampsia (RR = 1.3; 95% CI: 1.1-1.5), other vaginal delivery (RR = 2.2; 95% CI: 1.7-2.9) and caesarean section (RR = 1.9; 95% CI: 1.8-2.1) were also significantly associated with transfer. Birth to a first born child was associated with increased likelihood of transfer (relative risk (RR) 1.4; 95% CI: 1.2-1.5), while the likelihood was reduced (RR = 0.5; 95% CI: 0.3-0.9) when the father had no education.

Conclusions: In addition to strong associations between neonatal transfer and classical neonatal risk factors for morbidity and mortality, some pregnancy-related and demographic factors were predictors of neonatal transfer. Overall, transfer was more likely for babies with signs of poor health status or a complicated pregnancy. Except for a possibly reduced use of transfer for babies of non-educated fathers and a high transfer rate for first born babies, there were no signs that transfer was based on non-medical indications.

Background

Progress on United Nations’ Millennium Development Goal 4 (MDG4) to reduce the under-five mortality has been slower than anticipated due to high neonatal mortality in developing countries. Worldwide, about 4 million neonatal deaths occur each year, of these three quarter occur in the first week of life with the highest risk at the first day of life [1]. Estimated neonatal mortality in Tanzania is about 35 per 1000 live births, and neonatal deaths are estimated to account for 28% of the under-five mortality [2]. Both the infant mortality rate and the under -five mortality rate have decreased from 1990 to 2004; by 31% (from 99 to 68 deaths per 1000 live births) and 24% (from 147 to 112 deaths per 1000 live births), respectively. This decline was, however, observed for post-neonatal mortality only, while neonatal as well as maternal mortality remained unchanged [2,3]. Adequate neonatal care may therefore be an important factor for continued improvement. Socio-economic deprivations are known to cause poor perinatal outcome such as neonatal care admission [4-7], low birth weight [8-10] and increased perinatal mortality [10-13]. A review of international evidence in socio-economic inequalities in childhood mortality in low and middle income countries showed higher childhood mortality in low socio-economic groups within each country.
Referral in pregnancy and child birth can be categorised as self-referral or referral performed by health workers [16]. Self-referral implies that a woman (perhaps with the help of her family) seeks care at a health centre or a hospital. A study of 415 maternity admissions in Tanzania found that about 70% of the admissions could be categorized as self-referrals [16].

The presence of a NCU at the hospital gives an opportunity for all at risk babies to be admitted and managed by a paediatrician. The paediatric department at KCMC has established guidelines for care and management of newborns based on the condition of the newborn. Decision for transfer is usually done by midwives or a paediatrician based on the condition of the newborn; low Apgar score, prematurity, birth weight <1800 or birth weight >4000 g, congenital malformation and suspected infection. In addition, some obstetric conditions may necessitate baby transfer because they could represent a risk to the newborn. When a pregnancy complication indicates that the baby needs to be seen by a paediatrician, the paediatrician is informed in advance and attends the delivery to take care of the newborn in the labour ward or in NCU if transfer is necessary. The parents are usually informed about the reason for babies transfer but they are not asked for decision. Although KCMC is a private hospital, payment for the hospital bill is not considered as initial criteria for transfer or management of admitted newborns, therefore, all admitted babies receive same quality of care irrespective of the social background. The social welfare department within the hospital usually takes care of the hospital bills for families unable to pay.

The aim of our analysis was to estimate the influence of social background, pregnancy-related conditions and the condition of the newborn in relation to neonatal transfer to NCU. We explore these associations in a structured series of analyses, expecting most of the associations to be explained by the condition of the newborn. First, we expect social conditions to impact the likelihood of transfer by their effects on pregnancy complications and the condition of the newborn. Then we expect pregnancy complications to impact the likelihood of transfer by their effects on the condition of the newborn. Deviations from these expectations will appear as residual effects of social background and pregnancy complications after we adjust for the condition of the newborn. Such deviations will be inspected further since they could represent priority-settings or clinical judgment that incorporates social background or the background history of the delivery.
questionnaire. A verbal consent was obtained from the participants prior to the interview. Mothers also provided their antenatal visit card for more information such as date of first ANC visit, immunization history, malaria prophylaxis, drugs, illnesses recorded during follow up, weight at first ANC visit, number of ANC visits, as well as referral to ANC (self-referred or referred by health worker).

Information in the birth registry includes maternal health conditions before and during pregnancy, parents’ socio-demographic characteristics, complications during labour and delivery, and information on the newborn; sex, gestational age, birth weight, Apgar score, and child status in four categories: 1) live born 2) live born transferred to NCU 3) neonatal death in labour ward, 4) stillborn.
The paediatric registry form was recorded in the NCU for all neonates who were transferred. The neonatal registry includes information on primary reasons for transfer, management, and discharge/death diagnoses. The two databases were linked using the unique child identification number, the mother’s hospital registration, and the newborn’s birth registration number.

Variable definition
Transfer to NCU was the main outcome. Independent variables include socio-demographic characteristics including maternal, paternal and environmental factors, maternal health conditions before and during pregnancy, and complications during labour and delivery, as well as condition of the newborn (Tables 1, 2 and 3).

Data analysis
Data were analyzed using Statistical Package for Social Science (SPSS) program Version 15.0 for Windows (SPSS 15.0 Chicago Inc. III, USA). Cross tabulations and generalized linear models were used to obtain relative risks (RR) and corresponding 95% confidence intervals. From the bivariate analyses we present all variables with p-value less than 0.1, which were then entered into the multivariable analysis. Three steps were involved in the multivariable analysis. In the first step (model A) all socio-demographic factors and maternal health condition before pregnancy were included. In the second step (model B) we included all variables in step one as well as pregnancy and labour-related conditions. In the third and final step (model C), we included all variables in step one as well as pregnancy and labour-related conditions. In the third and final step (model C), we included all variables in step two as well as neonatal conditions. We used Poisson regression with robust variances to obtain a valid confidence interval when a log-binomial analysis failed to converge [17]. A priori we also considered some maternal conditions to be important and included in the final analysis, these were hypertensive conditions (preeclampsia, eclampsia and abruption placenta) and diabetes (pre-gestational or gestational).

