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Cause-specific neonatal morbidity and mortality in the Solomon Islands: An assessment of data from four hospitals over a three-year period

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Original Article

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ABSTRACT

Aim: Data on stillbirths and neonatal morbidity and mortality in low-middle income Pacific Island Nations such as Solomon Islands is limited, partly due to weak health information systems. We describe the perinatal mortality and clinical factors associated with poor newborn outcomes at four hospitals in Solomon Islands.

Methods: This was a registry based retrospective cohort study at three provincial hospitals and the National Referral Hospital (NRH) from 2014-2016 inclusive.

Results: 23,966 labour ward births and 3148 special care nursery (SCN) admissions were reviewed. Overall still birth rate (SBR) was 29.2/1000 births and the perinatal mortality rate (PNMR) was 35.9/1000 births. PNMR were higher in provincial hospitals (46.2, 44.0 and 34.3/1000) than at NRH (33.3/1000). The commonest reasons for admission to SCN across the hospitals were sepsis, complications of prematurity and birth asphyxia. SCN mortality rates were higher in the 3 provincial hospitals than at NRH (18.9% (95/598) vs 8.6% (202/2,550), P-value < 0.01). At NRH, the conditions with the highest case fatality rates (CFR) were birth asphyxia (21.3%), congenital abnormalities (17.7%), and prematurity (15.1%). Up to 11% of neonates did not have a diagnosis recorded.

Conclusions: The perinatal mortality rates are high and intrapartum complications, prematurity and sepsis are the main causes of morbidity and mortality for neonates at hospitals in Solomon Islands. Stillbirths account for 81% of perinatal deaths. These results are useful for planning for quality improvement at provincial level. Improved vital registration systems are required to better capture stillbirths and neonatal outcomes.

What is already known on this topic?

1. Neonatal mortality in low- and middle-income countries has improved at a slower rate than in older children over the last 20 years.
2. Perinatal mortality rates are unknown in Solomon Islands, and there is no system to routinely capture neonatal outcomes

What this paper adds?

1. Perinatal mortality is high in Solomon Island health facilities. A rate of 35.9 per 1000 births in the four hospitals is four times reported country estimates.
2. Perinatal mortality was 30% higher at provincial hospitals than the NRH
3. Higher rates of still births and newborn death were seen in provincial hospital SCNs compared with the NRH
4. At the NRH, birth asphyxia, congenital abnormalities and prematurity had the highest case fatality rates.

Keywords: Child health, child survival, maternal and child health, neonatal quality of care

INTRODUCTION

Solomon Islands is a lower middle-income country (LMIC) in the Western Pacific with increasing demand for newborn, child and maternal health services. There are rising births per capita due to a young population entering reproductive age(1). The country is considered a Small Island Developing State (SIDS), a recognised group of 58 low-lying nations with comparable economic, social and health challenges(2, 3).

There are a paucity of data relating to perinatal and neonatal outcomes in Solomon Islands and other SIDS in the Pacific. The most recent national census in Solomon Islands in 2009 did not report an estimate of neonatal deaths or stillbirths, although infant mortality rate was estimated at 22 per 1000 live births. Solomon Islands did not meet most of its health related Millennium Development Goal targets (4). Neonatal data mortality is not routinely reported by the Solomon Islands Ministry of Health and Medical Services (MHMS), however estimates by the Global Burden of Disease study and UNICEF place neonatal mortality at 8.33 and 9 per 1000 live births and stillbirth rate at 9.37 per thousand births (5, 6).

Births and causes of deaths are often not registered in low- and low-middle-income countries. Under-reporting of neonatal deaths is of specific concern, with neonatal mortality rates highest in countries and communities with the least information on deaths(7). Deaths on day of birth account for a third of all global neonatal deaths with two-thirds occurring in the first week of life(8). Some early neonatal deaths may be reported as stillbirths, thus further underestimating neonatal death rates(9). Data on cause and timing of neonatal deaths is important to effectively design perinatal and neonatal interventions in national policy and programs(10).

There are complex challenges to improving health care services for mothers and newborns in Solomon Islands. These include challenges in maintenance of health care facilities, distance and transport, environmental conditions (including the effects of climate change, floods, and earthquakes), and health care workforce issues including limited numbers, workforce planning, training, distribution, and few opportunities for skills enhancement(11). Due to

geographical and economic isolation from the only tertiary referral hospital (NRH) in Honiara, provincial hospitals play a pivotal role in neonatal care.

