Child Death Review Series II: Patterns of child death in England and Wales

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Abstract

Over the past century child mortality rates have fallen to very low levels in all developed countries. However, there remain wide variations both between and within countries, and in many child deaths factors can be identified which could be modified to reduce the risks of future deaths. An understanding of the nature and patterns of child death and of the factors contributing to child deaths is essential to driving preventive initiatives. This paper reports on the epidemiology of child deaths in England and Wales. It draws on available data, particularly death registration data and other available datasets, along with published literature to highlight the issues relevant to reducing child deaths in developed countries. We highlight the different patterns of mortality at different ages within five broad categories of death: perinatal causes, congenital abnormalities, acquired natural causes, external causes, and unexplained deaths. Within each category we explore what is known about the main causes of death and some of the contributory factors and highlight how this knowledge may be used to help drive prevention initiatives.

Introduction

In the first paper in this series [Fraser et al, in press] we outlined the background to and development of child death review in four high income countries: USA, England, Australia and New Zealand. We described the purpose, process and outputs of child death review and how these can contribute to a greater understanding of children's deaths and to learning lessons for prevention of future child deaths. An understanding of the nature and patterns of child death and of the factors contributing to child deaths is essential to driving preventive initiatives.

In this paper we report on the epidemiology of child deaths in England and Wales, drawing on publically available data, particularly death registration data, and other available datasets, along with published literature, to highlight the issues relevant to reducing child deaths in developed countries. Our aim in this paper is to use data from England and Wales as an example to explore the patterns of child deaths at different ages, and to consider the value and

limitations of official data on the primary cause of death. We have restricted our review to data on all infants, children and young people from birth to 19 years inclusive. Data are analysed and presented in 5-year age bands, separating out infant mortality: < 1year; 1-4 years; 5-9 years; 10-14 years; 15-19 years. Mortality rates are calculated per 1,000 live births for infants, and per 100,000 population for each of the other age bands.

A Medline literature search was carried out using the following terms: (child mortality/ OR infant mortality/) AND (United Kingdom.mp OR Great Britain/) Limited to English language, humans, all infant or child, and publications between 1990 and 2012. Titles and abstracts of 286 papers were reviewed, and the full text retrieved on 96 papers relevant to the epidemiology of infant and child mortality in the United Kingdom. Data were accessed from relevant publications and datasets on the Office for National Statistics (ONS) website (www.ons.gov.uk), including series DR (Mortality Statistics: deaths registered in England and Wales); Vital Statistics: Population and Health Reference Tables; Births by area of usual residence of mother; Mid-year population estimates; and Childhood, infant and perinatal mortality in England and Wales. Further data were obtained from Department for Education releases: Preventable Child Deaths in England: Years Ending 31 March 2011, and Biennial Reviews of Serious Case Reviews, 2005-7, 2007-9, and the Department for Transport releases, Reported road casualties Great Britain.[1-5]

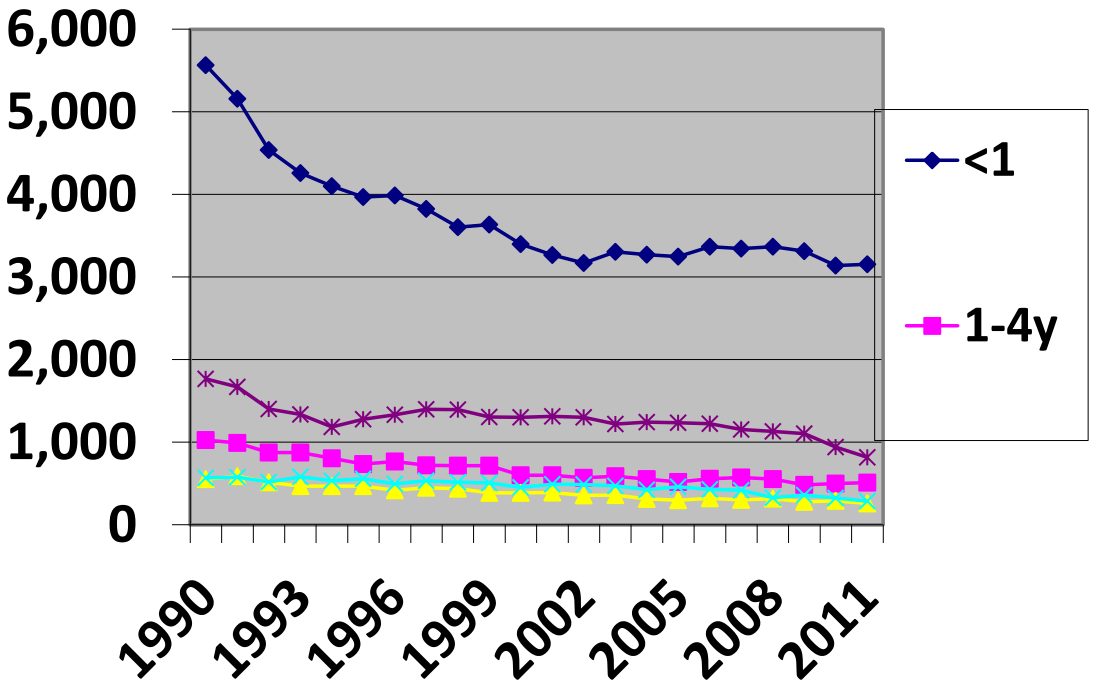
ONS data rely on death registrations, and are collated by year of registration rather than year of occurrence. This may introduce some inaccuracies in the data, due to delays in registration, particularly for external causes of death, where registration may be delayed pending coronial inquests. Further, only a single primary cause of death is recorded for these annual statistics, so the data may not provide a fully accurate or comprehensive understanding of the patterns of death. The denominator data rely on mid-year population estimates, extrapolated from earlier census data. This in turn may introduce inaccuracies in calculating mortality rates. In spite of these cautions, the data represent the most comprehensive overview of patterns of child mortality currently available at a national level for England and Wales.

Child Mortality in England and Wales

Annually, over 5,000 children and young people aged 0-19 die in England and Wales. Over the last century, numbers of child deaths have fallen in all age groups, a trend that has

continued, though less sharply, in recent years (Figure 1). The most substantial falls have been in infant deaths, falling from 5,564 (7.88 per 1,000 live births) in 1990 to 3,154 in 2011 (4.36 per 1,000 LB), although the biggest drops were in the 1990s. Numbers of deaths in each of the other age groups have fallen by close to 50% since 1990.

Figure 1: Child mortality, England and Wales, 1990-2011



In comparison to many other European countries, all-cause mortality in the United Kingdom remains high. A recent analysis of WHO data identified higher mortality specifically in conditions that are influenced by health service provision such as meningococcal disease, pneumonia and asthma, and concluded that if the UK health system performed as well as that of Sweden, as many as 1500 children might not die each year.[6] There are several possible explanations for this, some of which illustrate weaknesses of health care provision for children in this country, and further work is needed to identify and respond to such gaps in care. While cross-country comparisons are fraught with difficulty, it is essential that we take such data seriously and use them as a stimulus to action.

Although the numbers are small (particularly outside infancy) and therefore subject to potential year on year fluctuations, there are some regional differences in infant and child

mortality rates (Table 1). There is a trend towards higher rates in the Midlands and north of England, and lower rates in the south and east. The one exception to this general North-South gradient is the North East, which has a trend towards lower rates in all age groups (significant only for infant deaths).

Table 1: Child mortality, 0-14* United Kingdom, constituent countries and English regions, 2009-11, average annual numbers of live births and deaths (rates per 1,000 live births/100,000 population)

[Source: Office For National Statistics, Mortality Statistics: Deaths registered in England and Wales (Series DR); Births by Area of Usual Residence of Mother, England and Wales; Mid-Year Population Estimates. Available at: www.ons.gov.uk]

Country/Region	**Live Births**	**Infant Mortality**	**1-4 years**	**5-14 years**
England & Wales	717,710	3,202 (4.46)	499 (18.32)	602 (9.58)
Wales	35,496	150 (4.23)	20 (14.38)	35 (10.39)
English Regions				
North East	30,376	114 (3.74)[4]	20 (16.93)	25 (8.79)
North West	88,500	420 (4.75)[1]	78 (22.98)[2]	80 (10.09)
Yorkshire & Humber	66,593	347 (5.21)[2]	54 (20.96)	59 (9.93)
East Midlands	54,785	245 (4.47)	37 (17.36)	50 (10.00)
West Midlands	72,052	422 (5.85)[2]	46 (16.73)	63 (9.70)
East	72,519	282 (3.89)[6]	46 (16.12)	52 (7.73)[5]
London	131,733	584 (4.44)	86 (18.88)	94 (10.67)
South East	105,745	389 (3.68)[6]	61 (14.78)[5]	81 (8.22)[3]
South West	59,759	218 (3.64)[6]	40 (17.33)	50 (8.80)

* Data on mortality for 15-19 year olds are not available by English Region.