Ethical approval
The birth registry at Kilimanjaro Christian Medical Centre obtained ethical clearance from the Tanzania Ministry of Health, Institute of Science and Technology, from the Norwegian National ethics committee and from the Kilimanjaro Christian Medical College (KCM-College) research ethics committee in 1999. The protocol for this study was approved by KCM-College research ethics committee, with certificate no. 333 of 15th July 2010.

Results
A total of 21 206 live-born singletons were analysed. The majority of the mothers were married (89.7%), were residing in urban areas (61.9%), had primary school education (61.3%), and belonged to the Chagga tribe (58.2%). Mean maternal age at child birth was 27.4 (SD = 6.1) years, and 38.8% of the mothers had their first born child. Mean maternal pre-pregnancy weight and height were 62.7 (SD = 12.5) kilograms and 160.0 (SD = 6.7) centimetres, respectively. The mean number of antenatal care visits per women was 5 (SD = 2.1). Mean gestational age and birth weight were 39.1 (SD = 2.5) weeks and 3090 (SD = 544 grams), respectively.

A total of 3190 (15%) were transferred to NCU. Descriptive associations between transfer and socio-demographic, pregnancy-related and neonatal factors are shown in Tables 1, 2 and 3.

Socio-demographic characteristics and pre pregnancy conditions
After mutual adjustment of the socio-demographic and maternal pre-pregnancy health factors, most of the factors remained associated with neonatal transfer (Table 4; model A). First born babies and fourth or later born babies (RR 1.3; 95% CI: 1.2-1.4 and 1.2; 95% CI: 1.0-1.3, respectively) were shown to have a high risk of being transferred compared with second born babies. Babies of single mothers were more likely to be transferred compared to babies of married mothers (RR 1.3; 95% CI: 1.1-1.5). Both maternal overweight and obesity increased the risk of babies transfer. Babies born from families who do not boil water for drinking had increased risk of being transferred to NCU (RR 1.2; 95% CI: 1.1-1.3).

Pre-gestational diabetes mellitus was strongly associated with neonatal transfer to NCU (RR 4.4; 95% CI: 3.3-5.8). A history of acute or chronic lung disease other than tuberculosis showed a weaker association (RR 1.2; 95% CI: 1.1-1.4).

Pregnancy, labour and delivery
Factors related to pregnancy, labour and delivery were included in the multivariable model in B. Hypertensive conditions such as eclampsia and preeclampsia (RR 2.8; 95% CI:1.7-4.4 and 2.0; 95% CI: 1.7-2.3, respectively), labour-related complications such as premature rupture of membrane and abortion placenta (RR 2.9; 95% CI: 2.6-3.4 and 2.6; 95% CI: 1.6-4.1, respectively), and other vaginal delivery (i.e. breech, vacuum or forceps) and caesarean section delivery (RR 2.9; 95% CI: 2.3-3.6 and 2.1; 95% CI: 1.9-2.3, respectively) were all associated with transfer (Table 4; model B). Gestational diabetes increased the risk of babies transfer by 40% although not statistically significant. Referral to ANC and few ANC visits were also found to be important predictors of neonatal transfer to NCU (RR 1.3; 95% CI: 1.1-1.4 and 1.3; 95% CI: 1.2-1.4), respectively.
Table 1  Transfer to neonatal care unit (n = 3190) among 21 206 live-born according to socio-demographic factors

