BJMHR
British Journal of Medical and Health Research
Journal home page: www.bjmhr.com

Causes of death in children under 5-years: a 10-year retrospective autopsy review at the Korle-Bu teaching hospital mortuary; Accra Ghana. (2002 – 2012)

Der EM.[1,2]* Gyasi RK[1], Akosa BA[1]

1. Department of Pathology, School of Biomedical Sciences, Korle-Bu Teaching Hospital, Accra, Ghana

2. Department of Pathology, School of Medicine and Health Sciences, University for Development Studies, Tamale, Ghana.

ABSTRACT

Accurate data on the causes of death in children under the age of 5-years in Ghana are limited and usually from vital registrations and occasional clinical studies. The aim of this study was to identify and group the underlying causes of death in these children and offer recommendation. This was a retrospective autopsy study from January 2002 to December 2012. Approximately 5.0% of all autopsies performed during the study period were children under the ages of five years. The underlying causes of death were: infections (49.4%), injuries and poisons (20.1%), congenital and developmental abnormalities (17.5%), nutritional (5.3%), neoplasms (2.5%) and haemoglobinopathies (1.8%). Approximately 73.0% of the deaths were preventable. Majority (84.6%) of the deaths occurred in the community and in males (57.2%). Neoplasms related deaths commonly occurred in health facilities. Congenital and developmental abnormities deaths were commoner in neonates. Common infection related deaths were: malaria (37.7%), pneumonia (29.4%) and diarrhoea diseases (21.3%). For injuries and poisons; these were: burns (28.6%); road traffic accidents (26.7%) and drowning (21.5%). Malnutrition was the commonest nutritional cause of death, while lymphomas were the common neoplastic causes of death. Under five deaths were commoner in the community, boys and in the childhood period. Approximately 73.0% of these deaths could have been prevented, by paying attention to the immediate environment of children and use of appropriate medical interventions. We recommend that autopsy data on under five deaths be part of the routine health sector mortality data in Ghana.

Keywords: Ghana, under five, underlying causes, deaths, autopsy.

*Corresponding Author Email: maadelle@yahoo.com
Received 12 July 2016, Accepted 22 July 2016

Please cite this article as: Edmund DM *et al*., Causes of death in children under 5-years: a 10-year retrospective autopsy review at the Korle-Bu teaching hospital mortuary; Accra Ghana. (2002 – 2012). British Journal of Medical and Health Research 2016.

INTRODUCTION

Hospital based autopsy data on the causes of deaths in children under the age of 5-years are limited in most developing countries [1] and Ghana is not an exception. Concerns about the causes of deaths in subjects under the age of five years have been a major public health problem more than 3-decays ago. Hill et al[2] found that 10 out of 11 million under five deaths occurred in developing world, with Sub-Saharan Africa region including Ghana, accounting for more than one-third of the deaths. This concern may have been the driving force for the four health-related Millennium Development Goals (MDGs) that seeks then to reduce under-five mortality rate (U5MR) by two-thirds; from 93 children of every 1,000 dying before age five in 1990 to 31 of every 1,000 in 2015 (UNICEF). The causes of U5M vary globally and across countries reflecting the distribution of health and sanitation facilities. Recent studies in some African countries found rising trend in the causes of death in children under the age of 5-years. [3,4] with differences in the locations of death [5,6,7] .Studies have found that, two thirds of the under five deaths in the developing world are caused by diseases such as infections, most of which could have been prevented by low cost interventions such as, immunization, oral rehydration therapy (ORT), and antibiotics and are thus avoidable.[8,9,10,11,12] In Ghana, sources of data on under five deaths are usually from vital registration systems (birth and death registry), demographic health surveys and occasional clinical studies. These sources are inconsistent and skewed toward infectious diseases with very little information about other causes, such as neoplastic, congenital and developmental disorders, injuries and poisons. The aim of this retrospective autopsy study was to identify and group the causes of death in subjects under the age of 5-years and offer recommendations.

MATERIALS AND METHOD

Study design

This was a retrospective descriptive autopsy study.

Study Site

Data were gathered from records of autopsies performed at the Korle-Bu Teaching Hospital mortuary the largest in Ghana. Between 3, 000 and 6,000 autopsies are performed in a year. This mortuary receives cases from Korle-Bu teaching hospital, the Accra Metropolis, neighbouring towns and Districts, and other parts of Southern Ghana.