We performed a registry based retrospective cohort study to describe perinatal mortality and the factors associated with neonatal morbidity and mortality at the NRH and three provincial hospitals over a 3-year period, to inform planning for quality improvement in neonatal care.

MATERIALS AND METHODS

Study Design

We conducted a retrospective review of ward registers at three provincial hospitals and the National Referral Hospital (NRH) in Solomon Islands.

Setting and Context

Solomon Islands has a population of around 680,000(12), the 5th largest country by population in Oceania. Most recent census data identified a fertility rate of 4.2 per woman and half of the population were under 20-years of age(1). Total expenditure on health per capita was approximately \$107USD in 2015 (Australia \$4,035USD) (13). In 2013, there were 302 health facilities across Solomon Islands, mostly primary health clinics and area health centres within the catchment areas of 10 provincial hospitals.

A purposive sample of four hospitals were selected for this study (see Figure 1): NRH (Capital City Province), Gizo (Western Province), Kirakira (Makira-Ulawa Province), and Kilu'ufi, (Malaita Province). The four hospitals serve account for 80% of the national population. They are the four busiest delivery facilities in the country and received approximately one-third of all births from each respective province.

The NRH provides the highest level of care available for mothers and newborns. The country has 4 obstetricians and 4 paediatricians, all are based at the NRH. The NRH SCN provides a level of care most similar to a Level II nursery(14) with trained paediatric nurses, capacity for non-invasive ventilation with continuous positive airway pressure and access to surgical and subspecialty teams. Resident doctors staff provincial hospitals, and most can only deliver vaginal births. Provincial hospital SCN can provide oxygen, antibiotics, and intravenous

fluids depending on facility setup and staffing expertise(11). The Solomon Island Standard Treatment Manual provides basic guidelines on criteria for referral of newborns from smaller facilities to provincial hospitals. Transfer to NRH for mothers and neonates from provincial hospitals are determined on a case-by-case basis using commercially available flights. Transfer decisions within provinces are impacted by distance, challenges of terrain, availability of boats and vehicles, fuel availability, as well as prevailing weather conditions.

<insert figure 1 here>

Data Collection and Analyses

We examined SCN and labour ward registries at the study sites, reviewing data from the 1st of January 2014 to 31st December 2016 (inclusive). Where available in the SCN, we documented the following variables: date of birth, admission and discharge date, age at admission, sex, weight, referral source, diagnosis (es) and outcome (discharged, deceased). From the labour ward we documented total births, fresh and macerated stillbirths and neonatal deaths. The data were manually entered into Excel and EpiData, before cleaning and analysis in STATA (Version 15.1). All available clinical diagnoses were coded separately for each neonate according to the registry entries. Case definitions from a revised Wigglesworth classification(15-17) were then applied, and a single cause of death was assigned using a hierarchical order (see Table 1 for case definitions).

< insert table 1 here>

Study population and Definitions

The study population included all stillbirths and all neonates born at the hospital or admitted to the SCN before 28 days of life.

The following standardised definitions were used:

- Neonatal period = from birth to 28 completed days
- Stillbirth = foetus with 500g birth weight and/or 20 weeks gestation without signs of life at birth(18)
- Early neonatal death = death from day 0 – 6 of life

- Perinatal mortality rate = number of stillbirths and early neonatal deaths per 1000 births

This study was approved by the Solomon Islands Health Research and Ethics Review Board (project number HRE033/16) and the University of Melbourne Human Research Ethics Committee (HREC number 1646267.1).

RESULTS

Perinatal mortality

Between January 1st 2014 and December 31st 2016 there were a total of 23,966 births at the labour wards of the four hospitals studied. The facility with the highest number of births was NRH (see Table 2). Fresh stillbirths accounted for most stillbirths in all hospitals except Kirakira, where macerated stillbirths were slightly higher. The combined still birth rate across the hospitals was 29.2/1000 births and the perinatal mortality rate was 35.9/1000 births. Perinatal mortality was higher in provincial hospitals than at the NRH (283/6574 vs 579/17,392, P-value <0.01). Rates of low birth weight were similar at NRH (10.9%) and the provincial hospitals (11.8%). Data from Kirakira did not include referral source for neonates in the SCN, therefore inborn/outborn status could not be determined.