| Risk factors | Number live-born deliveries | Proportion (%) live-born babies transferred to NCU | RR (95% CI) | p-value |
|--------------|----------------------------|--------------------------------------------------|-------------|---------|
| Maternal factors* |                               |                                                   |             |         |
| Maternal age (years) |                               |                                                   |             |         |
| Under 18      | 480                         | 17.9                                             | 1.2 (1.0-1.5) | 0.106   |
| 18-25         | 8328                        | 14.5                                             | 1.0         |         |
| 26-35         | 10 272                      | 15.3                                             | 1.0 (1.0-1.1) |         |
| Over 35       | 2070                        | 15.7                                             | 1.0 (1.0-1.2) |         |
| Mother’s tribe |                               |                                                   |             |         |
| Chagga        | 12 311                      | 14.5                                             | 1.0         | 0.032   |
| Pare          | 2496                        | 16.2                                             | 1.0 (1.0-1.2) |         |
| Others        | 6355                        | 15.6                                             | 1.0 (1.0-1.2) |         |
| Marital status|                               |                                                   |             |         |
| Married       | 19 016                      | 14.6                                             | 1.0         | <0.0001 |
| Single        | 2086                        | 18.6                                             | 1.3 (1.2-1.4) |         |
| Birth order   |                               |                                                   |             | <0.0001 |
| 1st Child     | 8220                        | 16.4                                             | 1.2 (1.1-1.3) |         |
| 2nd Child     | 5985                        | 13.4                                             | 1.0         |         |
| 3rd Child     | 3287                        | 16.5                                             | 1.0 (0.9-1.1) |         |
| 4th or more   | 3714                        | 13.5                                             | 1.2 (1.1-1.4) |         |
| Mother’s education |                               |                                                   |             | 0.060   |
| No education  | 348                         | 17.8                                             | 1.2 (1.0-1.7) |         |
| Primary       | 12 990                      | 15.3                                             | 1.0 (1.0-1.1) |         |
| Sec/higher    | 7819                        | 14.4                                             | 1.0         |         |
| Mother’s occupation |                               |                                                   |             | <0.0001 |
| Professional  | 3355                        | 14.3                                             | 1.0         |         |
| Business      | 4821                        | 14.8                                             | 1.0 (0.9-1.2) |         |
| Service       | 1538                        | 15.4                                             | 1.1 (0.9-1.2) |         |
| Farmer        | 4003                        | 16.3                                             | 1.1 (1.0-1.3) |         |
| Housewife     | 5401                        | 15.4                                             | 1.1 (1.0-1.2) |         |
| Others        | 1955                        | 13.3                                             | 1.0 (0.8-1.1) |         |
| Body height (cm) |                               |                                                   |             | <0.0001 |
| <150          | 1505                        | 18.3                                             | 1.4 (1.2-1.5) |         |
| 150+          | 18 342                      | 14.1                                             | 1.0         |         |
| BMI (kg/m²)   |                               |                                                   |             | 0.013   |
| <18.5         | 1277                        | 14.1                                             | 1.1 (0.9-1.2) |         |
| 18.5-24.9     | 4787                        | 14.8                                             | 1.0         |         |
| 25-29.9       | 6793                        | 13.3                                             | 1.1 (1.0-1.2) |         |
| 30+           | 1496                        | 16.2                                             | 1.2 (1.1-1.4) |         |
| Genital mutilation |                               |                                                   |             | 0.086   |
| Yes           | 4752                        | 15.8                                             | 1.0 (0.9-1.0) |         |
| No            | 16 389                      | 14.8                                             | 1.0         |         |
| Drinking in pregnancy |                               |                                                   |             | 0.033   |
| Yes           | 8278                        | 14.4                                             | 1.0         |         |
| No            | 12 882                      | 15.4                                             | 1.1 (1.0-1.2) |         |
| Paternal factors* |                               |                                                   |             | 0.003   |
| Father’s age (years) |                               |                                                   |             |         |
| Under 26      | 3002                        | 16.7                                             | 1.1 (1.1-1.3) |         |
| 26-35         | 11 794                      | 14.6                                             | 1.0         |         |
| 36-45         | 5428                        | 14.5                                             | 1.0 (0.9-1.1) |         |
| Over 45       | 827                         | 17.7                                             | 1.2 (1.0-1.4) |         |
Significant factors in model A continued to be independent predictors for neonatal transfer also in model B, except for maternal body height below 150 cm. However, addition of variables in model B slightly reduced the relative risk for most factors.

Neonatal factors
In model C, neonatal factors were added into the multivariable model. All the selected neonatal factors were significantly associated with transfer to NCU, with the highest relative risks being for birth weight above 4000 g (RR 7.2; 95% CI: 6.5-8.0) and five minutes Apgar score below 7 (RR 4.0; 95% CI: 3.4-4.6) (Table 4; model C).

After inclusion of the neonatal factors, some prepregnancy factors, such as women giving birth to their first babies (RR 1.4; 95% CI: 1.2-1.5), maternal age 26-35 years (RR 1.2; 95% CI: 1.1-1.3), and single marital status (RR 1.2; 95% CI: 1.0-1.3) were still significantly associated with neonatal transfer. Lack of paternal education (RR: 0.5; 95% CI: 0.3-0.9) was negatively associated with transfer to NCU. Birth to fourth or later born babies, maternal overweight or obesity, pre-gestational diabetes and epilepsy were no longer significantly associated with neonatal transfer.

Discussion
In this registry based study from a tertiary hospital in Tanzania, we identified patterns of neonatal transfer to NCU. In a three-step analysis we studied socio-demographic factors, maternal health factors, and neonatal factors in relation to transfer. A particular aim was to assess whether socio-demographic factors were related to transfer to NCU beyond their association with well-defined medical risks. The analyses showed that neonatal factors by far had the strongest association with neonatal transfer, but that prepregnancy and pregnancy factors were also independently associated with transfer.

The incidence of neonatal transfer in this study was 15%, which is slightly higher than reported in previous studies both from developed [4,5] and developing countries [7,18].

Neonatal factors
The studied neonatal factors included classical risk factors for morbidity and mortality, such as birth weight,
preterm delivery, Apgar score and sex, and were as expected strongly related to neonatal transfer. Although the causal effect of birth weight is controversial [19] low birth weight is a good predictor of need for neonatal care. Low birth weight has been proposed to contribute 40-80% of neonatal morbidity and mortality [20,21]. Preterm delivery is estimated to account for 28% of all neonatal deaths [20].

We also found a very high admission rate of newborns with a birth weight above 4000 g. Fetal macrosomia is associated with obstetric complications and neonatal morbidity such as injuries, respiratory distress and hypoglycaemia. Observation for transient or persistent hypoglycaemia is a common reason for admission of high birth weight babies to NCU [22]. At KCMC, such babies will be discharged within 24 hours if there is no risk of persistent hypoglycaemia and the blood glucose level is normal. The outcome is in general good for these babies, and one may speculate whether observation without transfer to NCU for some of these babies would represent a better use of resources.

In general, male neonatal morbidity exceeds female morbidity, partly due to a higher occurrence of preterm birth and other neonatal risk factors [23]. The male-to-female ratio of transfer 1.24, declining to 1.18 in the adjusted analyses, corresponds well with the established higher risk in males, and does not indicate a difference in care according to infant sex.