Data Collection

All autopsy log books and hospital files were reviewed for the period of 2000 through 2014, for cases of death in subjects under 5-years for which autopsies were performed. Data was collected and cross-checked by two doctors, to prevent double entry. For each case of death

in subjects under 5-years, data was collected on age and gender, underlying cause of death and the category of death (coroner's or hospital). The cause of death in this study was based on review of clinical records, macroscopic autopsy findings and in some cases the microscopic findings.

Data analysis

The data was entered into a computerized spreadsheet and analyzed using SPSS software (Version 18). Frequency distributions, bar charts and descriptive statistics were calculated for each variable.

Inclusion criteria

All deaths in children under the age of 5-years for which autopsy were performed.

All deaths with complete autopsy report.

Exclusion criteria

All poorly preserved bodies that had autopsied performed.

Some definitions

1. **Coroner's deaths**: Coroner's deaths are deaths that occurred in the community or within 24-hours of admission to a health facility, where no definitive diagnosis was arrived at before death.
2. **Hospital deaths**: Hospital deaths on the other hand are deaths that occurred in a health facility while the patient was on treatment for a given diagnosis.
3. **Underlying cause of death (UCD)**: The underlying cause of death is the disease or injury that sets in motion the physiologic train of events culminating in organ or system failure
4. **Immediate cause of death**: Immediate cause of death is the consequence of the underlying injuries or diseases.

RESULTS AND DISCUSSION

Age and sex characteristics of deaths in children under 5- years

During the period of study (2002 to 2012), 41,959 autopsies were performed in our institution of which 2,099 (5.0%) were children (subjects) under the ages of five years. The ages of the victims ranged from a day to 59 months. More than half 1,204 (57.3%) of the subjects were within the age group 12 to 59 months. Approximately 57.2% of the deaths were males (table 1). In developing countries such as Ghana, hospital based autopsy statistics on causes of death in children under the age of five years are lacking compared to verbal autopsy, which unfortunately have very low validity.[1,2] In this current retrospective hospital based autopsy study, it was found that 5.0% of the deaths occurred in children under the ages of five years. This finding supports studies in other African countries such as Ethiopia[3] and Cambodia[4] that found increased proportions of deaths in this age group. More than half (57.3%), of all the

deaths occurred in the 12 to 59 months age group. This differs from other previous studies in both the developed and some developing countries that found under five deaths to commonly occur in the neonatal period.[5,6,7] Almost all the deaths occurred in the community and this differs from Rahbar et al[7] study in Iran that found that most under five deaths occurred in hospitals.

Table 1: Age and gender distribution of deaths in children under 5- years old

Age groups **Age (months)**	**Frequency (n)**	**Percentage (%)**
Neonate (≤1month)	314	15.0
Infants (>1≤11months)	582	27.7
Child (12-59 months)	1203	57.3
Total	**2099**	**100.0**
Gender		
Male	**1202**	**57.2**
Female	846	40.3
Not stated	51	2.5
Total	**2099**	**100.0**

Underlying causes of deaths and location

In this study 49.0% of the 2,099 deaths were due to infections and the associated complications, followed by injuries and poisons (19.3%), (figure 1, table 2). Overall, more than 73.6% of the under five deaths in Ghanaian children could been preventable if care was taken. This is in keeping with findings of causes of death in children under five years of age from previous studies.[8,9,10] This current study further offers support to studies in developing countries that found that most of the causes of under five deaths could have be prevented by proper planning, education of parents and the application of low-technology, evidence-based, cost-effective measures such as vaccines against childhood infections, the use of antibiotics to treat infections, micronutrient supplementation, insecticide-treated bed nets and improved family care and breastfeeding practices.[11,12]

Table 2: Underlying causes of death in children under the ages of 5-years

Major cause	**Neonate (n/%)**	**Infant (n/%)**	**Children (n/%)**	**Total**
Infections	85 (8.3)	342 (33.2)	602 (58.5)	1029
Injuries and poisons	43(10.5)	51 (12.5)	315 (77.0)	409
Congenital and developmental	136 (41.6)	91 (27.8)	100 (30.6)	327
Nutritional	7 (6.3)	50 (45.1)	54 (49.6)	111
Haemoglobinopathies	13 (31.7)	2 (4.9)	26 (63.4)	41
Neoplasms	1(1.9)	8 (15.1)	44 (83.0)	53
Others	34 (26.1)	38 (28.4)	65 (44.5)	137
Total	314	582	1,203	2,099