[1] Significantly higher than England & Wales rate at 0.05 level using Chi-square test on summed data for 3 years

[2] Significantly higher than England & Wales rate at 0.0005 level

[3] Significantly lower than England & Wales rate at 0.01 level

[4] Significantly lower than England & Wales rate at 0.001 level

[5] Significantly lower than England & Wales rate at 0.005 level

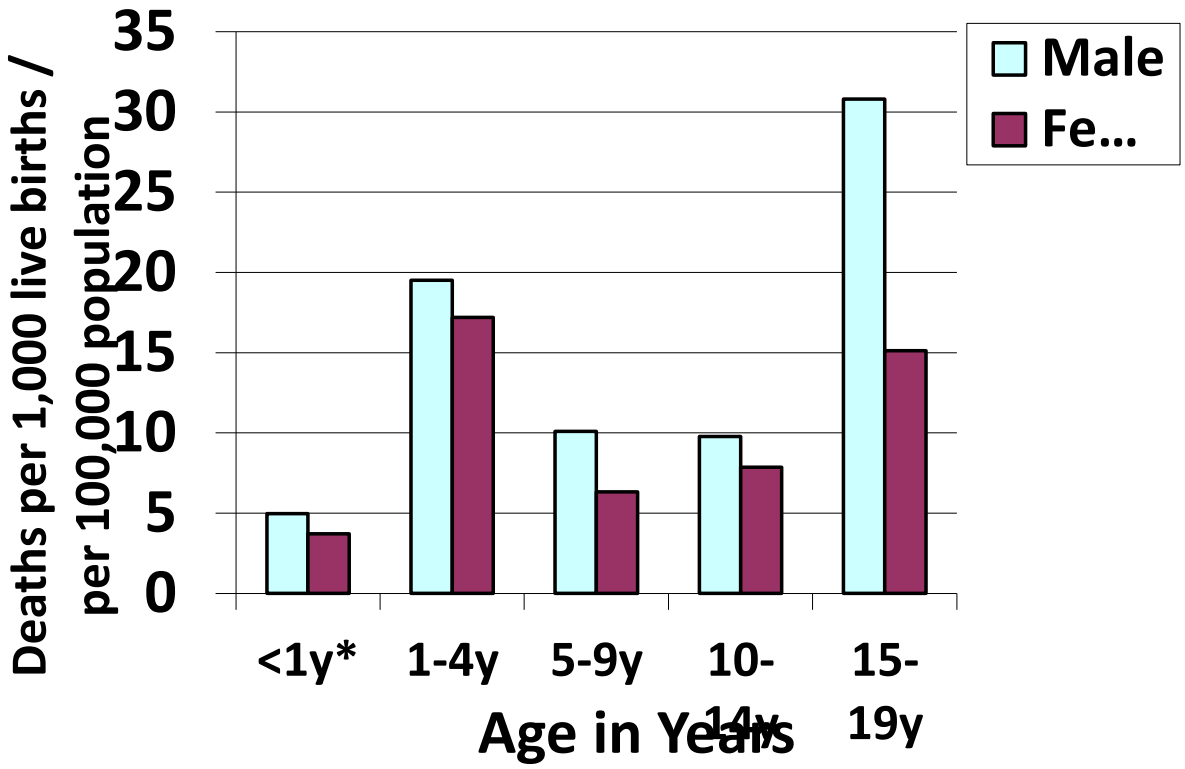
[6] Significantly lower than England & Wales rate at 0.0005 level

Patterns of child mortality

Alongside the overall reduction in numbers and rates of child deaths, there have been substantial shifts in the patterns and causes of these deaths. The highest rates of child deaths are in infancy, with rates far exceeding those in any other age group. At all ages boys show higher death rates than girls. Prior to the 1970s, the next highest rates were in children aged 1-4, a situation still found in many developing countries. Now however, rates of adolescent deaths exceed those of younger children, with much higher rates in teenage boys (Figure 2).

Figure 2: Child Mortality, England and Wales, 2011, rates per 1,000 live births / 100,000 population

(ONS: Mortality Statistics: Deaths registered in 2011)



*** Rates for <1year olds are presented as per 1,000 live births. Comparable rates per 100,000 would be 100 times the values shown here.**

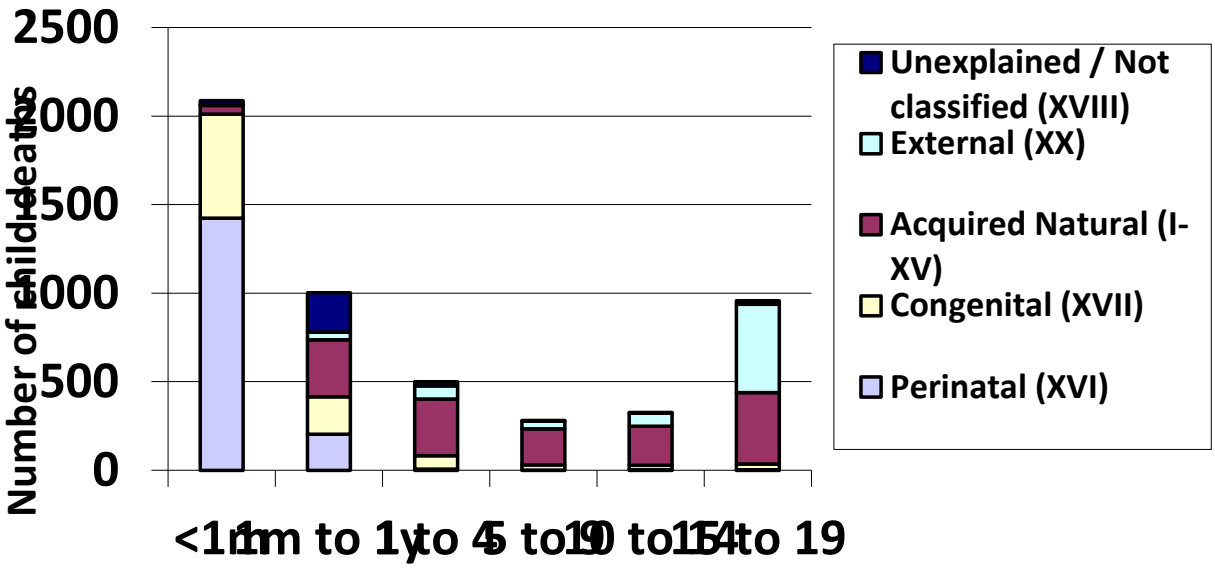
Deaths in the UK, as in most developed countries, are coded according to the tenth revision of the International Classification of Diseases (ICD10). ICD10 divides deaths into 19 disease categories, with specific disease entities within each. In order to explore the different patterns of child deaths, we have categorised those deaths registered under ICD10 into five broad groups: perinatal causes; congenital causes; acquired natural causes (including both acute and chronic medical and surgical conditions); external causes (including accidents, homicides and suicides); and deaths which remain unexplained (Table 2, Figure 3). The first three groups will include both expected and unexpected deaths (defined as the death of a child which was not anticipated as a significant possibility 24 hours before the death or where there was a similarly unexpected collapse leading to or precipitating the events which led to the death).[7] Deaths in the latter two groups are typically unexpected, although often the child may survive the initial unexpected event, only to die after some time on intensive care, or subsequently of longer term consequences of the initial event. It is important to bear in mind that precise diagnostic classification of child mortality is difficult due to the limitations of the death certification process, and due to the inevitable heterogeneity of disease processes.

Table 2: Causes of childhood deaths, England and Wales, average annual numbers and rates 2009-2011

[Source: Office For National Statistics, Mortality Statistics: Deaths registered in England and Wales (Series DR); Child Mortality Statistics: Childhood, infant and perinatal; Births by Area of Usual Residence of Mother, England and Wales; Mid-Year Population Estimates. Available at: www.ons.gov.uk]

Number (rate per 100,000) of Deaths by Cause												
Category (ICD Codes)	**< 1 month**		**1month to 1 year**		**1 to 4 years**		**5 to 9 years**		**10 to 14 years**		**15 to 19 years**	
	N	**(rate)**	**N**	**(rate)**	**N**	**(rate)**	**N**	**(rate)**	**N**	**(rate)**	**N**	**(rate)**
A: Perinatal Causes (XVI)	1,424	(199)	204	(29)	7	(<1)	1	(<1)	2	(<1)	2	(<1)
B. Congenital Causes (XVII)	587	(82)	211	(30)	76	(3)	28	(<1)	26	(<1)	33	(<1)
C: Acquired Natural Causes (I-XV)	49	(7)	321	(45)	319	(12)	205	(7)	220	(7)	403	(11)
D: External causes (XX)	5	(<1)	44	(6)	74	(3)	44	(1)	74	(2)	499	(14)
E: Unexplained / Otherwise Classified (XVIII)	23	(3)	222	(31)	24	(<1)	3	(<1)	4	(<1)	21	(<1)
Total, all causes	2,087	(292)	1,002	(140)	500	(18)	281	(9)	326	(10)	957	(27)

Figure 3: Patterns of child death by age, average annual numbers of child death, England and Wales, 2009-11



In the following sections, we will explore each of these broad categories in turn, highlighting what is currently known about child deaths and potential implications for preventive work.

Panel: Preventable child deaths

While these data can give us some indication of what conditions children are dying of, they do not provide a full understanding of why a child dies. A deeper understanding of the circumstances of each child's death, multiple causes and contributory factors is necessary to interpret the most profitable areas for preventive action. Various studies and inquiries have explored issues of preventability and contributory factors in relation to child deaths, including the CEMACH study, *Why Children Die*[8-10] and previous confidential enquiries.[11-17] Drawing on reports from all agencies involved with a child or family, the English Child Death Overview Panels review all children's deaths to determine whether there are identifiable factors that may have contributed to the death. As reported in the first paper in this series, 20% of all deaths reviewed were felt to have modifiable factors.[1][Fraser et al., in press] These data are presented below according to the categories listed above. As can be seen from the table, the highest proportions of deaths with identified modifiable factors are in the external causes and unexplained/unknown groups, with much lower proportions in the

perinatal and congenital categories.