### Table 2 Transfer to neonatal care unit (n = 3190) among 21 206 live-born according to maternal health conditions

| Risk factors       | Number live-born deliveries | Proportion (%) live-born babies transferred to NCU | RR (95% CI) | p-value |
|--------------------|----------------------------|---------------------------------------------------|-------------|---------|
| **Before pregnancy** |                            |                                                   |             |         |
| Medication regular | 493                        | 18.9                                              | 1.3 (1.1-1.5) | 0.013   |
| Diabetes           | 49                         | 69.4                                              | 4.7 (3.9-5.6) | <0.0001 |
| Hypertension       | 143                        | 21.7                                              | 1.5 (1.1-2.0) | 0.021   |
| Epilepsy           | 64                         | 25.0                                              | 1.7 (1.1-2.6) | 0.026   |
| Gyn. Disease       | 1122                       | 17.5                                              | 1.2 (1.0-1.4) | 0.020   |
| Lung disease       | 1950                       | 16.6                                              | 1.1 (1.0-1.2) | 0.040   |
| Malaria            | 12 258                     | 14.9                                              | 1.0 (0.9-1.1) | 0.899   |
| Anaemia            | 406                        | 17.0                                              | 1.2 (0.9-1.5) | 0.267   |
| Tuberculosis       | 77                         | 18.2                                              | 1.3 (0.7-2.2) | 0.703   |
| **During pregnancy** |                            |                                                   |             |         |
| No ANC attendance  | 137                        | 34.3                                              | 2.3 (1.8-2.9) | <0.0001 |
| Referred to ANC§   | 2284                       | 21.0                                              | 1.5 (1.4-1.6) | <0.0001 |
| ANC < 5 visits     | 13 168                     | 16.2                                              | 1.3 (1.2-1.4) | <0.0001 |
| Anaemia            | 449                        | 18.3                                              | 1.2 (1.0-1.5) | 0.050   |
| Gestational Diabetic | 17                        | 47.1                                              | 3.1 (1.9-5.2) | <0.0001 |
| Hypertension       | 72                         | 30.6                                              | 2.0 (1.4-2.9) | <0.0001 |
| Preeclampsia       | 711                        | 32.1                                              | 2.2 (2.0-2.5) | <0.0001 |
| Eclampsia          | 27                         | 70.4                                              | 4.7 (3.7-6.0) | <0.0001 |
| Bleeding           | 239                        | 23                                                | 1.5 (1.2-2.0) | <0.0001 |
| Malaria            | 4314                       | 14.4                                              | 1.0 (0.9-1.0) | 0.167   |
| Tuberculosis       | 414                        | 15.0                                              | 1.0 (0.8-1.3) | 0.969   |
| HIV infection      | 784                        | 16.1                                              | 1.0 (0.8-1.1) | 0.528   |
| **Complications**  |                            |                                                   |             |         |
| Abruptio placenta  | 29                         | 65.5                                              | 4.4 (3.4-5.7) | <0.0001 |
| PROM               | 468                        | 54.7                                              | 3.9 (3.5-4.2) | <0.0001 |
| Bleeding >500 mls  | 36                         | 33.3                                              | 2.2 (1.4-3.5) | 0.001   |
| Placenta previa    | 51                         | 45.1                                              | 3.0 (2.2-4.1) | <0.0001 |
| Caesarean section  | 6472                       | 24.2                                              | 2.3 (2.2-2.5) | <0.0001 |
| Other Vaginal delivery | 317                      | 33.4                                              | 3.2 (2.7-3.8) | <0.0001 |
| Other unspecified  | 373                        | 24.7                                              | 1.7 (1.4-2.0) | <0.0001 |

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a- Numbers for reference categories not given, each variable had complete data
§- First ANC visit triggered by health workers

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Risk of neonatal transfer was high in mothers with preeclampsia, eclampsia and abruption placenta, however no or weak effects were observed after inclusion of neonatal factors in the model. Hypertensive conditions in pregnancy are associated with preterm birth and low birth weight [15,24-27], and many cases of abruption placenta occur at a low gestational age, which explain the indirect association between these complications and neonatal transfer. The direct cause of transfer would be the preterm birth.

Other conditions, such as premature rupture of membrane, caesarean section and operative vaginal delivery, showed a high risk of neonatal transfer also after accounting for the neonatal condition of the baby. The high rate of transfer for babies born with mothers having PROM is similar to what is reported elsewhere [15]. Premature rupture of the membrane (PROM) is associated with preterm delivery and low birth weight [15,27]. A previous study at KCMC reported a high prevalence (38%) of low birth weight babies after PROM [27]. Such babies are at higher risk of developing neonatal infection. Antibiotic prophylaxis given to mothers with PROM has shown to reduce risk of infection in the newborn [28,29]. The high transfer rate after PROM in our data is likely to be explained by the fact that a majority of mothers with a history of PROM did not receive antibiotic prophylaxis prior to delivery, due to late arrival to the centre.

Mothers with less than five antenatal care visits were more likely to have their baby transferred and this association persisted after we took into account our measures of the condition of the newborn. Amount of antenatal care plays a role in neonatal outcome [30-32], and each additional ANC visit has previously been found to offer a protective effect on neonatal outcome [31]. When the mother had been referred for antenatal care, however, the risk of transfer was increased.

Pre pregnancy factors

Among diseases that the mothers had before the pregnancy, only lung disease remained significantly associated with neonatal transfer when pregnancy conditions and neonatal conditions were accounted for (Table 4, model C). Pre-gestational diabetes was strongly related to transfer in models A and B, but the association disappeared after accounting for the neonatal conditions in model C. Noteworthy, gestational diabetes had a weak and non-significant association with transfer, and the relative risk was not affected by adjustment for neonatal factors. The low risk of transfer in babies born to mothers with gestational diabetes compared to babies of mothers with pre-gestational diabetes is also reported elsewhere [5,15,33].