SCN admission characteristics

There were a total of 3148 special care nursery admissions at the four hospitals (see Table 2). Whilst smaller numbers of deaths occurred in provincial centres, the fatality rate of neonates admitted to the SCN was significantly higher as compared with NRH: 18.9% (95/598) vs 8.6% (202/2,550), P-value < 0.01. The most common diagnosis for a neonate admitted to a SCN across all settings was sepsis; followed by prematurity, birth asphyxia and congenital abnormalities (see Figure 2). Between 4 – 11% of admitted neonates had no admission diagnoses recorded; other data fields were incomplete at all hospitals except Gizo.

<insert figure 2 here>

NRH SCN characteristics

Further analysis was possible at NRH due to availability of detailed data. Almost half (49.3%) of neonates admitted were male, 41.2% were female (9.5% missing sex) (Table 2). Deaths in the first three days of life accounted for 69.7% of all deaths. Mean birth weight was 2801g (SD 830g). 1,801 (82.6%) of neonates admitted to the SCN were inborn. Median age at admission was day 0 (IQR 0 – 1) for inborn and day 4 of life (IQR 2 – 10 days) for out-born, and median duration of admission was 5 days for all admissions (IQR 4 – 7).

< insert table 2 here >

NRH SCN Mortality Characteristics

During the study period, there were 202 deaths (7.9% of total 2550 admissions) in the special care nursery with variation based on diagnosis (see table 3). Figure 3 examines the relationship between diagnosis and death by presenting the proportion of babies with each diagnosis that died. Sepsis constituted the majority of admissions (51.6%) yet accounted for 11.4% of neonatal deaths and had the lowest CFR. The highest proportion of deaths was from prematurity (57.4% of neonatal deaths) which made up 30.1% of all admissions. Extremely low birth weight (ELBW) and very low birth weight (VLBW) newborns constituted 7.0% (n = 178) of all admissions, but 33.2% (n = 67) of deaths and proportion of deaths increased with decreasing birth weight. Median length of stay was 22 days for VLBW neonates, 5 days for normal weight neonates and 1 day for ELBW neonates due to high case fatality rate in this group.

<insert table 3 here >

< Insert figure 3 >

Discussion

In this study we documented very high SBR and PNMR in four hospitals with the highest number of deliveries in Solomon Islands, a low-resource Pacific island setting. Perinatal outcomes were significantly worse in provincial hospitals compared with NRH. Mortality rates were twice as high for neonates admitted at provincial hospital SCN than at NRH; those admitted with birth asphyxia, congenital abnormalities and prematurity had the highest CFR. This is one of the few studies outlining in detail the perinatal mortality in Solomon Islands, where reporting on stillbirths and newborn deaths is not yet routine.

Whilst the population attending a provincial hospital may include a greater proportion of higher risk births, the average still birth rate of 29.2 per 1000 births in the four hospitals in our study is higher than estimates for the entire country of 17.6 per 1000(19), and higher than other countries in the region (12.2 per 1000 overall)(20). This study supports findings from previous reports in Solomon Islands, where high perinatal mortality rates in Gizo of 42 per 1000 births and Kirakira of 31 per 1000 births were identified (21-23). NRH had the lowest stillbirth rate in this study, despite receiving most anticipated high-risk deliveries. This finding may reflect access to caesarean section, instrumental deliveries, ultrasound and intrapartum monitoring as compared with provincial hospitals where these are less available. Of the provincial hospitals, Kirakira had a lower stillbirth rate compared to the other hospitals, a possible reflection of the smaller catchment area and better accessibility by road compared to other provincial hospitals. Fresh stillbirth suggests death during the intrapartum period, in the 12 hours prior to delivery(9). The high rate of fresh stillbirths identified in this study may also reflect misclassification of early neonatal deaths as fresh stillbirths, as has been reported previously(19). This hypothesis is supported by observations of reduction in fresh stillbirth rates following implementation of resuscitation programs in other countries, likely due to improved recognition.(19)

The profile of neonatal morbidity and mortality in Solomon Islands is comparable to other low- and low-middle income countries where mortality is highest in low birth weight or pre-term neonates, and most deaths occurring in the first days of life are from intrapartum complications(16, 24-32). Other countries in the region face similar challenges. In Timor Leste, a study of the National Hospital Guideo Valadares, Dili found a mortality rate of

11.4% for hospitalised neonates (30). The highest risk was from prematurity, birth asphyxia and congenital abnormalities. In Goroka Hospital, Papua New Guinea, very low birth rate, septicaemia and birth asphyxia were the most frequent causes of death for neonates(32). In Fiji, a study using a perinatal mortality audit showed delays in seeking care, and delay in the provision of adequate care at health facilities contributed to stillbirth and neonatal deaths(31).