Category of Death	Number of deaths reviewed (% of all deaths in this category)	Number (%) with modifiable factors identified
Perinatal/neonatal event	1,449 (36%)	148 (10%)
Chromosomal, genetic and congenital abnormalities	968 (24%)	70 (7%)
Acquired natural causes	957 (24%)	178 (19%)
External	342 (9%)	225 (66%)
Unexplained/Unknown	302 (8%)	179 (59%)
Total	**4,018 (100%)**	**800 (20%)**

Perinatal and Congenital Causes

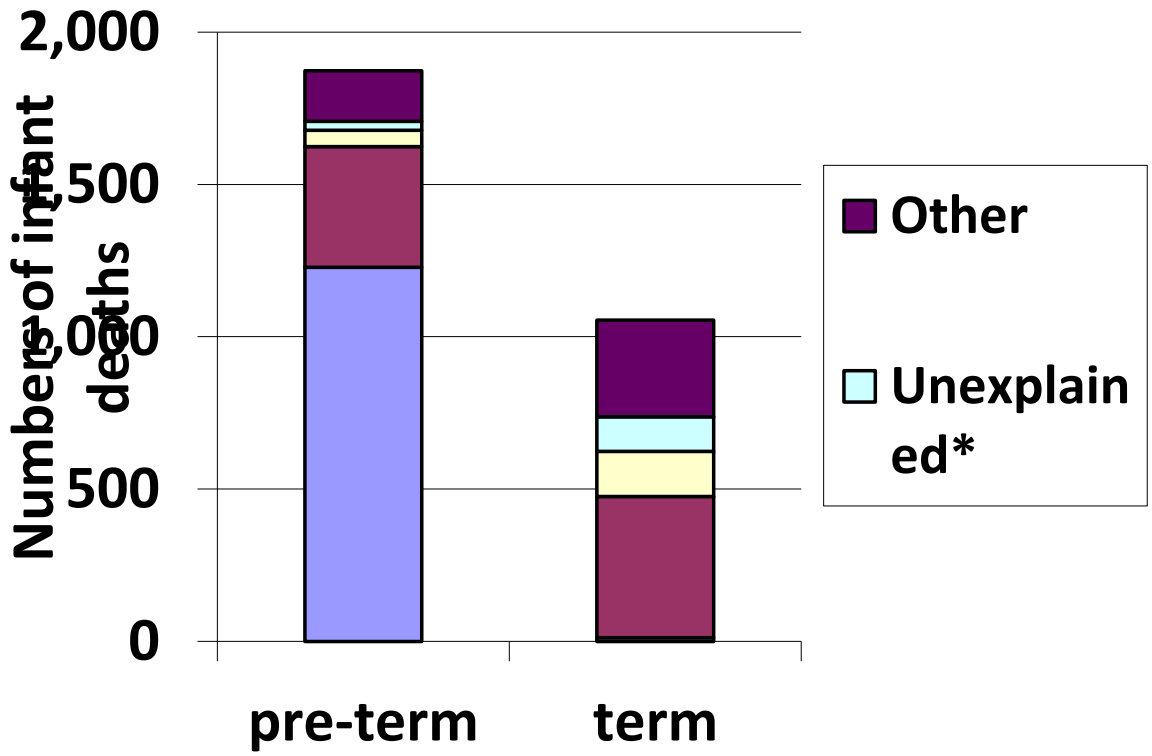
The highest rates of child mortality are in infancy, particularly those in the first week (early neonatal) and first month (neonatal) of life. Throughout infancy, but particularly in the neonatal period, perinatal and congenital causes of death predominate (Appendix 1). Neonatal deaths – deaths occurring within 28 days of birth – can best be considered separately in term and preterm babies because the causes of death, and the relative importance of different causes of death, are very different in these two groups (Figure 4). In term babies, perinatal hypoxic-ischaemic injury and congenital malformations, particularly congenital heart defects, are the dominant causes of death, accounting for 58% of all neonatal deaths. In contrast, among preterm babies, deaths from respiratory disease and intraventricular /periventricular haemorrhage (IVH/PVH), sometimes collectively referred to as 'problems of prematurity' are predominant, accounting for 2/3 of all deaths. However malformation remains the second most frequent cause of death accounting for 21% of deaths. These different factors often interact. When, for example, cardiac malformation is combined with prematurity, it is more likely to be lethal than the same malformation in a term baby.[18]

In relation to infant deaths, by far the biggest single group of causes of death is that of the consequences of prematurity (infection, including necrotising enterocolitis; lung disease, and brain damage); but this effect is confined to babies born below 32 weeks of gestation. While some inroads can be made through improvements in perinatal care, strategies to prevent extreme prematurity are likely to have the greatest impact in reducing these deaths.[19] Understanding the range of clinical, social and environmental factors contributing to premature delivery may prove more fruitful in learning how to reduce these deaths. At the

very extreme of viability, there has been little change in outcome since 1995 with virtually no survivors at 22 weeks, and merely delayed death at 23 weeks.[20, 21]

Figure 4: Infant deaths in pre-term and term infants

(Source: Gestation-specific infant mortality in England and Wales, 2010, ONS 2012)



* The data presented in this table are from the ONS release on gestation-specific infant mortality by broad cause groups. These rely on linked death and birth registration data. Unexplained deaths reported here are those classified as R95 (sudden infant death syndrome) only. Other deaths coded using R96 (Other sudden death, cause unknown), R98 (unattended death) or R99 (other ill-defined and unspecified causes of mortality) will be included in the category 'other'.

Because of the increasing success of neonatal surgical procedures, renal support and corrective cardiac surgery, improved survival for some malformations, including previously lethal trisomies, has been accompanied by a tendency for some babies to die post-neonatally who would previously have died before 28 days.[22-24] Indeed, each year, 600 children die

outside the neonatal period of congenital anomalies and the consequences of perinatal conditions, nearly 1/3 of those dying after infancy (Table 2). While such improvements are welcomed, this can present obstetricians and neonatologists with ethical dilemmas, particularly in relation to resuscitation at birth and intervention with extremely premature infants. Many of these children would be classified as living with a life-limiting condition and may require palliative care at some point, although often with long periods when this is not necessary.[25] Care for these children differs from established models of palliative care in adulthood, and comprises around a third of paediatric patients requiring palliative care.[26-28]

Acquired Natural Causes

Throughout childhood, children may die as a result of a wide range of acquired medical and surgical conditions. Outside infancy, rates of these acquired natural causes overall are fairly constant between 7 and 12 deaths per 100,000 population per year. The commonest groups of conditions are neurological disorders, respiratory and cardiovascular disorders, infections and cancers (Appendix 2). Of the 1,600 annual child deaths (28 days – 19 years) from acquired natural causes, nearly 80% are accounted for by one of the above categories. Deaths from other acquired medical and surgical conditions are individually rare. While modifiable factors may be identified in approximately 20% of deaths in this category (Panel), in the main, these relate to organisational factors in service delivery, and individual factors contributing to poor team working and delayed recognition of the sick child.[8, 10] Other than vaccination for infectious diseases, public health measures probably are less significant in relation to children's deaths from acquired natural causes, although they will have implications for adult health and mortality.

Diseases of the nervous system account for around 20% of all childhood deaths. The largest category within this group are conditions related to cerebral-palsy, many of which might therefore more accurately be regarded as perinatal and congenital causes of death. Infection and respiratory failure remains the final common pathway for many such children. Degenerative CNS and muscular diseases together account for around 3% of all child deaths and may present a particular burden on children, families and health services, with protracted courses requiring continuing support and intervention. Although deaths from epilepsy are thought to be rare, there is no specific ICD code for unexpected deaths in Epilepsy (SUDEP). The 2002 National Clinical Audit of Epilepsy-Related deaths identified deficiencies of care in

77% of 180 epilepsy deaths (of which 22 were children), including inadequate drug management, inadequate access to specialist care, and inadequate investigations.[29]

Deaths from acquired cardiovascular disease fall into two main categories: cardiomyopathy-type conditions and cerebrovascular diseases. Sudden Cardiac Death is an umbrella term used for the many different causes of unexpected cardiac arrest in young people. These include various cardiomyopathies, myocarditis, coronary artery disease, channelopathies, and a variety of other rare disorders.[30] The incidence of sudden cardiac death in young people is estimated to be 1 in 100,000 per life year, but this is likely to be an underestimate due to the lack of standardised post-mortem procedures and genetic testing in this group of patients. It is likely that up to 10% of all sudden unexpected deaths in infancy are related to channelopathies though it is likely these are underreported.[30, 31]

The predominant causes of death involving the respiratory system are infections, including influenza and pneumonia (66%). In 2009/10, 70 deaths were related to pandemic influenza A H1N1 infection equating to a childhood mortality rate of 0.6 per 100,000. 64% of children who died had pre-existing disorders.[32] Non-infectious respiratory deaths are individually rare: in 2009 there were 23 deaths identified as being due to asthma. During the last 30 years the proportion of all deaths caused by respiratory illness in children aged 28 days -16 years has fallen from 30.8% to 9.9%.[33] .