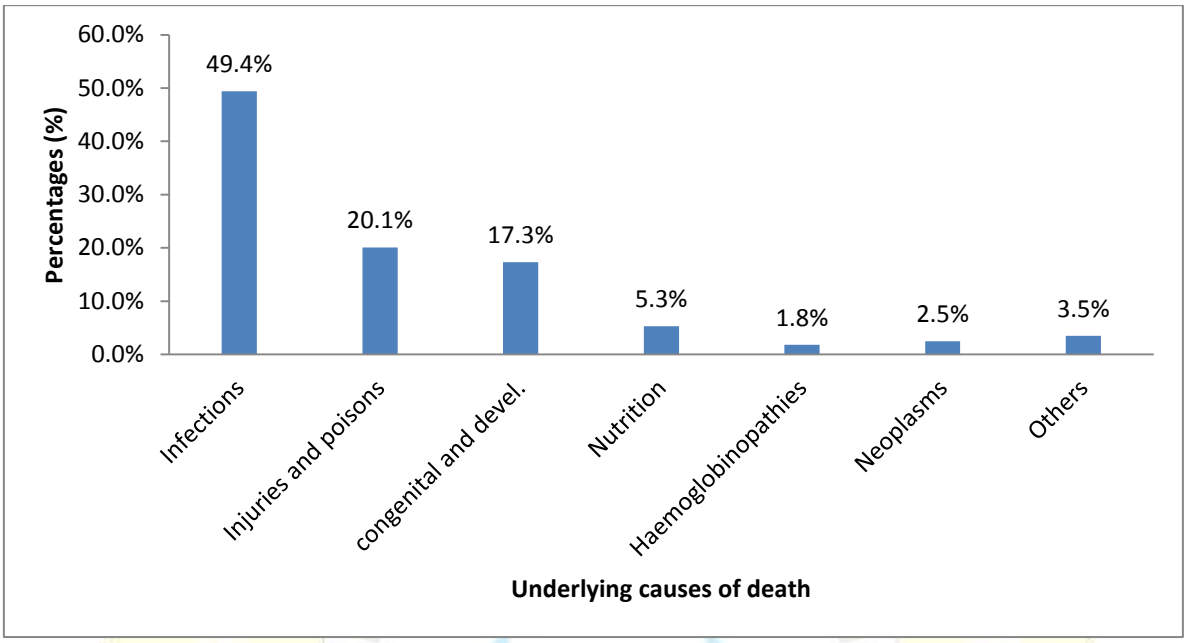

Figure 1: Underlying causes of death in children under the age of 5-years

Stratifying the deaths in subjects under the age of 5 years by age groups, most deaths were commoner in children (group 12-59 months), except congenital and developmental related deaths that were commoner in the neonatal period 135 (41.6%) (table 2). Studies have found that certain disease conditions were commoner in certain age groups.[13,14,15] For instance, in the post-neonatal period the common causes of death were infections, congenital and developmental abnormalities. Injuries and neoplastic causes were common causes in childhood period. The age characteristics of the current study is in accord with studies in Bangladesh[13], India[14] and china.[15]

Deaths in children under the age of 5-years commonly occurred in the community (coroner's) except neoplasms, which were commoner in health facilities (table 3). For all categories of the underlying causes of death in this study, boys were commonly affected than girls and thus matched with global statistics.[16,17]

Table 3: Distribution of underlying causes of deaths by location (community and hospital)

Causes	Coroner (n/%)	Hospital (n/%)	Total
Infections	914 (88.8)	112 (11.2)	1029
Injuries and poisons	396 (98.0)	8 (2.0)	404
Congenital and developmental	207 (63.3)	120 (36.7)	327
Nutritional	93 (83.8)	18 (16.2)	111
Neoplasms	24 (45.3)	29 (54.7)	53
Haemoglobinopathies	27 (65.9)	14 (34.1)	41
Others	84 (62.7)	50 (37.3)	134

Infections as underlying causes of death in children under the ages of 5-years

Infection related deaths were commoner 595 (58.7%) in children age 12-59 months Table 2.