The disparity in perinatal and SCN fatality rates between provincial hospitals and the NRH raises questions. Referral bias might lead to higher mortality rates in the tertiary referral hospital, but the opposite findings suggest there are barriers to referral of seriously ill or high-risk neonates, and limitations in quality of care. There are limited avenues for referral from provincial hospitals due to geographical isolation, transport, cost, communication and clear referral criteria and pathways. Women from remote health clinics with obstetric emergencies and sick newborns may have experienced delays in reaching a provincial hospital, so are in poorer condition on arrival. The delays in problem recognition, seeking care, transport delays and facility delays have been well described(33) as well as poorer outcomes in “out-born” neonates into referral centres(16, 26, 27, 34, 35). This local referral bias, and onward referral obstacles, are likely to partly account for the higher mortality rates in provincial hospitals compared to the tertiary centre. This is compounded by provincial hospital’s limited resources: fewer staff with fewer opportunities for continuing professional development and training.

Estimates of perinatal mortality from this study are discordant with the estimated neonatal mortality rates for the country. Solomon Islands was one of several countries in the Western Pacific Region that did not meet more than half of health-related Millennium Development Goals targets, including under-5 mortality rates(4). Yet reported estimates of neonatal mortality for Solomon Islands now place the country as having reached Sustainable Development Goal targets(5, 6). Solomon Islands Census, most recently completed in 2009, provided estimates of child mortality, however questions relating to newborns and stillbirths were absent(1). Although a health survey in 2015 estimated neonatal mortality rates between 5 and 15 depending on province, very few neonatal deaths and stillbirths were captured in the survey sample, affecting validity of the results(36). National estimates rely on available data sources (e.g. vital registration, published literature, country consultations and surveys).

Global Burden of Disease studies use a diverse range of data sources where available and statistical analysis to determine trends(37). Caution in interpreting national estimates is required, so that programmatic and funding attention for newborn care is not undermined by underestimates of neonatal mortality rates for the country.

Perinatal mortality is not routinely reported in Solomon Islands and the available data has gaps in demographic and diagnostic details. Most low- and middle-income countries have incomplete, sparse or unreliable data on neonatal deaths and stillbirths(9, 38, 39). Our findings emphasise the need for improved data collection for mortality rates and causes of death through routine collection systems, standardised with ICD Codes(40). Facility based data systems for monitoring newborn outcomes have been recommended to address data gaps where vital registration systems are not in place(7), and these are feasible at large scale in low and middle income countries(41-43). Emphasis is placed on determining the causes of death in the newborn period, to inform programme design and monitoring (44), however policy and funding interventions may be limited by gaps in data and subsequent interpretation.

Estimating neonatal mortality is challenging in this setting with disbursed health facilities and births, and inaccurate reporting of neonatal deaths. There has been no formal process for neonatal mortality auditing, until recently at NRH(45). Neonatal mortality rate and causes of death are core indicators for Early Newborn Action Plans (ENAP)(46) and for the Sustainable Development Goals. Current reports are based on estimations from a combination of vital registration systems, census or surveys where available(46). However, reliable civil registration data is not available for 92% of the world's births(44)-(47). Where national data collection systems are limited, and newborns have low visibility, audits such as this can provide valuable information on the aetiology of newborn morbidity and mortality.

This study has several limitations. The retrospective design allows only the available written record to be analysed, which were incomplete in some fields for more than 10%. There was no clear distinction between some clinical diagnoses such as whether low birth weight was due to prematurity or intrauterine growth restriction and therefore diagnoses of prematurity may have been overestimated. The hierarchical method of death classification used in this study allows an overview of causes of death but does not reflect the complexity of co-existing

diagnoses. Neonates who died after leaving hospital at home, or in another facility would not be identified in these data. Despite being located at the same facility, the SCN and labour wards of each hospital operate distinctly with their records, and there is no linkage for the outcomes of newborns between the two. This could be addressed by establishing a civil registry, with a unique identifying number for each child allowing greater tracking of births, deaths and causes of death (46). A better system is needed for vital registration in Solomon Islands, where paper records are not reliable and electronic systems are not yet available.