Although a large proportion of the mortality burden from infectious disease has been eliminated through public health measures, infections remain one of the commonest acquired causes of death in childhood, particularly in the pre-school period. Infection can cause death in previously healthy children, but more commonly is the final complication in children with other co-morbidities. In particular, infections contribute to approximately 25% of all deaths from haematological malignancy and 5% of all deaths from solid tumours.[34] In a survey of infection-related deaths between 2003 and 2005 in children aged 28 days to 14 years in England and Wales, there were 1,368 infection-related deaths documented, constituting 20% of all deaths in this age range. An underlying medical condition was recorded in 50% cases, the most common being prematurity in infants (52%), cerebral palsy in 1 to 4 year olds (24%), and malignancy in 5 to 14 year olds (28%). Of the 837 deaths where a pathogen was coded, 59% specified bacterial infection, 31% viral infection, and 8% fungal infection.[35] Meningococcal disease is the most common fatal bacterial infection accounting for 24% of

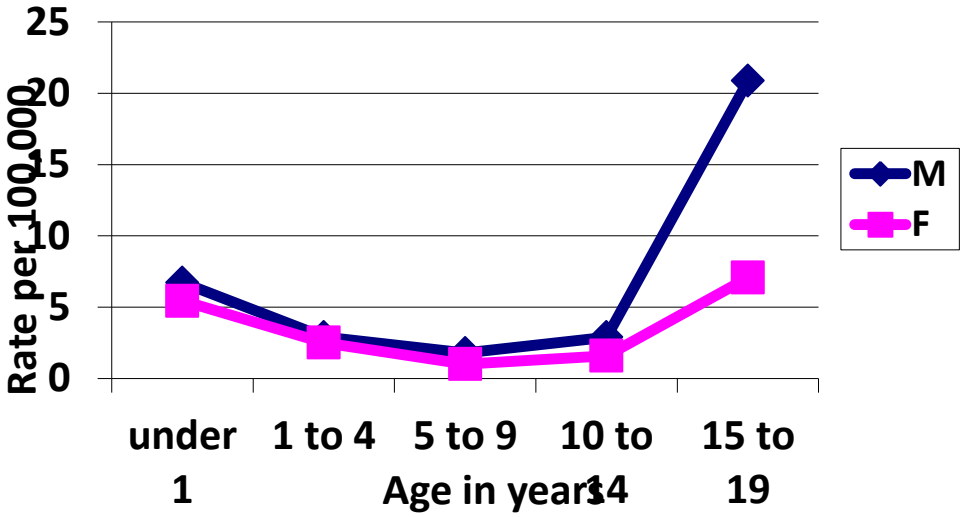
all deaths due to infectious diseases in children aged 28 days -14 years. While the incidence of invasive meningococcal disease has declined in the last decade, the United Kingdom has a higher incidence than elsewhere in Europe (17:100,000 under 5 year olds compared to 7.37:100,000 for Europe as a whole).[36, 37] In keeping with changes seen following the introduction of other vaccines, the development of novel vaccines against the most common serotype B strain may dramatically change the epidemiology of meningococcal disease in the future.[38, 39]

Cancer statistics in children are largely classified using a system that takes into account both the site and the histology of the tumour. Cancer is the most common cause of death in children aged 1-14 years, accounting for 18% of all deaths in this age group. Rates of cancer mortality are highest in early childhood and adolescence. In spite of increases in cancer incidence, global age standardised mortality rates for childhood cancer in the UK have fallen by 59% since the 1960s, from 7·5 deaths per 100 000 in 1965–69 to 3.1 deaths per 100 000 in 2000–04.[40] This downward trend is seen in all diagnostic groups but to varying degrees. Dramatic improvements in the treatment of leukaemias in the 1970s and 1980s have led to brain and other CNS tumours overtaking leukaemias as the most common cause of cancer deaths, with deaths from other solid tumours being less common.

External Causes

In contrast to other groups of child death, deaths from external causes predominate in the older age groups, particularly among adolescents, where they account for over 50% of all deaths. There is a wide disparity between the sexes, with rates in adolescent boys in particular being nearly three times those of adolescent girls (Figure 5). This is particularly affected by rates of transport accidents which in turn account for over 50% of all external deaths in this age group. Nevertheless, the trend for all external causes of death has been downwards in each age group, with overall numbers of deaths from external causes falling from an average of nearly 3,000 deaths per year in the 1970s to less than 1,000 per year in the 2000s. This category of death is also that with the most potential for prevention, with two thirds of deaths reviewed by Child Death Overview Panels identifying modifiable factors.[1]

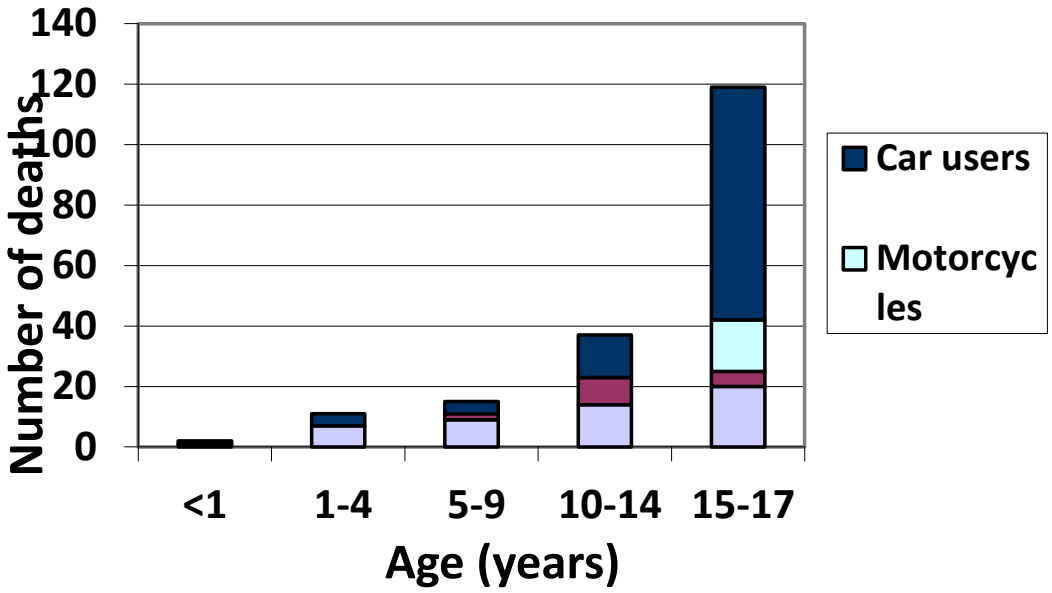
Figure 5: Rates of external causes of death, England and Wales, 2009-11



Traffic Deaths

Road traffic casualties make up the highest number of child deaths from external causes in older children and teenagers, but are relatively uncommon in infants and pre-school children. The Department for Transport reported a total of 28,477 personal injury road accidents in children and young people aged 0-17 in 2011, of which 125 (0.4%) were fatal.[5] Children and young people account for 14.0% of all road-traffic injuries and 6.6% of all fatalities. Over the last 10 years child casualties have declined in spite of increased distances travelled by children. However, some of these gains have been achieved at the expense of children walking and cycling less.[41] The number of fatalities is low throughout early childhood, but pedestrian and cyclist fatalities rise among secondary school-age children and motorcycle and car-user fatalities reach very high levels in older teenagers (Figure 6).[4, 42] Child road-traffic casualties are higher on weekdays than at weekends, with peaks corresponding to the start and end of school, and generally higher rates in the afternoons. Small numbers of child fatalities have been reported in contexts other than on public highways, including low-speed vehicle run-over fatalities in young children[43] and all-terrain vehicles driven by young people.[44] While much progress has been made in reducing transport fatalities, this remains one of the areas most amenable to further prevention through legislation, environmental modification, engineering, education and training.[45, 46]

Figure 6: Child road transport fatalities, 2009[4]



Other non-intentional injuries

In contrast to traffic fatalities, other non-intentional injuries have two peaks in incidence: in infancy and early childhood, and in adolescence. Drowning is the second most common external cause of death, followed by falls and fire-related injuries.[47] Each year, around 38 children and young people aged 0-19 die as a result of accidental drowning and submersion. At all ages, boys are more likely to drown and there are two peaks, in boys and girls aged 1-4 years (0.3-0.6 per 100,000), and in boys aged 15-19 (0.9 per 100,000). There are 22 deaths (0-19 years) each year from falls, largely in adolescent males; and 12 deaths from exposure to smoke, fire and flames or burns and scalds, 51% of these being aged 1-4 years. Death may result from extensive surface burns or scalds, or more commonly through smoke inhalation.

Other accidental causes of suffocation and strangulation are found in young infants presenting as sudden unexpected death in infancy; in toddlers, in whom, for example, accidental strangulation by curtain or blind cords has been identified as a potentially preventable cause;[1, 48] and in adolescents, in whom it may be difficult to distinguish accidental from intentional hanging . Choking deaths are rare (8 deaths per year in 0-19 year olds). Similarly, poisoning is rare in childhood (5 deaths of 0-14 year olds each year), although this again increases in adolescence with a total of 32 accidental poisoning deaths in 15-19 years recorded each year (rates of 1.2 and 0.5 per 100,000 for adolescent boys and girls respectively). Many of these adolescent deaths are related to illicit drug use, and others may be difficult to distinguish from more intentional overdoses.

There is a dilemma in assessing deaths from non-traffic related injuries, particularly injuries in the home: the distinction between accidents, neglect (particularly in relation to poor supervision), and homicide or suicide may not be clear.[49] The registered cause of death does not give any indication of the factors that may have contributed to the death, and these can only be determined by a more detailed review of all the circumstances of and background to child's death.