Majority 889 (88.8%) of the deaths occurred in the community or within 24-hours of admission to a health facility where no definitive diagnosis was made before death (coroner cases) Table 3. Many of the deaths were males 576 (58.2%). The common infection related deaths in descending order were: malaria (37.7%), pneumonia (29.4%), diarrhoea diseases (21.3%), meningitis (3.6%) and sepsis (2.1%) Table 4. Infections as causes of death in human particularly in the developing countries have been a major public health concern. In this autopsy based study in Ghana, the common infection related causes of deaths in children under the age of five years in descending order were: malaria, pneumonia, diarrhoea diseases, meningitis and sepsis. This support publications in Sub-Saharan Africa, that found that increased numbers (40%) of deaths in children under 5-years were due to malaria and its complication, followed by pneumonia (21%) [5,18,19] This however differs from other studies that found pneumonia as the leading cause of death in subjects under five years. [11,20,21] For instance, Yazoume et al,[20] in Nairobi, found pneumonia as the leading cause of death (25.7%) followed by diarrhoea diseases (22.0%). Again, Perry et al[21] in their study in rural Haiti found that 45% of all under deaths were due to pneumonia followed by enteric diseases. Further still others found diarrhoea as the leading cause of death in these subjects.[22,23] It is cleared from this point that, when it comes to infections as causes of death in children under 5 years, several factors must be taken into accounts such as the extend of immunization, urban and peri-urban development and the sanitation practice of the country. This complex nature of infection as a cause of death in children under five years, is supported by saul et al[24] study that compared the causes of deaths in children under the age of 5-years in Sub Saharan Africa and South Asia, both developing countries. They found the pattern of deaths as: pneumonia (23% and 23%), malaria (24% and <1%), diarrhoea (22% and 23%), 'neonatal sepsis and (29% and 52%), measles (2% and 1%).

Injuries and poisons as underlying causes of death in children under the ages of 5-years

Table 4: Infections as causes of deaths in children under 5-years

	Children Frequency(n/%)	Infants Frequency(n/%)	Neonates Frequency(n/%)	Total Frequency(n/%)
Infections				
Malaria	290	96	4	390 (37.9)
Pneumonia	130	119	54	303 (29.4)
Diarrhoea	121	90	8	219 (21.3)
Meningitis	22	12	2	36 (3.6)
Sepsis	5	3	14	22 (2.1)
HIV/AIDS	8	11	1	20 (1.9)
tuberculosis	14	3	0	17 (1.7)
Encephalitis	5	2	0	7 (0.7)
Bronchiolitis	4	3	0	7 (0.70
Primary	0	0	1	1 (0.1)

peritonitis				
Hepatic abscess	0	0	1	11 (0.1)
pericarditis	3	0	0	3 (0.3)
Endocarditis	0	1	0	1 (0.1)
Viral hepatitis	0	1	0	1 (0.1)
Acute UTI	0	1	0	1 (0.1)
Febrile illness	2	0	0	2 (0.2)
Total	602	342	85	1029 (100.0)

Table 5: Injuries and poisons as causes of deaths in children under 5-years

Injuries and poisons	Children Frequency(n/%)	Infants Frequency(n/%)	Neonates Frequency(n/%)	Total n(%)
Burns	94	19	4	117 (28.6)
Road traffic accidents	91	17	1	109 (26.7)
Drowning	83	3	2	88 (21.5)
Birth trauma	0	4	32	36 (8.8)
Poisons	10	5	1	16 (3.9)
Foreign body aspiration	9	1	2	12 (2.9)
Fall from height	7	1	0	8 (2.0)
Electrocution	8	0	0	8 (2.0)
Assault	8	1	0	9 (2.2)
Strangulation	3	0	1	4 (1.0)
Falling wall	9	0	0	9 (2.2)
Heat stroke	3	0	0	3 (0.7)
Drug reaction	1	0	0	1 (0.2)
Snake bite	1	0	0	1 (0.2)
Total	315	51	43	409 (100.0)

Table 6: Congenital and developmental disorders as causes of under deaths

Congenital and Developmental disorders	Children Frequency (n)	Infants Frequency (n)	Neonates Frequency (n)	Total n(%)
Congenital heart disease	72	57	57	186 (56.9)
Prematurity	2	2	42	46 (14.1)
Obstructive uropathy	2	8	4	14 (4.3)
Multiple abnormalities	4	0	9	13 (4.0)
Biliary duct atresia	1	6	3	10 (3.1)
Hirschsprung	6	1	1	8 (2.4)
Exomphalus major	0	1	7	8 (2.4)
Tracheo-oesophageal fistulas	1	6	1	8 (2.4)
Hydrocephalus	2	5	0	7 (2.1)
Spinal bifida	2	2	3	7 (2.1)
Gastro-intestinal Atresia	2	1	2	5 (1.5)
Imperforate anus	0	0	4	4 (1.2)
Valvular disorders	4	0	0	4 (1.2)
Laryngeal atresia	1	0	1	2 (0.6)
Vascular malformation	0	2	0	2 (0.6)
Hypospadia repair post-surgery	1	0		1 (0.3)
Down syndrome	0	0	1	1 (0.3)
Siamese twins	0	0	1	1 (0.3)
Total	100	91	136	327 (100.0)