Women giving birth to their first child and single mothers were more likely to have their baby transferred to NCU, also after accounting for pregnancy conditions and neonatal conditions. Birth to a first child and single

### Table 3 Transfer to neonatal care unit (n = 3190) among 21 206 live-born according to newborn health conditions

| Risk factors | Number live-born deliveries | Proportion (%) live-born babies transferred to NCU | RR (95% CI) | p-value |
|--------------|-----------------------------|-----------------------------------------------|-------------|---------|
| Birth weight (g) |                             |                                               |             | <0.0001 |
| 500-1499    | 173                         | 95.4                                          | 9.8 (9.3-10.4) |         |
| 1500-2499   | 1652                        | 41.5                                          | 4.3 (4.0-4.6)  |         |
| 2500-3999   | 18 607                      | 9.7                                           |             |         |
| 4000-6000   | 714                         | 69.7                                          | 7.2 (6.7-7.7)  |         |
| Apgar score 5 min |                           |                                               |             | <0.0001 |
| <7          | 442                         | 91.9                                          | 6.9 (6.6-7.2)  |         |
| 7+          | 20 590                      | 13.4                                          |             |         |
| Gestation age (weeks) |                         |                                               |             | <0.0001 |
| 25-33       | 447                         | 70.5                                          | 5.6 (5.2-6.1)  |         |
| 34-36       | 1401                        | 27.3                                          | 2.2 (2.0-2.4)  |         |
| 37+         | 17 603                      | 12.5                                          | 1.0          |         |
| Presentation |                             |                                               |             | <0.0001 |
| Cephalic    | 20 862                      | 14.8                                          | 1.0          |         |
| Breech      | 238                         | 28.2                                          | 1.9 (1.6-2.3)  |         |
| Transverse  | 28                          | 21.4                                          | 1.5 (0.7-3.0)  |         |
| Sex         |                             |                                               |             | <0.0001 |
| Male        | 10 904                      | 16.6                                          | 1.2 (1.2-1.3)  |         |
| Female      | 10 162                      | 13.3                                          | 1.0          |         |

x-The total in some variables does not sum to 21 206 due to missing data
Table 4 Linear regression model factors for neonatal transfer to neonatal care unit

| Risk factors                              | Model A^a | Model B^b | Model C^c |
|-------------------------------------------|-----------|-----------|-----------|
| **Pre-pregnancy factors**                 | RR (95%CI)| RR (95%CI)| RR (95%CI)|
| Maternal age (Ref. 18-25 years)           |           |           |           |
| Under 18 years                            | 1.0 (0.8-1.4) | 1.0 (0.8-1.4) | 0.9 (0.7-1.2) |
| 26-35 years                               | 1.3 (1.1-1.4)** | 1.2 (1.1-1.3)** | 1.2 (1.1-1.3)** |
| Over 35 years                             | 1.1 (0.9-1.3) | 1.0 (0.8-1.3) | 1.0 (0.8-1.2) |
| Birth order (Ref. 2nd child)              |           |           |           |
| 1st child                                 | 1.3 (1.2-1.4)** | 1.3 (1.2-1.5)** | 1.4 (1.2-1.5)** |
| 3rd child                                 | 1.0 (0.8-1.1) | 1.0 (0.9-1.1) | 1.0 (0.9-1.1) |
| 4th or more                               | 1.2 (1.0-1.3) | 1.3 (1.1-1.4)** | 1.1 (1.0-1.3) |
| Body mass index (Ref 18.5-24.9)           |           |           |           |
| Underweight (<18.5)                       | 1.0 (0.9-1.2) | 1.0 (0.9-1.2) | 1.0 (0.9-1.2) |
| Overweight (25-29.9)                      | 1.2 (1.1-1.3)** | 1.2 (1.0-1.3)** | 1.1 (1.0-1.2) |
| Obesity (30+)                             | 1.3 (1.1-1.5)** | 1.2 (1.1-1.4)** | 1.1 (1.0-1.3) |
| Single marital status                     | 1.3 (1.1-1.5)** | 1.2 (1.1-1.4)* | 1.2 (1.0-1.3)* |
| Body height <150 cm                       | 1.2 (1.1-1.4)* | 1.0 (0.9-1.2) | 1.1 (0.9-1.2) |
| Paternal age (Ref 26-35 years)            |           |           |           |
| Under 26 years                            | 1.2 (1.0-1.3) | 1.1 (1.0-1.3) | 1.2 (1.0-1.3)* |
| 36-45 years                               | 1.0 (0.9-1.1) | 0.9 (0.8-1.0) | 0.9 (0.8-1.1) |
| Over 45 years                             | 1.1 (0.9-1.4) | 1.1 (0.9-1.4) | 1.1 (0.9-1.3) |
| Father’s education (Ref sec/high)         |           |           |           |
| No education                              | 1.2 (0.7-2.3) | 0.8 (0.5-1.5) | 0.5 (0.3-0.9)* |
| Primary school                            | 1.0 (0.9-1.1) | 1.0 (0.9-1.1) | 1.0 (0.9-1.1) |
| Pre-gestational diabetic                  | 4.4 (3.3-5.8)** | 3.5 (2.6-4.7)** | 1.6 (0.7-3.3) |
| Maternal Lung disease                     | 1.2 (1.1-1.4)** | 1.2 (1.1-1.4)** | 1.2 (1.0-1.3)* |
| Maternal Epilepsy                         | 1.6 (1.0-2.6) | 1.9 (1.2-2.9)** | 1.4 (0.9-2.2) |
| Not boiling drinking water                | 1.2 (1.1-1.3)** | 1.1 (1.0-1.3)** | 1.1 (1.0-1.2) |
| **Pregnancy, labour and delivery**        |           |           |           |
| Mother referred to ANC^5                  | -         | 1.3 (1.1-1.4)** | 1.2 (1.0-1.3)* |
| ANC < 5 visits                            | -         | 1.3 (1.2-1.4) | 1.2 (1.1-1.3)** |
| Gestational Diabetic                      | -         | 1.4 (0.6-3.4) | 1.4 (0.5-4.5) |
| Hypertension                              | -         | 1.5 (0.9-2.4) | 1.2 (0.7-1.9) |
| Preeclampsia                              | -         | 2.0 (1.7-2.3)** | 1.3 (1.1-1.5)** |
| Eclampsia                                 | -         | 2.8 (1.7-4.4)** | 0.9 (0.6-1.6) |
| Abruptio placenta                         | -         | 2.6 (1.6-4.1)** | 1.1 (0.7-1.8) |
| Premature rupture of membrane             | -         | 2.9 (2.6-3.4)** | 2.3 (1.9-2.7)* |
| Caesarian section                         | -         | 2.1 (1.9-2.3)** | 1.9 (1.8-2.1)** |
| Other vaginal delivery                    | -         | 2.9 (2.3-3.6)** | 2.2 (1.7-2.9)** |
| Other unspecified complications           | -         | 1.8 (1.4-2.3)** | 1.5 (1.2-1.9)** |
| **Neonatal factors**                      |           |           |           |
| Birth weight >4000 g                       | -         | -         | 7.2 (6.5-8.0)** |
| Birth Weight 1500-2500 g                   | -         | -         | 2.8 (2.5-3.1)** |
| Birth weight <1500 g                       | -         | -         | 3.0 (2.3-4.0)** |
| Gestational age below 34 weeks            | -         | -         | 1.8 (1.5-2.1)** |
| Gestational age 34-36 weeks                | -         | -         | 1.3 (1.1-1.5)** |
| Five minutes Apgar score <7               | -         | -         | 4.0 (3.4-4.6)** |
| Male sex                                  | -         | -         | 1.2 (1.1-1.3)** |