Fatal maltreatment and deaths from assault

An estimated 5-15 infants (0.7-2.3 per 100,000) and 15-45 children aged 1-14 (0.2-0.5 per 100,000) die violent deaths each year.[50] There is some evidence that these rates have fallen over the past 30 years.[50-52] In contrast, rates of violent death in adolescence have not fallen, particularly amongst adolescent males, and an estimated 32-117 young people aged 15-19 years die violent deaths each year (up to 4.2 per 100,000 males and 2.0 per 100,000 females).[50] Accurate estimates are difficult because of the difficulties in classification and in identifying the cause of death. [53-56]

Patterns of violent death vary across the age spectrum, and do not form a homogeneous group (Box 2).[57-59] A study of 267 Serious Case Reviews into fatal cases of maltreatment in England over a four year period gave an overall incidence of 0.63 cases per 100,000 0-17 year olds per year.[59] Of these, 108 (40%) were considered to be directly caused by physical abuse or neglect, and in a further 138 (50%) maltreatment was considered a factor in the death, though not the direct cause of death. In as many as 40% of maltreatment-related deaths, low levels of neglect may be a factor. Although a wide range of family- and community-based interventions are available to prevent child maltreatment, for most there is little evidence of effectiveness, and more work is needed through well-designed randomised trials with adequate outcome measures and follow-up.[60]

Panel: Categories of fatal maltreatment[59]

A Infanticide and "covert" homicide

Fatalities, usually of very young infants, many shortly after birth and typically perpetrated by the mother using less overtly violent means, or in which the cause of death is not immediately apparent. Includes deaths as a result of abandonment or exposure, asphyxiation, drowning, strangulation or poisoning where there is some indication that there was some intent to kill.

B Severe physical assaults

Includes cases of severe physical violence, with or without associated neglect. The mode of death in these cases is typically a violent assault, most commonly an inflicted head injury, including shaking and shaking-impact injuries, but also multiple injuries and abdominal injuries. Other deaths may include the use of firearms, beatings, stabbings and strangulation but where there was not an obvious intent to kill.

C Extreme neglect / deprivational abuse

Cases where the direct cause of death is extreme neglect or deprivation of the child's needs, e.g. through starvation or exposure, or where there is evidence of deliberate failure to respond to medical needs of the child.

D Deliberate / overt homicides

Deaths in which there appears to be some intent to kill the child. In these deaths, the fact of homicide is likely to be immediately apparent. Includes deaths caused by stabbings and firearms or severe beatings where there appears to be intent to kill; homicides with associated sexual assaults; and cases of killings of multiple family members or of multiple killings with subsequent suicide of the perpetrator ("extended suicides"). This may include deaths from house fires with evidence of arson with intent to kill.

E Deaths related to, but not directly caused by, maltreatment

Deaths which are felt to be related to maltreatment, but in which the maltreatment cannot be considered a direct cause of death. May includes sudden unexpected deaths in infancy (SUDI) with clear concerns around parental care; fatal accidents where there may be issues of parental supervision and care; children dying of natural causes whose parents may not have sought medical intervention early enough; and deaths of older children as a long-term consequence of previous maltreatment, or through suicide or risk-taking behaviours linked to prior maltreatment.

Suicide and deliberate self-harm

Deaths as a result of deliberate self-harm are rare below the age of 10. Although deaths from hanging, poisoning or other potentially intentional events do occur at younger ages, it is very difficult to determine intent, and such deaths are more likely to be attributed to other accidental causes than to suicide. Coroners are only able to attribute a death to suicide when the evidence is "beyond reasonable doubt." Thus the true rates of suicide and deliberate self-harm will be higher than those recorded.[9, 61] National recorded rates of suicide and fatal self-harm in younger teenagers (10-14) are 0.2 per 100,000 (5-6 deaths per year) and equal for males and females; among older teenagers (15-19), the rates are 1.0 and 3.4 for females and males respectively (18 and 62 deaths per year respectively). Hanging is the commonest mode of death, accounting for 78% of suicides of young people, followed by jumping (7%), and

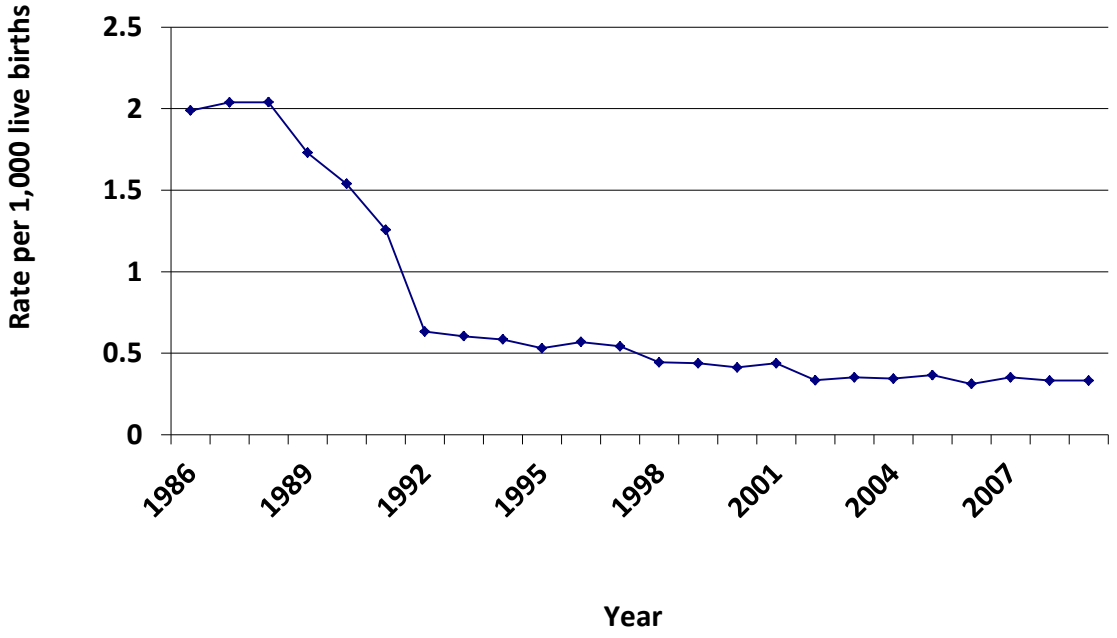
poisoning (4%). In contrast with the United States, suicides involving firearms are very rare (just 6 recorded cases in the past 3 years). Although much is known about the epidemiology and risk factors for self-harm and suicide in young people, there remain significant gaps in our knowledge and much more work is needed to identify effective evidence-based interventions to reduce suicide rates.[61]

Unexplained Deaths

Sudden unexpected deaths that remain unexplained despite thorough investigation are most common in infants under the age of 9 months. The instigation of thorough multiagency investigation after all unexpected infant deaths[62] has led to the identification of causes for an increased proportion of such deaths in recent years, most importantly from infection, metabolic disorders and cardiac rhythm disorders.[7, 63, 64] For the remaining unexpected and unexplained infants deaths - those meeting the definition of Sudden Infant Death Syndrome (SIDS)[65] – thorough investigation of the circumstances of death and comparison with population-based control infants has allowed the identification of a number of risk factors. Avoidance of such risk factors – notably prone sleeping position – has been followed by a marked reduction in incidence of such deaths, from around 2 per 1,000 live births in the late 1980s to less than 0.4 per 1,000 in the past few years. It is notable that, following the initial dramatic fall in rates of SIDS in the early 1990s, the rate has continued to fall (Figure 7).

It has been argued that some of the reduction in SIDS deaths has been due to diagnostic shift, with deaths previously being registered as SIDS, now being labelled 'unascertained' or as due to accidental suffocation.[66-68] Data from the Office for National Statistics show that between 2000 and 2010 the rates of sudden unexpected death in infancy, including both SIDS and 'unascertained' deaths, fell from over 0.55 to 0.36 per 1000 live births. It is unclear what proportion of this decline may be the result of better ascertainment of causes of natural death, but as the fall in SUDI closely parallels the reduction in overall infant mortality rates, diagnostic shift is unlikely to be responsible for much of this decline. Furthermore, detailed case review through 'rapid response' processes[62, 69] has identified common factors contributing to SUDI deaths, regardless of the final assigned cause of death.[63, 70-72]

Figure 7: Rates of unexplained infant deaths, 28 days – 1 year (ICD codes R95-99) per 1,000 live births, England & Wales



The sudden unexpected death of a child aged more than a year that remains unexplained despite thorough investigation is rare, with an incidence estimated at around 1 in 10,000 per year in the second year of life and much lower rates at older ages.[73] The clinical, epidemiological and pathological characteristics associated with such deaths are less well defined, though recent studies have shown a relationship with a past history of febrile convulsions, and abnormalities identified in the hippocampus suggestive of the consequences of unobserved seizures.[74]

Deaths in children with life-limiting conditions

Children with life-limiting conditions do not easily fit into any distinct diagnostic group, but rather span a range of categories, particularly perinatal and congenital causes, and acquired natural causes. Moreover, there are many children who survive an initial external injury, but with ongoing life-limiting disability. The 2006 confidential enquiry into child deaths demonstrated that a significant proportion of all child deaths occurred in those with pre-morbid disease, including a high proportion with life-limiting conditions.[9] Life-limiting conditions refer to those that are likely to reduce a child's life span and that can be described by one or more of the categories developed by the Association for Children with life-threatening or terminal conditions and their families (ACT) and the Royal College of Paediatrics and Child Health (RCPCH) (Table 3).[75, 76]

Table 3: Categories of life-limiting or life-threatening conditions [75]

	Category	Examples
I	Life-threatening conditions for which treatment may be feasible but can fail	A child with cancer that is unresponsive to chemotherapy, irreversible organ failure of heart, liver, kidney
II	Conditions where premature death is inevitable but where there may be long periods of intense treatment aimed at prolonging life and allowing participation in normal activities	Cystic fibrosis, a child with muscular dystrophy with steadily decreasing respiratory muscle power
III	Progressive conditions without curative treatment options, where treatment is exclusively palliative and may commonly extend over many years	Batten's disease, mucopolysaccharidoses
IV	Irreversible but non-progressive conditions causing severe disability leading to susceptibility to health complications and the likelihood of premature death	A child with severe cerebral palsy who dies of an acute respiratory infection, multiple disabilities such as following brain or spinal cord injuries

The ACT/RCPCH system describes trajectories, rather than individual conditions.[77] This flexibility is a significant strength of the system, but also means it has historically been difficult to collect epidemiological data about specific conditions. Among the most common life-threatening conditions are Duchenne Muscular Dystrophy (DMD) and cancer.[26, 27] Both have shown marked changes over the last 10 to 15 years, with increased likelihood of survival with DMD well into the third decade,[78] and the likelihood of long-term remission from childhood cancer continuing to increase.[79] Children's palliative care services now rarely see some conditions, such as cystic fibrosis, once thought to be lethal within childhood. At the same time, significant numbers of children now survive extremely premature birth at the cost of significant neurological sequelae.[80] There is evidence that children with life limiting

conditions make up an increasing burden of ongoing child morbidity as well as contributing to overall child mortality.[81]

In contrast to the other categories of death, children who die with identified life-limiting conditions may be less likely to have identifiable modifiable factors, ranging from 4% in children dying of cancer, to 14% in those with chronic medical conditions. [1] What is important for this group of children is that child death review processes may help drive improvements in the quality of care for the child and family, including end of life care (Panel).