Table 7: Neoplastic lesions as causes of under deaths

Neoplastic	Children Frequency (n)	Infants Frequency (n)	Neonates Frequency (n)	Total n(%)
Lymphomas	17	1	0	18 (34.0)
Brain tumours	11	0	0	11 (20.8)
Nephroblastoma	8	1	0	9 (17.0)
Neuroblastoma	1	2	1	4 (7.5)
Retinoblastoma	4	0	0	4 (7.5)
Leukaemias	2	0	0	2 (3.8)
Immature teratoma	1	0	0	1 (1.9)
Alveolar Rhabdomyosarcoma	0	1	0	1 (1.9)
Retroperitoneal tumour	0	1	0	1 (1.9)
Angiosarcoma of liver	0	1	0	1 (1.9)
Mediasternal tumour	0	1	0	1 (1.9)
Total	44	8	1	53 (100.0)

Table 8: Other underlying causes of death in children under 5-years

Others	Children Frequency (n)	Infants Frequency (n)	Neonates Frequency (n)	Total n(%)
Unascertained	7	9	16	32 (28.6)
Volvulus and intussusception	6	15	5	26 (23.2)
Atelectasis	0	0	4	4 (3.6)
Cerebral oedema	11	2	1	14 (12.5)
Liver cirrhosis	4	2	1	7 (6.3)
Seizure disorder	3	3	0	6 (5.4)
Sudden death	0	3	0	3 (2.8)
Nephrotic syndrome	2	0	1	3 (2.8)
GI bleeding	0	1	2	3 (2.8)
Failure to thrive	2	0	1	3 (2.8)
Hypoglycaemia	0	0	1	1 (0.9)
Cerebral palsy	3	0	0	3 (2.8)
Asthmatic attack	2	0	0	2 (1.8)
End stage kidney disease	2	0	0	2 (1.8)
Hepatomegaly	1	0	0	1 (2.8)
Adrenal insufficiency	1	0	0	1 (2.8)
Renal stones	0	1	0	1 (2.8)
Total	44	36	32	112 (100.0)

A total of 411 (20.1%) deaths in this study were due to injuries and poisons. The major causes in descending were: burns (28.6%); road traffic accidents (26.7%, consisting of 95 pedestrians and 14 passengers)), drowning (21.5%), birth trauma (8.8%) and poisons (3.9%) table 4. The immediate causes of death were: head injury 96 (28.0%), asphyxia 43 (10.0%), and haemorrhagic shock 28 (7.0%). The great majority 321 (78.1%) were in the 12-59 months age group Table 2. Almost all deaths 403 (98.5%), occurred in the community (coroner cases) Table 3. Many (64.0%) of the deaths were males. Injuries as causes of under five deaths are common and of a growing global public health problem especially in most developing countries, including sub-Saharan Africa.[25] Clinical or autopsy data on injuries and

poisons as underlying causes of death are lacking in Ghana. In this retrospective autopsy study, 20.1% of the deaths were due to injuries and poisons. The high proportion of injuries related under five deaths in this study may be due to the fact that for the past decays, Accra has seen massive industrial and domestic infrastructural expansion coupled with the increased inflow of vehicles and pedestrians on the roads, a pattern that is similar to most major cities in Africa[26]. The underlying causes in descending order were: burns, road traffic accidents, drowning, birth trauma and poisons. This pattern is similar to Nordberg et al study in sub-Saharan Africa,[26] but differs from Agran et al[27] study that found the leading major causes of injury in descending order as falls, poisoning, transportation, foreign body, and fires/burns. The current retrospective autopsy found that injuries commonly occurred in the community and in boys more than girls. The current findings are therefore similar to studies across the globe that reported that boys are more likely than girls to experience and die as a result of injuries and poisons. [28,29,30] The great disparity between girls and boys in relation to injuries as a causes of under five deaths may be related to differences in behaviour, in the type of activities boys and girls are engaged in the community, schools and homes.

Nutritional causes of death in children under the ages of 5-years

One hundred and eight of the deaths (5.3%) in subjects under 5-years were nutrition related. There 67 (60.4%) cases of malnutrition and 44 (39.5%) cases of anaemia. Majority 93 (86.1%) of the deaths occurred in the community. The deaths were common 53 (49.0%), in the age group 12-59 months. Poor nutrition status in a child is strongly associated with vulnerability to diseases, to delay physical and mental development, and to increased risk of dying.[31] Approximately, 5.3% of all the deaths were related to nutrition and that 60.4% were due to malnutrition. The age group commonly affected was 12 – 59 years. Malnutrition has been identified as a major cause of under five deaths in developing countries particularly after the neonatal period.[32] The current study therefore support previous studies that identified malnutrition as a major cause of under-five death across the globe.[33,34]