Conclusion

High perinatal mortality rates in Solomon Island hospitals highlight the need for programs to improve maternal health and care during the critical intrapartum period, and to address challenges in accessing quality care, referral pathways and delays. Support for improving neonatal quality of care at provincial hospitals, with data collection systems that allow routine analysis are needed. Having a unique identification number system for all births that was used at every health encounter would assist accuracy of data and continuity of care.

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Figure 1: Map of Solomon Islands with study sites highlighted

Legend: A = Honiara B = Gizo C = Kilu'ufi D = Kirakira

Table 1: Case definition and clinical diagnosis criteria for cause of death classification from a revised Wigglesworth classification(15-17)

Cause of death	Case definition	Clinical diagnosis in registry
Congenital abnormalities	Lethal congenital abnormality: congenital heart, spina bifida, gastrointestinal malformation, other congenital syndromes	Multiple congenital malformation, congenital heart disease, spina bifida/hydrocephalus/anencephaly, 'syndromic baby' and death due to systemic conditions such as gastrointestinal or renal failure
Prematurity	Prematurity, respiratory distress syndrome in preterm, necrotising enterocolitis in preterm	'Prematurity' 'Very low birth weight' or 'Extremely low birth weight' Neonatal death with the following diagnosis if gestational age < 33 weeks or birth weight < 2500g if gestational age is not known: Respiratory distress Birth asphyxia Necrotizing enterocolitis Infection
Birth asphyxia	Neonatal encephalopathy, birth asphyxia, hypoxic ischaemic encephalopathy	'Birth asphyxia' but excluding preterm infants Seizures and/or coma in the first two days of life in a term baby

Sepsis	Neonatal infection, sepsis/septicaemia, meningitis, pneumonia, presumed sepsis	<p>Early neonatal death in a term baby with no congenital malformations and a specific history of acute intrapartum insult or obstructed labour</p> <p>‘Neonatal infection’</p> <p>Sepsis/septicaemia</p> <p>Meningitis</p> <p>Pneumonia/acute respiratory tract infection</p> <p>Neonatal infection</p> <p>Pyrexia of unknown origin</p> <p>Omphalitis</p> <p>Cellulitis</p>
Diarrhoea	Neonatal death due to diarrhoea	
Other	Specific cause of neonatal death not included in above:	<ul style="list-style-type: none"> – neonatal jaundice – meconium aspiration syndrome – respiratory distress syndrome in term babies

Table 2: Hospital Labour Ward and SCN Demographics and Statistics 2014 - 2016

Labour Ward	Hospital	NRH	Kilu'ufi	Gizo	Kirakira	Total
	Percentage of annual province births at hospital ¹	100%	29.6%	25.3%	32.4%	
	Median Births per Month (range)	483 (385 - 605)	83 (55 – 111)	63 (40-97)	36 (22-59)	-
	Total Births (number)	17392	2988	2275	1311	23966
	Total Still births (macerated, fresh)	473 (203, 270)	108 (45, 63)	90 (3, 87)	30 (16,14)	701 (267, 434)
	Early neonatal deaths	106	30	10	15	161
	Still birth rate	27.2	36.1	39.6	22.9	29.2
	Perinatal mortality rate	33.3	46.2	44.0	34.3	35.9

SCN	Hospital	NRH	Kilu'ufi	Gizo	Kirakira	Total
	Admissions	2550	300	200	98	3148
	Total Deaths (inborn, outborn)	202 (138, 30 [†])	56 ([†])	24 (10, 14)	15 ([†])	297
	SCN fatality rate [§]	7.9%	18.7%	12.0%	15.3%	9.4%

¹Source = MHMS Health Information 2013

†Incomplete data

§SCN Fatality Rate = percentage of deaths from all admissions to the SCN

Figure 2: SCN discharge diagnosis by percentage

Table 3: NRH SCN Demographics and outcomes 2014-2016 (202 deaths, 2550 admissions)

Demographic		Admissions		CFR (%)	Deaths	
		n	% of admissions		n	% of deaths
Cause of Death	Congenital Abnormality	96	3.8	17.7	17	8.4
	Prematurity	767	30.1	15.1	116	57.4
	Birth Asphyxia	127	5.0	21.3	27	13.4
	Sepsis	1315	51.6	1.8	23	11.4
	Other	135	5.3	7.4	10	5.0
	Not recorded	110	4.3	8.2	9	4.5
	Total	2550			202	
Admission weight	<1000g	45	1.8	77.8	35	17.3
	1000 – 1499g	133	5.2	24.1	32	15.8
	1500 – 2499g	594	23.3	8.6	51	25.2
	2500 – 3999g	1,542	60.5	4.5	69	34.1
	> 4000g	144	5.6	4.9	7	3.5

Not recorded	92	3.6	8.7	8	4.0
Total	2550			202	

Figure 3. The proportion of deceased babies based on their diagnosis and the overall proportion deceased (top bar) at NRH.