Panel: The role of child death review in children with life-limiting conditions

Children with LLC are, by definition, expected to die within childhood, but that does not mean there are no unexpected deaths among this group of patients. High quality palliative care depends on decision-making by family and healthcare team that is appropriate and well-informed, particularly around the time of death. Fundamental to those decisions is to distinguish as clearly as is practically possible between a mode of death that is inevitable because of the natural history of the condition, and one that can and should be avoided. Analysis of data gathered during the child death review process provides exactly the evidence needed for that critical distinction. It would be ethically quite wrong to assume that, simply because a child has a condition that will ultimately limit life, death should automatically be attributed to that condition, rather than investigated where appropriate. The implication would be that the lives of such children lacked the same value as those in whom cure is possible. On the other hand, where the death does occur in an anticipated manner, it is important not to add to the family's distress through inappropriate and intrusive investigations.

It must be recognised that not all deaths that occur in this group of patients are caused by the underlying condition. Such children remain vulnerable to fatal accidents, and at risk of neglect or abuse. Furthermore, there is an additional risk that parents seek to alleviate the suffering of their child through some form of 'mercy killing,'[82] or indeed that the child may choose to take their own life. Since mercy killing is illegal in most countries, there are no data to indicate how widespread it is. A number of individual high-profile

cases[83, 84] have been discovered, and it seems probable that there are others that are not detected. The term 'mercy killing' has also been used to describe two of the categories of neonate in whom euthanasia is permitted by the Groningen protocol[85] which together account for 42% of neonates on Dutch neonatal care units in whom life-sustaining treatment was withdrawn.[86] However, it is important to distinguish between agreed protocols for the withdrawal of life-sustaining treatment in hospital or hospice settings, and individuals who choose to end another's life, for whatever reason, outside the bounds of law.

Good palliative care does not of itself make death in childhood less likely. In fact one could argue the reverse - that by discouraging invasive interventions that are inappropriate, one effect of free access to good palliative care might even be a slight increase in mortality during childhood. A possible strength of paediatric services in the UK, where there is a tradition of excellence in specialist palliative care, is that death is not necessarily seen, as it is in many cultures, as the worst possible outcome. Families and healthcare teams correctly recognise that interventions aimed merely at prolonging life may not always be in a child's best interests. In these circumstances, child death review can act as a driver for improving supportive services, including palliative care services, for these children and their families.

Future challenges

The highest mortality rates are in infancy and the greatest scope for further reductions may lie as much in reducing antenatal and perinatal risk factors as in further technological improvements to perinatal care. Socio-economic gradients in infant mortality persist, suggesting that wider social policy measures may be equally important to further reductions.[87, 88]

Deaths from acquired natural disease occur throughout childhood. In many of these, child death review can identify modifiable factors which could help reduce the risks of future deaths. Although rates for each individual cause of death are low, generic measures to improve recognition of serious illness in children, both in primary and secondary care, may help to reduce overall mortality..[8-10] There would appear to be generic lessons

around adequate history taking and examination, taking note of parental concerns, being alert to the significance of repeat presentations or of missed appointments, and around communication with parents, that go beyond any specific condition but which could make significant changes to patient care. Recognition of serious illness in low-prevalence settings is not easy, but may be helped by the use of clinical decision rules, identification of specific clinical indicators, careful listening to parents, and clinical intuition by experienced clinicians.[89]

Prevention of deaths from external causes requires knowledge of the circumstances within which children are dying and local patterns of both mortality and morbidity. Preventive activities in relation to non-intentional injuries in children are dependent on collaborative working between police, health, local authority services and other statutory and voluntary agencies. Distinguishing homicide and suicide from accidents may not be easy and requires a thorough systematic investigation, drawing on information and expertise from across agencies. Such investigation is important for all unexpected deaths and should be considered a right for all children and families.[90] Further prevention of maltreatment-related and other violent deaths may be dependent on recognising and tackling specific risks associated with different patterns or types of death. Learning lessons through Serious Case Reviews may contribute to this, but the process needs to be strengthened to look beyond superficial explanations and individual blame.[91]

In spite of dramatic reductions in SIDS rates, there remains scope for further improvements. Key risk factors for SIDS are well-known and further reductions may be dependent on influencing behaviour in the most vulnerable groups.[63] Unexplained sudden deaths in older children are less well understood, and there is a continuing need for further research in this area.

Children with life-limiting conditions make up a significant and increasing burden of morbidity and mortality. It is important for these children and families to receive appropriate services and choices around end-of-life care planning, and access to home- and hospice-based palliative care.

Conclusions

This paper has provided an overview of patterns of child mortality in England and Wales which can help to inform initiatives aimed at preventing future children's deaths. An understanding of these patterns is an important starting point in responding to and learning from children's deaths. There are however limitations in the accuracy and validity of single-cause death registrations and collations of national data. It is important therefore to go beyond looking at the final cause of death, to exploring the different factors contributing to child mortality.

This deeper question of why a child died is crucially important to parents, and should be important to all professionals concerned with child welfare. Addressing these wider issues requires a more in-depth analysis of information gathered about the child, the family, and the circumstances of the death. The final paper in this Series will explore what is known about the factors contributing to child mortality in high-income countries. An accompanying commentary suggests some strategies with potential to further reduce child mortality in high income countries.

Author Contributions

All authors contributed to gathering and interpreting data for this paper and to the writing of initial drafts. All authors have seen and approved the final submission.

Conflicts of Interest

Dr Sidebotham runs the Warwick advanced course in the management of unexpected child death. He has received grant money from the Department for Education for research into child death review and the development of training materials on child death review.
Dr Fraser and Professor Fleming are on the faculty of the Warwick advanced course in the management of unexpected child death.
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Key messages

- Annually over 5,000 infants, children and young people die in England and Wales
- Mortality is highest in infancy, dropping to very low levels in the middle childhood years, before rising again in adolescence
- Patterns of mortality vary with age and gender; perinatal and congenital causes predominate in infancy, with acquired natural cause being prominent in later childhood
- Over 50% of adolescent deaths arise from external causes
- Deaths in children with recognised life-limiting conditions may account for 50% or more of all child mortality in this country

References

1. Department for Education. Child Death Reviews: Year ending 31 March 2011. London: Department for Education; 2011.

2. Brandon M, Bailey S, Belderson P. Building on the Learning from Serious Case Reviews: A two-year analysis of child protection database notifications 2007-2009. London: Department for Education; 2010.
3. Brandon M, Bailey S, Belderson P, Gardner R, Sidebotham P, Dodsworth J, et al. Understanding Serious Case Reviews and their Impact
A Biennial Analysis of Serious Case Reviews 2005-07
London: Department for Children, Schools and Families; 2009.
4. Department for Transport. Child casualties in reported road accidents Great Britain: 2008. London: Department for Transport; 2010.
5. Department for Transport. Reported road casualties Great Britain: main results 2011: London; 2012.
6. Wolfe I, Cass H, Thompson MJ, Craft A, Peile E, Wiegersma PA, et al. Improving child health services in the UK: insights from Europe and their implications for the NHS reforms. BMJ. 2011; **342**: d1277.
7. Fleming P, Blair P, Bacon C, Berry P. Sudden unexpected deaths in infancy. The CESDI SUDI studies 1993-1996. London: The Stationery Office; 2000.
8. Harnden A, Mayon-White R, Mant D, Kelly D, Pearson G. Child deaths: confidential enquiry into the role and quality of UK primary care. Br J Gen Pract. 2009; **59**(568): 819-24.
9. Pearson GE. Why Children Die: A Pilot Study 2006; England (North East, South West and West Midlands), Wales and Northern Ireland. London: CEMACH; 2008.
10. Pearson GA, Ward-Platt M, Harnden A, Kelly D. Why children die: avoidable factors associated with child deaths. Arch Dis Child. 2010.
11. Centre for Maternal and Child Enquiries (CMACE). Perinatal Mortality 2009: United Kingdom. London: CMACE; 2011.
12. Maternal and Child Health Research Consortium. Confidential enquiry into still births and deaths in infancy: 4th annual report, 1 Jaunary - 31 December 1995. London: Maternal and Child Health Research Consortium; 1997.
13. NCEPOD. Surgery in children: are we there yet? London: National confidential enquiry into patient outcome and death; 2011.
14. NCEPOD. Deaths in acute hospitals: caring to the end? London: National confidential enquiry into patient outcome and death; 2009.
15. NCEPOD. Trauma: who cares? London: National confidential enquiry into patient outcome and death; 2007.
16. NCEPOD. Who operates when? London: National confidential enquiry into patient outcome and death; 2003.
17. NCEPOD. Extremes of age, The 1999 report of the National confidential enquiry into peri-operative death. London: National confidential enquiry into patient outcome and death; 1999.
18. Tanner K, Sabrine N, Wren C. Cardiovascular malformations among preterm infants. Pediatrics. 2005; **116**(6): e833-8.
19. Rattihalli R, Smith L, Field D. Prevention of preterm births: are we looking in the wrong place? The case for primary prevention. Arch Dis Child Fetal Neonatal Ed. 2012; **97**(3): F160-1.
20. Costeloe KL, Hennessy EM, Haider S, Stacey F, Marlow N, Draper ES. Short term outcomes after extreme preterm birth in England: comparison of two birth cohorts in 1995 and 2006 (the EPICure studies). BMJ. 2012; **345**: e7976.
21. Seaton SE, King S, Manktelow BN, Draper ES, Field DJ. Babies born at the threshold of viability: changes in survival and workload over 20 years. Arch Dis Child Fetal Neonatal Ed. 2013; **98**(1): F15-20.