*a p-value less than 0.05
** p-value less than 0.01
* In each step variables entered were all which had p-value of < 0.1 in univariable analysis including maternal age although p-value was slightly above 0.1 (0.106). The lowest risk category in each group was used as a reference. Results are presented for all variables which were significant at least once in any of the three steps.

Model A, first step; adjusted for pre pregnancy factors
Model B, second step; variables in model A plus conditions in pregnancy, labor and delivery
Model C, third step; variables in model B plus neonatal factors
^5- First ANC visit triggered by health workers
motherhood are classical risk factors for neonatal mor-
bidity and mortality [9,10,12,18,34,35]. However, the
40% higher risk of admission for a first born child in the
fully adjusted model (model C), is higher than what one
would expect according to previous knowledge on mor-
bidity and mortality associated with first delivery. In a
previous study from the same hospital, perinatal mortal-
ity was not associated with birth order except for a
higher perinatal mortality in offsprings of mothers with
three or more previous pregnancies [11]. To further ela-
borate this finding, we performed a regression analysis
with a finer categorization of Apgar score. In this
model, the parity effect was still statistically significant,
half reduced. In a setting with limited obstetric ser-
vice, the generally higher neonatal stress on first born
babies might be even more evident.

In line with previous findings [36-38] we found that
overweight and in particular obese mothers had a high
risk of having their baby transferred to NCU. Maternal
obesity is associated with some pregnancy complications
[33,36-40] and overweight or obese mothers are more
likely to have high birth weight babies [37,38,40]. A
meta-analysis review showed a lower risk of low birth
weight among babies of overweight or obese mothers
compared to normal weight mothers, however the risk of
very low birth weight and extremely low birth weight
was increased due to more induced preterm deliveries
in overweight or obese mothers [41]. In our data, the
association of neonatal transfer associated with maternal
overweight and obesity was weakened but still statisti-
cally significant after adjustment for pregnancy condi-
tions, however disappeared after adjustment for neonatal
conditions. Hence, pregnancy conditions and neonatal
conditions seem to be mediators in the association
between maternal overweight and neonatal transfer. A
similar pattern was seen for mothers of short stature,
where an increased risk seen in model A seemed to be
linked to a higher rate of pregnancy complications for
these mothers.

Drinking unboiled water was one of the factors asso-
ciated with neonatal transfer. Waterborne disease
including diarrhoea and dysentery is prevalent in Tanza-
nia, therefore, it is recommended to boil water for
drinking including tap water. In our study 92% of the
participants used tap water, however only 31% boiled
water for drinking. In a study from Tanzania, lack of
boiling water prior to consumption was more common
in households with low income, and lack of proper
knowledge on the importance of how to handle and
store water safely was associated with E.coli occurrence
[42]. Both ignorance and poverty might be the major
barriers to boiling drinking water.

Lack of paternal education was associated with a low
chance of neonatal transfer (RR = 0.5; 95% CI: 0.3-0.9)
in the fully adjusted model. Although our results should
be interpreted with care due to the low numbers (110
fathers with no education) and a confidence interval
close to one, the findings could reflect low focus on
neonatal health care in deprived families. A previous
study using the same birth registry reported that patern-
al socio-demographic factors seemed to be more
important predictors of perinatal mortality than mater-
nal socio-demographic factors in this area [11]. How-
ever, such an interpretation is not compatible with the
principle that transfer mechanisms should be unaffected
by parental and family influence.