Cause-specific neonatal morbidity and mortality in the Solomon Islands: An assessment of data from four hospitals over a three-year period

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Original Article

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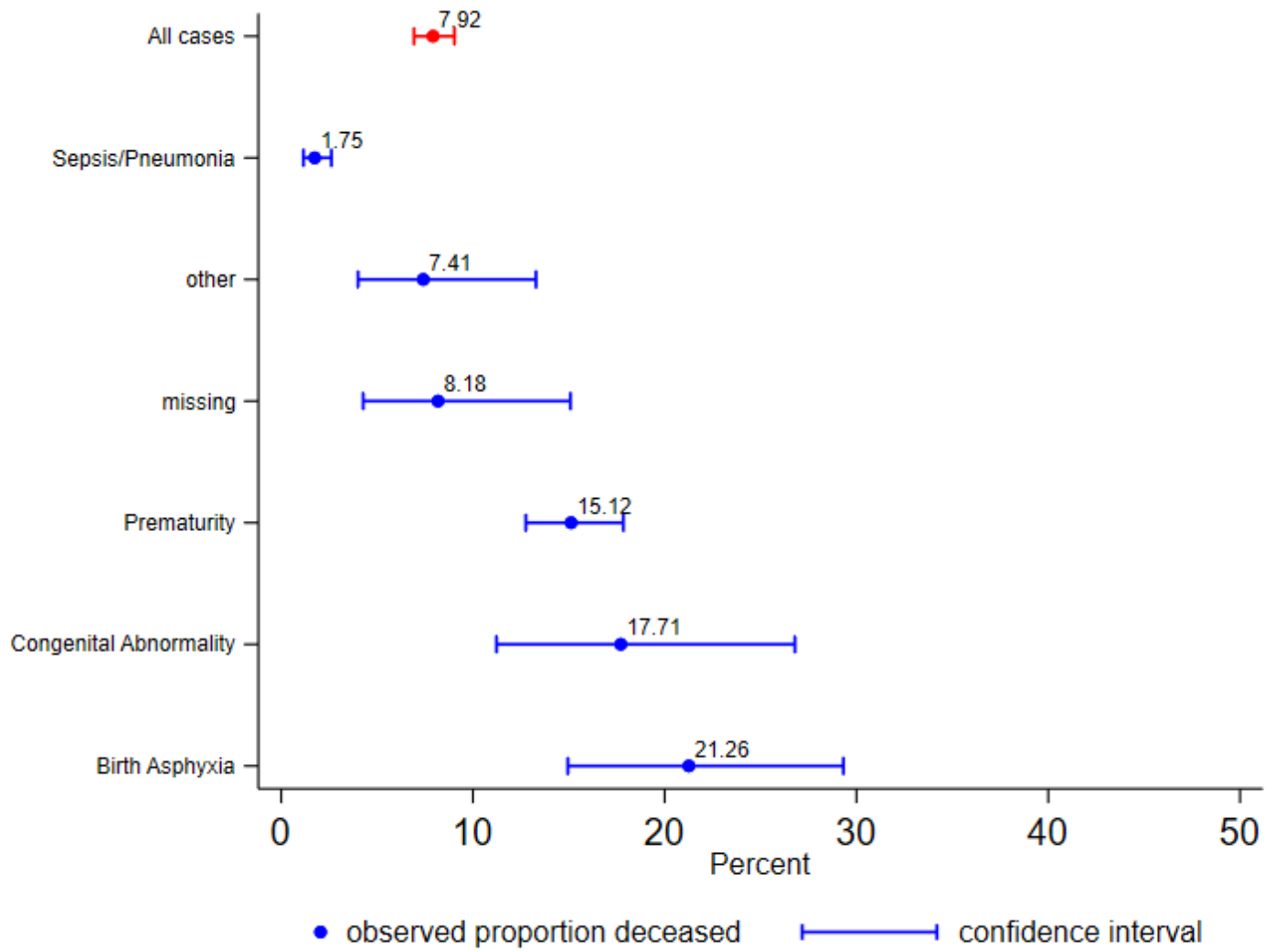