Congenital and Developmental abnormalities as underlying causes of death in children under the ages of 5-years

A total of 327 (15.5%) deaths were related to congenital and development abnormalities and mostly within the neonatal period 145 (40.4%) table 2. Two-third (66.6%) of the deaths occurred in the community (coroner cases) table 3. A little over half (52.3%) were males. The common underlying causes were: CHD (56.9%, mostly VSD 42%), prematurity (14.3%), obstructive uropathy (4.3%), multiple congenital abnormalities (4.0%) and biliary duct atresia (3.1%), table 5. Congenital and development disorders do not commonly appear in mortality data in Ghana and other developing countries. This is partly so because of high burden of

infectious diseases in these countries especially after the first 28 days.[35] In China and other developed countries congenital abnormalities and prematurity are the main causes of under five deaths.[7,36] In this study developmental and congenital disorders contributed significantly (15.6%) to under five mortality with 33.4% of the deaths occurring in health facilities. Although not the leading cause of death in children under five years as in China,[7] it is third underlying cause of death in this study. This calls for interventions directed at perinatal care, antennal and postnatal care, and genetic counselling in Ghana for early detection and management of chromosomal and peripartum abnormalities as well as complications. This will lead to reduction in the proportions of developmental and congenital disorder as causes of under five deaths in Ghana.

Neoplasms as underlying causes of death in children under the ages of 5-years

Approximately 2.5% of the deaths were related to neoplasms. Majority of these deaths occurred in children (82.4%), table 2 and in males (74.5%). Many of the deaths occurred in a health facility 27 (52.9%) table 3. The underlying causes of death descending order were: lymphoma (34.0%), brain tumours (20.8%), nephroblastoma (17.0%), neuroblastoma (7.5%) and retinoblastoma (7.5%) table 5. Neoplastic causes of death in children has been reported by clinical[37] and autopsy studies [38] in Ghana and beyond.[39] Approximately 2.5% of the deaths were due to neoplastic lesions and commonly in health facilities (52.9%). The underlying causes in descending order were: lymphoma, brain tumours, nephroblastoma, and neuroblastoma. This pattern is in keeping with previous studies in Ghana and in the sub-region. [37,38,40] The pattern may also be due to the high prevalence of malaria and HIV in Sub-Saharan Africa, both infections being associated with increased risk of high grade lymphomas. The finding of the current study however differs from the patterns in advanced countries like the United States of America where leukaemia is the commonest cause of cancer morbidity and mortality[41,42,43] in children under five years.

Haemoglobinopathies and bleeding disorders as underlying causes of death

A total of (2.0%) of the deaths were due to haemoglobinopathies and bleeding disorders. The underlying causes of death were sickle cell death 25 (61.0%), bleeding disorders including haemolytic disease of the new born 15 (36.6%) and S-B-Thal (2.4%). Many of the deaths occurred in community 25 (67.6%). Twenty-six (70.3%) of the deaths were within 12-59 months of age. Haemoglobinopathies has been reported in the literature as major causes of under-five mortality.[44,45] In this current retrospective autopsy study, 2.0% of deaths were related to haemoglobin and bleeding disorders, particularly sickle cell disease (SCD) (61.0%). This is comparable with studies in Africa,[46] United Kingdom and the United States of America [47,48] that found SCD as the commonest haemoglobinapthy and the leading

underlying cause of death in children under five years with disorders of haemoglobin. In this current study, many of the deaths occurred in community (67.6%). This differs from Alessandra et al study in Tanzania which found that high proportions of haemoglobinapthy related deaths occurred in health facilities.[49]

The main limitation of the study was its retrospective design, as locating the families becomes more difficult over the years, as well as their incapacity incomplete autopsy records, by the pathologists. It was also difficult to classify all the causes of death and this resulted 5.3% of the cases classified as others.

CONCLUSION

The current study found that under five deaths were commoner in the community, in boys and in the childhood period. Approximately 73.0% of under five deaths could have been prevented, by paying attention the immediate environment of the children and the by the use of appropriate medical interventions. We recommend that autopsy data on under five deaths be part of the routine health sector mortality data in Ghana.

ACKNOWLEDGEMENT

We will like to thank all consultants, residents and the biomedical staff of the Department of Pathology for their support.