Strengths and limitations
The study was based on a hospital based birth registry,
where data are carefully collected according to standar-
dized procedures, ensuring complete coverage of births
on a daily basis including weekends and holidays. Informa-
tion was collected by designated midwives using a
structured questionnaire-based interview, and medical
records were used to verify the information from the
questionnaire. The sample size was relatively large and
enabled us to study many risk factors in relation to neo-
natal transfer. Hence, the data allowed us to study the
relationship between socio-demographic characteristics,
maternal health and complications during delivery, and
neonatal characteristics, with transfer to neonatal inten-
sive care unit. Selection bias was reduced by excluding
all medically indicated referral births from rural areas
where the mother would not probably deliver at KCMC
if not referred. The excluded cases accounted for 52% of
all referrals and 75% of all medical referrals.

About 29% of the deliveries in the Kilimanjaro region
occur at home [20], and the study results may not be
representative of the entire population within the area.
Although women who give birth at the hospital largely
differ with respect to socio-demographic status, the
socio-demographic variation in the community may be
even larger and towards a less privileged population. It
is therefore possible that the observed risks are underes-
timated as compared to the region.

We applied an analytical approach where the various
classes of variables were included in regression models
through three steps. The purpose of this was to identify
which factors that mediated any association with tran-
sfer. Our analyses are based on a limited set of variables,
and there may be important risk factors of neonatal
transfer that we have not been able to account for.
Hence, the effects obtained in the models may represent
a mixture of effects of the studied factors and effects of
factors not accounted for. In particular, our measures of
the condition of the newborn were probably too crude
to fully account for the clinical judgement of the baby's
condition and the need for transfer.
Despite these limitations, we believe that our study, based on structured collection of information with a hospital based design combined with careful considerations of possible biases, represent findings of importance. True population data are difficult to collect in sub-Saharan Africa. Investment in competence building and data collection should start with key hospitals, and efforts should be done to include well-defined populations, in order to generate relevant and representative data to address the important public health issues within the general population.

Conclusions
Our study has demonstrated the combined effect of socio-demographic, maternal health conditions and neonatal factors in predicting transfer to NCU. The relationship between socio-demographic, maternal health characteristics and neonatal factors observed in this study reflects traditionally known predictors of neonatal morbidity and mortality. As for the pre-pregnancy factors, most of the associations with transfer were accounted for by pregnancy complications and neonatal factors. An exception from this was a possibly reduced use of transfer for babies of non-educated fathers. The potential effect of paternal social status both on neonatal health and on access to health care for mother and baby needs more attention. Another exception that needs to be further explored is the 40% higher rate of transfer among first born babies. With respect to neonatal factors, one might speculate whether the high number of babies above 4000 g transferred to the NCU represents an optimal use of resources, as the outcome of these babies is in general good.

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Authors’ contributions
BTM: Study design, methodology, data analysis and manuscript writing. RTL, GSK, RO, OK, AKD: Study design, methodology, manuscript writing. All authors approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

References
1. Zupan J: Perinatal Mortality in Developing Countries. N Eng J Med 2005, 352(20):2047-2048.
2. National Bureau of Statistics, Tanzania and ORC Macro: Tanzania demographic and health survey 2004-05. Dar es Salaam, Tanzania. National Bureau of Statistics and Calverton, MD, USA: ORC Macro 2005.
3. Masanja H, Savigny D, Smithson P, Schellenberg J, John T, Mbuya C, Upunda G, Boerma T, Victoria G, Smith T, Mishinda H: Child survival gains in Tanzania: analysis of data from demographic and health surveys. Lancet 2008, 371:1276-1283.
4. Manning D, Brewster B, Bundred P: Social deprivation and admission for neonatal care. Arch Dis Child Fetal Neonatal Ed 2005, 90(4):F337-F343.
5. Prung H, Bauman A, Tran M, Yang L, McDonnell J, Michel L, Hillman K: Factors that influence special care nursery admissions to a district hospital in South-western Sydney. J Paediatr Child Health 2005, 41(3):119-124.
6. Jonas O, Roder D, Chan A: The Association of low Socioeconomic status in Metropolitan Adelaide with maternal demographic and Obstetric characteristics and Pregnancy Outcomes. Eur J Epidemiol 1992, 8(5):708-714.
7. Yunis K, Beydoun H, Kohgali M, Alameh M, Tamim H: Low socioeconomic status and neonatal outcomes in an urban population in a developing country. J Matern Fetal Neonatal Med 2003, 14(5):338-343.
8. Varela de Barbae J, Soriano T, Albaleado R, Juaman M, Calle ME, Martinez D, Dominguez-Rojas V: Risk factors for low birth weight: a review. Eur J Obstet Gynecol Reprod Biol 2004, 116:3-15.
9. Edshiby EM, Schmalisch G: The effect of maternal anthropometric characteristics and social factors on gestational age and birth weight in Sudanese newborn infants. BMC Public Health 2008, 8(24).
10. Grijbokovs A, Bygren LO, Svarthol B: Socio-demographic determinants of poor infant outcome in north-west Russia. Paediatr Perinat Epidemiol 2002, 16(3):255-262.
11. Habib AN, Lie RT, Onoie O, Shao J, Bergsæe P, Dalvæt AK: Socio demographic characteristics and perinatal mortality among singletons in North East Tanzania: a registry-based study. J Epidemiol Community Health 2006, 62:960-965.
12. Forssas E, Gissler M, Silvenon M, Hennemik E: Maternal predictors of perinatal mortality: the role of birth weight. Int J Epidemiol 1999, 28:475-478.
13. Hindesaker SG, Olsen BE, Bergsæ PA, Gashka P, Lie RT, Klâve G: Perinatal Mortality in Northern Rural Tanzania. J Health Popul Nutr 2003, 21(1):8-17.
14. Houweiling TA, Kunst AE: Socio-economic inequalities in childhood mortality in low- and middle-income countries: a review of the international evidence. Br Med Bull 2010, 93(1):17-26.
15. Ross MG, Dowrey AC, Bemis-Heys R, Nguyen M, Jacques DL, Stanziano G: Prediction by maternal risk factors of neonatal intensive care admissions: Evaluation of >59,000 women in national managed care programs. Am J Obstet Gynecol 1999, 181(4):835-842.
16. John A, Kavalewski M, Kimata SS: Obstetric care in southern Tanzania: does it reach those in need? Trop Med Int Health 1998, 3(11):926-932.
17. Schmidt C, Kohlmann T: When to use the odds ratio or the relative risk? Int J Public Health 2008, 53(3):165-167.
18. Sammens-Vaughan ME, Ashley DC, McCaw-Binns AM: Factors determining admission to NCU in Jamaica. Paediatr Perinat Epidemiol 2001, 15(2):100-105.
19. Wilcox AJ: On the importance– and the unimportance– of birthweight. Int J Epidemiol 2001, 30(6):1233-1241.
20. Lawn JE, Cousins S, Zupan J: 4 million neonatal deaths: When? Where? Why? Lancet 2005, 365(9462):891-900.
21. World Health Organization: The world health report make every mother and child count. Geneva 2005.
22. Gillian JR, Coomord DV, Russ R, Bay RC: Big infants in the neonatal intensive care unit. Am J Obstet Gynecol 2005, 192(6):1948-1953.22.
23. Zeitlin J, Saurel-Cubizolles M-J, de Mouzon J, Rivera L, Ancel P-Y, Blondel B, Kaminski M: Fetal sex and preterm birth: are males at greater risk? Hum Reprod 2002, 17(10):2762-2768.