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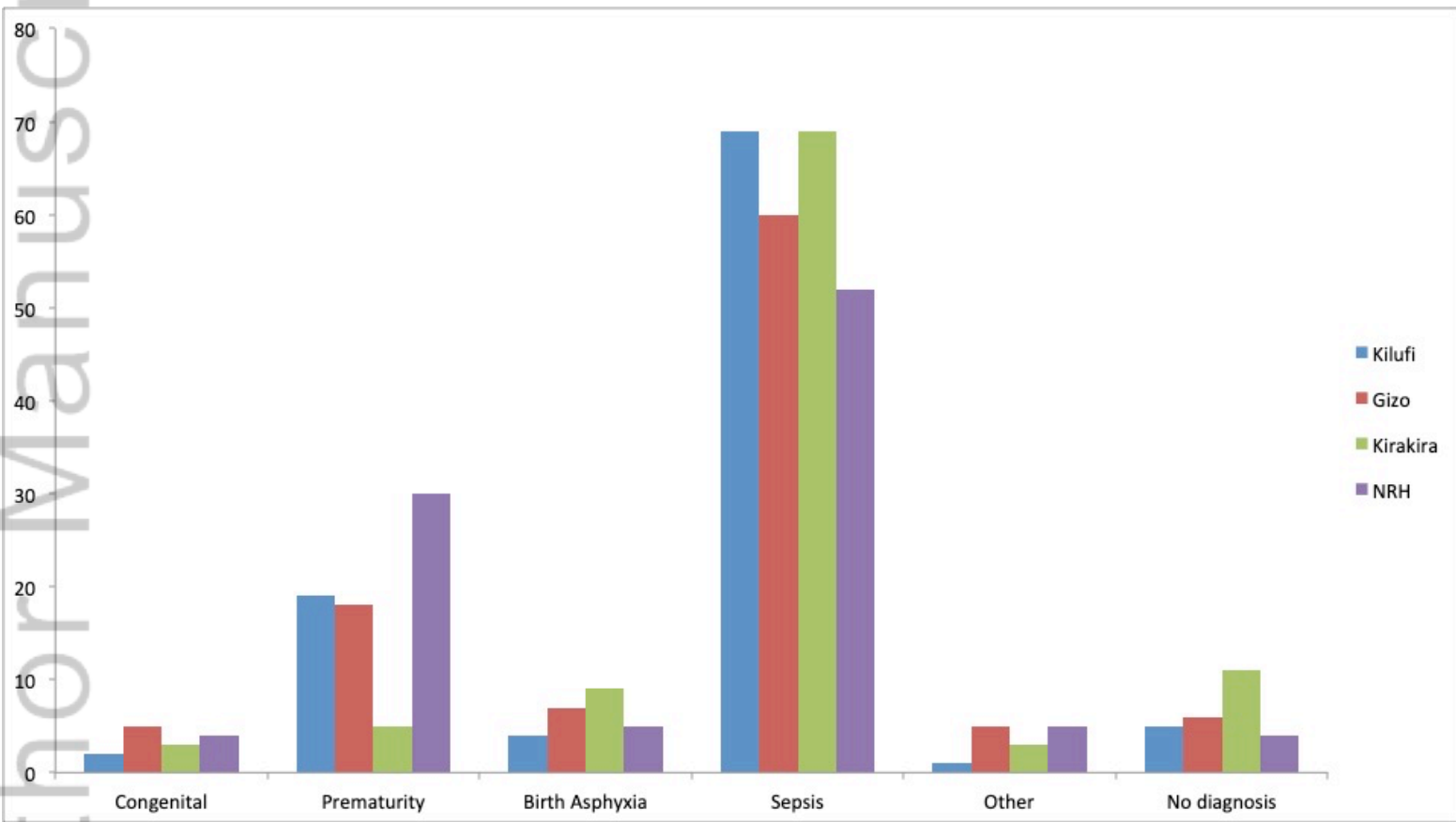
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JPC_14699_proportion_deceased.tiff



JPC_14699_SCN Discharge Dx by Percentage.tiff



JPC_14699_SI Map.tiff



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