REFERENCES

1. Murray CJ, Lozano R, Flaxman AD, et al. Using verbal autopsy to measure causes of death: the comparative performance of existing methods. BMC Med. 2014;12:15.
2. Hill K, Pande R, Mahy M, Jones G. trends in child mortality in the developing world. 1960 – 1996. New York: UNICEF; 1999.
3. Central Statistical Agency, Ethiopia/ICF International. Ethiopia Demographic and Health Survey 2011 (Addis Ababa, 2012).
4. National Institute of Statistics, Directorate General for Health/ICF Macro. Cambodia Demographic and Health Survey 2010 (Phnom Penh/Calverton, Maryland, 2011).
5. Black RE, Morris SS, Bryce J, 2003. Where and why are 10 million children dying every year. Lancet 361: 2226–2234.
6. United Nations Inter-agency Group for Child Mortality Estimation. Levels & Trends in Child Mortality: Report 2012. New York, United Nations Children's Fund, 2012.
7. Rahbar M, Ahmadi M, Lornejad HR, Habibelahi A, Sanaei-Shoar T, Mesdeaghinia AR. Mortality Causes in Children 1–59 Months in Iran. Iran J Public Health. 2013; 42(Supple1): 93–97.
8. 8.Sacarlal J, Nhacolo AQ, Sigaúque B, Nhalungo DA, Abacassamo F, Sacoor CN, Aide P, Machevo S, Nhampossa T, Macete EV, Bassat Q, David C, Bardají A, Letang

E, Saúte F, Aponte JJ, Thompson R, Alonso PL. A 10 year study of the cause of death in children under 15 years in Manhiça, Mozambique. BMC Public Health. 2009 Feb 24;9:67. doi: 10.1186/1471-2458-9-67.

9. Lurán A, López E, Pinilla C, Sierra P. Mortality by avoidable causes in preschool children. Biomedica. 2009 Mar;29(1):98-107
10. Rimsza ME, Schackner RA, Bowen KA, Marshall W Can child deaths be prevented? The Arizona Child Fatality Review Program experience. Pediatrics. 2002 Jul;110(1 Pt 1):e11.
11. 11.UNICEF. State of the World's Children 2009: Maternal and newborn health. New York: UNICEF; 2008.
12. Jones G, Steketee WR, Black ER, Bhutta AZ, Morris SS. How many child deaths can we prevent this year? Lancet 2003;362:65 – 71.
13. Liu L, Li Q, Lee RA, Friberg IK, Perin J, Walker N, Black RE. Trends in causes of death among children under 5 in Bangladesh, 1993–2004: an exercise applying a standardized computer algorithm to assign causes of death using verbal autopsy data. Popul Health Metr. 2011;9:43.
14. Singh Ms, Deorari AK, Paul VK, Murali MV, Mathur M. Primary causes of neonatal deaths in a tertiary care hospital in Delhi: an autopsy study of 331 cases. Ann Trop Pediat. 1990;10(2):151–157.
15. Igor Rudan Kit Yee Chan,Jian SF Zhang, Evropi Theodoratou Xing Lin Feng,Joshua A Salomon, Joy E Lawn, Simon Cousens Causes of deaths in children younger than 5 years in China in 2008 The Lancet 2010;375:1083–1089.
16. Fazzio I, Mann V, Boone P. Temporal trends (1977–2007) and ethnic inequity in child mortality in rural villages of southern Guinea Bissau. BMC Public Health. 2011;11:683.
17. Humphrey L, Bello S, Rousham E. Sex differences in infant mortality in Spitalfields, London. J Biosoc Sci. 2012;44:95–119.
18. Bryce J, Boschi-Pinto C, Shibuya K, Black RE, and WHO Child Health Epidemiology Reference Group, 2005. WHO estimates of the causes of death in children. Lancet 365: 1147–1152.
19. Rudan I, Boschi-Pinto C, Biloglav Z, Mulholland K, Campbell H. Epidemiology and etiology of childhood pneumonia. Bull World Health Organ 2008; 86: 408–416.
20. Yazoume Ye, Eliva Zulu., Maurice Mutisya, Benedict Orindi, Jacques Emina and Catherine Kyobutungi: Seasonal Pattern of Pneumonia Mortality among Under-Five Children in Nairobi's Informal Settlements Am J Trop Med Hyg 2009; 81: 770-775.