24. Ayaz A, Muhammad T, Hussain SA, Habib S: Neonatal outcome in pre-eclamptic patients. J Ayub Med Coll Abbottabad 2009, 21(2):53-55.

25. Jehan A, Musaarat J, Nadra S: Perinatal outcome in pregnancy induced hypertensive mothers. Pak Armed Forces Med J 2010, 33(10):667-671.

26. Sibai BM, Lindheimer M, Hauth J, Caritis S, VanDorsten P, Klebanoff M, MacPherson C, Landon M, Miodovnik M, Paul R, Meis P, Dombrowski M: Risk factors for Preeclampsia, abruptio placenta, and adverse neonatal outcomes among women with chronic hypertension. N Eng J Med 2010, 362(1):39-47.

27. Siza JE: Risk factors associated with low birth weight of neonates among pregnant women attending a referral hospital in northern Tanzania. Tanzan Health Res Bull 2008, 10(1):1-8.

28. Egarter C, Leitich H, Karas H, Wieser F, Husslein P, Kaider A, Schemper M: Antibiotic treatment in preterm premature rupture of membranes and neonatal morbidity: A metaanalysis. Am J Obstet Gynecol 1996, 174(2):589-597.

29. Cousens S, Blencowe H, Gravett M, Lawn JE: Antibiotics for pre-term prelabour rupture of membranes, prevention of neonatal deaths due to complications of pre-term birth and infection. Int J Epidemiol 2010, 39:1341-143.

30. Owolabi AT, Fatusi AO, Kuti O, Adeyemi A, Faturoti SO, Obiajuwa PO: Maternal complications and perinatal outcomes in booked and unbooked Nigerian mothers. Singapore Med J 2008, 49(7):S26-S31.

31. Brown C, Sohani S, Khan K, Lilloff R, Mukhwana W: Antenatal care and perinatal outcomes in Kwale district, Kenya. BMC Pregnancy Childbirth 2008, 8(1):2.

32. Blondel B, Duttilh P, Delour M, Usan S: Poor antenatal care and pregnancy outcome. Eur J Obstet Gynecol Reprod Biol 1993, 50:191-196.

33. Ray JG, Vermeulen MJ, Shapiro JL, Kenshole AB: Maternal and neonatal outcomes in pregestational and gestational diabetes mellitus, and the influence of maternal obesity and weight gain: the DEPOSIT study. Q J Med 2001, 94(7):347-356.

34. Simiyu DE: Morbidity and mortality of low birthweight infants in the newborn unit of Kenyatta National hospital Nairobi. East Afr Med J 2004, 81(7):367-374.

35. Wasunna A, Mohammed K: Morbidity and outcome of low birthweight babies of adolescent mothers at Kenyatta National Hospital, Nairobi. East Afr Med J 2002, 79(10):539-542.

36. Diet A, Grint JC: Obesity and pregnancy. J Obstet Gynaecol 2008, 28(1):14-23.

37. Ramachenderan J, Bradford J, McLean M: Maternal obesity and pregnancy complications: a review. Aust NZ J Obstet Gynaecol 2009, 49(3):228-235.

38. Yogev Y, Visser GHA: Obesity, gestational diabetes and pregnancy outcome. Semin Fetal Neonat Pediatr 2009, 14(2):77-84.

39. Chen M, McNiff C, Madan J, et al: Maternal obesity and neonatal Apgar scores. J Mat Med Neonat Pediatr 2010, 33(1):89-95.

40. Ehrenberg HM, Mercer BM, Catalano PM: The influence of obesity and diabetes on the prevalence of macrosomia. Am J Obstet Gynecol 2004, 191:664-668.

41. McDonald SD, Han Z, Muller S, Beyene J: Overweight and obesity in mothers and risk of preterm birth and low birth weight infants: systematic review and meta-analyses. BMJ 2010, 341:c3428.

42. Hartstone LC, Knight J, Riley JJ: Water in Tanzania: A Role for Extension. J Int Agr Ext Educ 2006, 13(1):59-71.

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