22. Irving C, Richmond S, Wren C, Longster C, Embleton ND. Changes in fetal prevalence and outcome for trisomies 13 and 18: a population-based study over 23 years. J Matern Fetal Neonatal Med. 2011; **24**(1): 137-41.
23. Tennant PW, Pearce MS, Bythell M, Rankin J. 20-year survival of children born with congenital anomalies: a population-based study. Lancet. 2010; **375**(9715): 649-56.
24. Knowles RL, Bull C, Wren C, Dezateux C. Mortality with congenital heart defects in England and Wales, 1959-2009: exploring technological change through period and birth cohort analysis. Arch Dis Child. 2012; **97**(10): 861-5.
25. ACT/RCPCH. A guide to the development of children's palliative care services. 1 ed. Bristol and London: ACT/RCPCH; 1997.
26. Hain RDW. Palliative care in children in Wales: a study of provision and need. Palliat Med. 2005; **19**: 137-42.
27. Taylor LK, Miller M, Joffe T, Parslow RC, Aldridge J, Bailey CC, et al. Palliative care in Yorkshire, UK 1987-2008: survival and mortality in a hospice. Arch Dis Child. **95**(2): 89-93.
28. Brook L, Hain R. Predicting death in children. Arch Dis Child. 2008; **93**(12): 1067-70.
29. Hanna N J, Black M, Sander JWS, Smithson WH, Appleton R, Brown S, et al. The National Sentinel Clinical Audit of Epilepsy-Related Death: Epilepsy–death in the shadows. . Norwich: Stationery Office; 2002.
30. Papadakis M, Sharma S, Cox S, Sheppard MN, Panoulas VF, Behr ER. The magnitude of sudden cardiac death in the young: a death certificate-based review in England and Wales. Europace. 2009; **11**(10): 1353-8.
31. Arnestad M, Crotti L, Rognum TO, Insolia R, Pedrazzini M, Ferrandi C, et al. Prevalence of long-QT syndrome gene variants in sudden infant death syndrome. Circulation. 2007; **115**(3): 361-7.
32. Sachedina N, Donaldson LJ. Paediatric mortality related to pandemic influenza A H1N1 infection in England: an observational population-based study. Lancet. 2010; **376**(9755): 1846-52.
33. Panickar JR, Dodd SR, Smyth RL, Couriel JM. Trends in deaths from respiratory illness in children in England and Wales from 1968 to 2000. Thorax. 2005; **60**(12): 1035-8.
34. Bate J, Ladhani S, Sharland M, Chisholm J, Lamagni T, Ramsay M, et al. Infection-related mortality in children with malignancy in England and Wales, 2003-2005. Pediatr Blood Cancer. 2009; **53**(3): 371-4.
35. Ladhani S, Pebody RG, Ramsay ME, Lamagni TL, Johnson AP, Sharland M. Continuing impact of infectious diseases on childhood deaths in England and Wales, 2003-2005. Pediatr Infect Dis J. 2010; **29**(4): 310-3.
36. Halperin SA, Bettinger JA, Greenwood B, Harrison LH, Jelfs J, Ladhani SN, et al. The changing and dynamic epidemiology of meningococcal disease. Vaccine. 2012; **30 Suppl 2**: B26-36.
37. European Centre for Disease Prevention and Control. Annual Epidemiological Report 2011. Reporting on 2009 surveillance data and 2010 epidemic intelligence data. Stockholm: ECDC; 2011.
38. Chang Q, Tzeng YL, Stephens DS. Meningococcal disease: changes in epidemiology and prevention. Clinical epidemiology. 2012; **4**: 237-45.
39. Dull PM, McIntosh ED. Meningococcal vaccine development--from glycoconjugates against MenACWY to proteins against MenB--potential for broad protection against meningococcal disease. Vaccine. 2012; **30 Suppl 2**: B18-25.
40. Stiller C. Childhood cancer in Britain : incidence, survival, mortality. Oxford: Oxford University Press; 2007.

41. DiGuiseppi C, Roberts I, Li L. Influence of changing travel patterns on child death rates from injury: trend analysis.[Erratum appears in BMJ 1997 May 10;314(7091):1385]. BMJ. 1997; **314**(7082): 710-3.
42. Department for Transport. Reported road casualties Great Britain: 2009. London: The Stationery Office; 2010.
43. Griffin B, Watt K, Wallis B, Shields L, Kimble R. Paediatric low speed vehicle run-over fatalities in Queensland. Inj Prev. 2011; **17 Suppl 1**: i10-3.
44. Denning GM, Harland KK, Ellis DG, Jennissen CA. More fatal all-terrain vehicle crashes occur on the roadway than off: increased risk-taking characterises roadway fatalities. Inj Prev. 2012.
45. Harvey A, Towner E, Peden M, Soori H, Bartolomeos K. Injury prevention and the attainment of child and adolescent health. Bull World Health Organ. 2009; **87**(5): 390-4.
46. Desapriya E, Sones M, Ramanzin T, Weinstein S, Scime G, Pike I. Injury prevention in child death review: child pedestrian fatalities. Inj Prev. 2011; **17 Suppl 1**: i4-9.
47. Morrison A, Stone DH. Unintentional childhood injury mortality in Europe 1984-93: a report from the EURORISC Working Group. Inj Prev. 1999; **5**(3): 171-6.
48. Sethi S. Preventing the preventable. Community Pract. 2010; **83**(7): 16.
49. Sibert J, Sidebotham P. Deaths from unintentional injuries. In: Sidebotham P, Fleming P, editors. Unexpected death in childhood: a handbook for practitioners. Chichester, UK: Wiley; 2007. p. 61-74.
50. Sidebotham P, Atkins B, Hutton JL. Changes in rates of violent child deaths in England and Wales between 1974 and 2008: an analysis of national mortality data. Arch Dis Child. 2012; **97**(3): 193-9.
51. Pritchard C, Sharples A. Violent deaths of children in England and Wales and the major developed countries 1974-2002: possible evidence of improving child protection? Child Abuse Review. 2008; **17**(5): 297-312.
52. Pritchard C, Williams R. Comparing Possible 'Child-Abuse-Related-Deaths' in England and Wales with the Major Developed Countries 1974-2006: Signs of Progress? British Journal of Social Work. 2010; **40**(6): 1700-18.
53. Palusci VJ, Wirtz SJ, Covington TM. Using capture-recapture methods to better ascertain the incidence of fatal child maltreatment. Child Abuse & Neglect. 2010; **34**(6): 396-402.
54. Brookman F, Nolan J. The dark figure of infanticide in England and Wales: complexities of diagnosis. J Interpers Violence. 2006; **21**(7): 869-89.
55. Crume TL, DiGuiseppi C, Byers T, Sirotnak AP, Garrett CJ. Underascertainment of child maltreatment fatalities by death certificates, 1990-1998. Pediatrics. 2002; **110**(2 Pt 1): e18.
56. Smith K, Flatley J, Coleman K, Osborne S, Kaiza P, Roe S. Homicides, Firearm Offences and Intimate Violence 2008/09
Supplementary Volume 2 to Crime in England and Wales 2008/09. London: Home Office; 2010.
57. Guileyardo JM, Prahlow JA, Barnard JJ. Familial filicide and filicide classification. Am J Forensic Med Pathol. 1999; **20**(3): 286-92.
58. Fujiwara T, Barber C, Schaechter J, Hemenway D. Characteristics of infant homicides: findings from a U.S. multisite reporting system. Pediatrics. 2009; **124**(2): e210-7.
59. Sidebotham P, Bailey S, Belderson P, Brandon M. Fatal child maltreatment in England, 2005-2009. Child Abuse & Neglect. 2011; **35**(4): 299-306.
60. Macmillan HL, Wathen CN, Barlow J, Fergusson DM, Leventhal JM, Taussig HN. Interventions to prevent child maltreatment and associated impairment. Lancet. 2009; **373**(9659): 250-66.