21. Perry HB, Ross AG, Fernand F. Assessing the causes of under-five mortality in the Albert Schweitzer. Hospital service area of rural Haiti. Rev Panam Salud Publica. 2005;18:178–86.
22. Bull World Health Organ vol.86 n.9. Geneva Sep. 2008. Diarrh as the leading cause of death in children under the ages of 5-years. http://dx.doi.org/10.1590/S0042-96862008000900015
23. Boschi-Pino C, Velebit L, shibuya K. Estimating child mortality due to diarrhoea in developing countries. BullWorld Health Organ 2008;710 – 717.
24. Saul S Morris, Robert E Black and Lana Tomaskovic: Predicting the distribution of under-five deaths by cause in countries without adequate vital registration systems. Int. J. Epidemiol. 2003;32 :1041-1051.(doi: 10.1093/ije/dyg241).
25. 23. GBD 2013 Mortality and Causes of Death Collaborators. (2015). Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*, *385*(9963), 117–171. http://doi.org/10.1016/S0140-6736(14)61682-2
26. Nordberg E . Injuries as a public health problem in sub-Saharan Africa: epidemiology and prospects for control. East Afr Med J. 2000;77(12 Suppl):S1-43.
27. Agran PF, Anderson C, Winn D, Trent R, Walton-Haynes L, Thayer S. Rates of pediatric injuries by 3-month intervals for children 0 to 3 years of age. Pediatrics. 2003;111(6 Pt 1):e683-92.
28. 28.WHO, UNICEF. World report on child injury prevention. Geneva: WHO UNICEF; 2008.
29. United Nations Children's Fund 2001, A League Table of Child Deaths by Injury in Rich Nations, Innocenti Report Card, Issue no.2, UNICEF Innocenti Research Centre, Florence.
30. Australian Institute of Health and Welfare 2002, Australia's children: their health and wellbeing 2002, AIHW, Canberra.
31. R.E. Black and others, "Maternal and child undernutrition and overweight in low-income and middle-income countries", *Lancet*, published online 6 June 2013. Available at http://dx.doi.org/10.1016/S0140-6736(13)60937-X
32. Quiroga EF. Death rate by malnutrition in children under the age of five in Colombia. Biomedica. 2012; 32:499-509. doi: 10.1590/S0120-41572012000400005.
33. Pelletier D. The potentiating effects of malnutrition on child mortality: epidemiologic evidence and policy implications. Nut Rev. 1994;52:409–15.

34. WHO. Malnutrition-The Global Picture. World Health Organization. Available at http://www.who.int/home-page/. Acessed on 1 January 2013.
35. World Health Organization Global Health Observatory. Available from http://apps.who.int/gho/data/node.main.CODWORLD?lang=en (accessed 29 August 2013).
36. J.L. Fleiss. Statistical methods for rates and proportions. New York, John Wiley & Sons, 1981.
37. Welbeck JE, Hesse AA. Pattern of childhood malignancy in Korle Bu Teaching Hospital, Ghana. West Afr Med J. 1998;17(2):81–84.
38. Gyasi RK, Tettey Y. Childhood Deaths from Malignant Neoplasms in Accra Ghana Med J. 2007 Jun; 41(2): 78–81.
39. Wagner HP, Antic V. The problem of paediatric malignancies in the developing world. Ann N Y Acad Sci. 1997;824:193–204.
40. Onwasigwe CN, Aniebue PN, Ndu AC. Spectrum of paediatric malignancies in Eastern Nigeria 1989–1998. West Afr Med J. 2002;21(1):31–33
41. Young JL, Muller RW. Incidence of malignant tumors in US children. J Paediatrics. 1975;2:245–258.
42. Surveillance Epidemiology and End Results from 1975–2000 Division of Cancer control and Population Sciences. National Cancer Institute Reports 2003 presentation by American Cancer Society. 2004. p. 23.
43. U.S. Cancer Statistics Working Group. *United States Cancer Statistics: 1999–2012 Incidence and Mortality Web-based Report.*
44. Pereira S.A, Brener S, Cardoso C.S,. Proietti A.B. Sickle cell disease: quality of life in patients with hemoglobin SS and SC disorders. Rev Bras Hematol Hemoter.2013; 35: 325–331.
45. Fernandes A.P, Januário J.N, Cangussu C.B, Macedo D.L, Viana M.B. Mortality of children with sickle cell disease: a population study. J Pediatr 2010; 86:279–284.
46. Modell B, Darlison M. Global epidemiology of haemoglobin disorders and derived service indicators. Bulletin of the World Health Organization 2008; 86: 480–487
47. Quinn CT, Rogers ZR, McCavit TL & Buchanan GR. Improved survival of children and adolescents with sickle cell disease. Blood 2010; 115*:* 3447–3452.
48. Telfer P, Coen P, Chakravorty S *et al.* Clinical outcomes in children with sickle cell disease living in England: a neonatal cohort in East London. Haematologica 2007 92:905–912.

49. Alessandra PS, Gabriella OL, Livia MLS, Marco SV. Characterization of mortality in children with sickle cell disease diagnosed through the Newborn Screening Program. Pedriatria. 2015;91: 242 - 247