61. Hawton K, Saunders KE, O'Connor RC. Self-harm and suicide in adolescents. Lancet. 2012; **379**(9834): 2373-82.
62. Sidebotham P, Pearson G. Responding to and learning from childhood deaths. BMJ. 2009; **338**: b531.
63. Blair PS, Sidebotham P, Evason-Coombe C, Edmonds M, Heckstall-Smith EM, Fleming P. Hazardous cosleeping environments and risk factors amenable to change: case-control study of SIDS in south west England. BMJ. 2009; **339**: b3666.
64. Cote A. Investigating sudden unexpected death in infancy and early childhood. Paediatr Respir Rev. 2010; **11**(4): 219-25.
65. Willinger M, James L, Catz C. Defining the sudden infant death syndrome (SIDS): deliberations of an expert panel convened by the National Institute of Child Health and Human Development. Pediatric Pathology. 1991; **11**: 677-84.
66. Shapiro-Mendoza CK, Tomashek KM, Anderson RN, Wingo J. Recent national trends in sudden, unexpected infant deaths: more evidence supporting a change in classification or reporting. Am J Epidemiol. 2006; **163**(8): 762-9.
67. Kim SY, Shapiro-Mendoza CK, Chu SY, Camperlengo LT, Anderson RN. Differentiating cause-of-death terminology for deaths coded as sudden infant death syndrome, accidental suffocation, and unknown cause: an investigation using US death certificates, 2003-2004. J Forensic Sci. 2012; **57**(2): 364-9.
68. Overpeck MD, Brenner RA, Cosgrove C, Trumble AC, Kochanek K, MacDorman M. National underascertainment of sudden unexpected infant deaths associated with deaths of unknown cause. Pediatrics. 2002; **109**(2): 274-83.
69. Fleming PJ, Blair PS, Sidebotham PD, Hayler T. Investigating sudden unexpected deaths in infancy and childhood and caring for bereaved families: an integrated multiagency approach. BMJ. 2004; **328**(7435): 331-4.
70. Shapiro-Mendoza CK, Kimball M, Tomashek KM, Anderson RN, Blanding S. US infant mortality trends attributable to accidental suffocation and strangulation in bed from 1984 through 2004: are rates increasing? Pediatrics. 2009; **123**(2): 533-9.
71. Hauck FR, Herman SM, Donovan M, Iyasu S, Merrick Moore C, Donoghue E, et al. Sleep environment and the risk of sudden infant death syndrome in an urban population: the Chicago Infant Mortality Study. Pediatrics. 2003; **111**(5 Pt 2): 1207-14.
72. Trachtenberg FL, Haas EA, Kinney HC, Stanley C, Krous HF. Risk factor changes for sudden infant death syndrome after initiation of Back-to-Sleep campaign. Pediatrics. 2012; **129**(4): 630-8.
73. Krous HF, Chadwick AE, Crandall L, Nadeau-Manning JM. Sudden unexpected death in childhood: a report of 50 cases. Pediatr Dev Pathol. 2005; **8**(3): 307-19.
74. Kinney HC, Armstrong DL, Chadwick AE, Crandall LA, Hilbert C, Belliveau RA, et al. Sudden death in toddlers associated with developmental abnormalities of the hippocampus: a report of five cases. Pediatr Dev Pathol. 2007; **10**(3): 208-23.
75. Association for Children with life-threatening or terminal conditions and their families, Royal College of Paediatrics and Child Health. A guide to the development of children's palliative care services. London: ACT; 1997.
76. Association for Children with life-threatening or terminal conditions and their families. A Guide to the Development of Children's Palliative Care Services. 3 ed. Bristol: ACT; 2009.
77. Wood F, Simpson S, Barnes E, Hain R. Disease trajectories and ACT/RCPCH categories in paediatric palliative care. Palliat Med. **24**(8): 796-806.
78. Eagle M, Baudouin SV, Chandler C, Giddings DR, Bullock R, Bushby K. Survival in Duchenne muscular dystrophy: improvements in life expectancy since 1967 and the impact of home nocturnal ventilation. Neuromuscul Disord. 2002; **12**(10): 926-9.

79. O'Leary M, Krailo M, Anderson JR, Reaman GH. Progress in childhood cancer: 50 years of research collaboration, a report from the Children's Oncology Group. Semin Oncol. 2008; **35**(5): 484-93.
80. Iijima S, Arai H, Ozawa Y, Kawase Y, Uga N. Clinical patterns in extremely preterm (22 to 24 weeks of gestation) infants in relation to survival time and prognosis. Am J Perinatol. 2009; **26**(6): 399-406.
81. Fraser LK, Miller M, Hain R, Norman P, Aldridge J, McKinney PA, et al. Rising national prevalence of life-limiting conditions in children in England. Pediatrics. 2012; **129**(4): e923-9.
82. Ryan M, White S. Frances Inglis killed son 'with love in her heart'. 2010 [cited 2011 January]; Available from: http://news.bbc.co.uk/1/hi/uk/8466140.stm
83. Farnsworth CH. Mercy killing in Canada stirs calls for changes in law. The New York times. 1994: A6.
84. Sneiderman B. The Latimer mercy-killing case: a rumination on crime and punishment. Health law journal. 1997; **5**: 1-26.
85. Verhagen E, Sauer PJ. The Groningen protocol--euthanasia in severely ill newborns. N Engl J Med. 2005; **352**(10): 959-62.
86. Verhagen AA, Dorscheidt JH, Engels B, Hubben JH, Sauer PJ. End-of-life decisions in Dutch neonatal intensive care units. Arch Pediatr Adolesc Med. 2009; **163**(10): 895-901.
87. Smith LK, Manktelow BN, Draper ES, Springett A, Field DJ. Nature of socioeconomic inequalities in neonatal mortality: population based study. BMJ. 2010; **341**: c6654.
88. Hollowell J, Kurinczuk JJ, Brocklehurst P, Gray R. Social and ethnic inequalities in infant mortality: a perspective from the United kingdom. Semin Perinatol. 2011; **35**(4): 240-4.
89. Van den Bruel A, Haj-Hassan T, Thompson M, Buntinx F, Mant D. Diagnostic value of clinical features at presentation to identify serious infection in children in developed countries: a systematic review. Lancet. 2010; **375**(9717): 834-45.
90. RCPath, RCPCH. Sudden unexpected death in infancy: A multi-agency protocol for care and investigation. London: Royal College of Pathologists, Royal College of Paediatrics and Child Health; 2004.
91. Munro E. The Munro review of child protection: Final report - a child-centred system. London: Department for Education; 2011.

Appendix 1: Infant deaths by ONS cause groups and gestational age, babies born in 2007 - 2008 (from Gestation-specific infant mortality In England and Wales, 2007-2008 tables, ONS 2010)

ONS Cause groups	ALL	Gestational Age					
		Under 24 weeks	Pre-term	Term	Post-term	Low but Inconsistent[1]	Not stated
All infant deaths	2981	658	1215	1008	47	4	49
Congenital anomalies	873	64	332	441	23	-	13
Antepartum infections	55	8	22	21	4	-	-
Immaturity related conditions	1274	572	656	12	-	4	30
Asphyxia, anoxia or trauma (intrapartum)	203	-	54	143	5	-	1
External conditions	35	-	5	29	1	-	-
Infections	140	2	47	87	3	-	1
Other specific conditions	41	1	13	27	-	-	-
Sudden infant deaths	143	2	27	107	6	-	1
Other conditions	217	9	59	141	5	-	3

1 Under 22 weeks gestational age with birthweight 1,000g or more

Appendix 2: ICD 10 categories of child deaths from acquired natural causes (28 days – 19 years), England and Wales, 3-year average, 2009-2011

Number (rate per 100,000) of Deaths by ICD category												
ICD 10 Category	**1month – 1 year**		**1 to 4 years**		**5 to 9 years**		**10 to 14 years**		**15 to 19 years**		**1 month – 19 years**	
	N	**(rate)**	**N**	**(rate)**	**N**	**(rate)**	**N**	**(rate)**	**N**	**(rate)**	**N**	**% of all deaths from acquired natural causes**
I Certain infectious and parasitic diseases	63	(9)	51	(2)	15	(<1)	11	(<1)	17	(<1)	157	10.7%
II Neoplasms	15	(2)	69	(3)	75	(2)	78	(2)	122	(3)	359	24.4%
III Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	12	(2)	10	(<1)	5	(<1)	6	(<1)	9	(<1)	42	2.9%
IV Endocrine, nutritional and metabolic diseases	27	(4)	32	(1)	17	(1)	18	(1)	29	(1)	124	8.4%
V Mental and behavioural disorders	1	(<1)	1	(<1)	2	(<1)	2	(<1)	14	(<1)	20	1.3%
VI Diseases of the nervous system	70	(10)	59	(2)	36	(1)	45	(1)	90	(3)	300	20.4%
VII/VIII Diseases of the eye and adnexa; Diseases of the ear and mastoid	0	(0)	0	(0)	0	(0)	1	(<1)	1	(<1)	2	0.2%

process												
IX Diseases of the circulatory system	38	(5)	25	(1)	15	(<1)	20	(1)	54	(2)	152	10.4%
X Diseases of the respiratory system	65	(9)	55	(2)	29	(1)	27	(1)	36	(1)	211	14.4%
XI Diseases of the digestive system	22	(3)	12	(<1)	7	(<1)	6	(<1)	15	(<1)	62	4.2%
XII/XIII Diseases of the skin and subcutaneous tissue; Diseases of the musculoskeletal system and connective tissue	3	(<1)	3	(<1)	2	(<1)	6	(<1)	8	(<1)	21	1.5%
XIV Diseases of the genitourinary system	5	(1)	2	(<1)	2	(<1)	2	(<1)	4	(<1)	16	1.1%
XV Pregnancy, childbirth, puerperium	0	(0)	0	(0)	0	(0)	0	(0)	3	(<1)	3	0.2%
All Acquired causes	**321**		**319**		**205**		**220**		**403**		**1,468**	**100%**