Traumatic and other non-natural childhood deaths in Manitoba, Canada: A retrospective autopsy analysis (1989-2010)

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ABSTRACT

OBJECTIVE: The goals of analyzing all non-natural childhood deaths in Manitoba for the 22-year period (1989-2010) are to highlight preventable causes of death and to document temporal trends that might be influenced by changes in society.

METHODS: The 1989 to 2010 pediatric autopsy database at the Winnipeg Health Sciences Centre and records from the Office of the Chief Medical Examiner were searched for all non-natural deaths ≤ 18 years age. All files were reviewed in detail. Data collected included demographic characteristics, manner of death, details of cause and circumstances leading to death, and survival time after the event.

RESULTS: For the 22-year period, the total number of non-natural childhood deaths after which autopsy was performed in Manitoba was 581 for males and 409 for females in a population of approximately 1.23 million (2010 estimate). This represents 22.1% of the total childhood deaths in Manitoba during the study period. A higher proportion of children living in rural and northern communities died from non-natural causes. Of all accidents, which peaked in 1999, road traffic incidents accounted for the majority. Of suicides, which peaked in 2005, hanging in the 15-18 year group accounted for almost all cases. Of homicides, child abuse deaths at <3 years age was the most frequent cause. For all causes, most individuals were dead at the scene or died shortly thereafter.

CONCLUSIONS: Most non-natural childhood deaths in Manitoba might be avoidable through education about prevention strategies and by correction of social inequities. Improved transportation to hospital from remote locations would likely have little impact on survival.

KEY WORDS: Epidemiology; trauma; death; adolescent; hanging; accidental

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Manner of death is categorized as natural, accident, suicide, homicide and undetermined. Death may be due to disease (i.e., natural) or external factors. Statistics Canada reported that during the period 2004-08, the leading causes of death in children were accidental injuries (~30%), malignant neoplasms (~16%), congenital anomalies (~8%), suicide (~4%), heart disease (~4%) and assault (~3%).¹ Injuries are the leading cause of childhood death in developed nations, accounting for almost 40% of deaths between 1 and 14 years.² In Canada in 2004, there were $>13,000$ deaths and 211,000 hospitalizations due to injury with a total cost of CAD \$19.8 billion; children aged 15-19 years accounted for a substantial proportion of these.^{3,4} In Manitoba, 1994-97 administrative data indicate that injuries accounted for $>50\%$ of all deaths at 1-9 years of age and 70% of deaths at 10-19 years of age.⁵

Most mortality statistics are derived from administrative databases, which are subject to coding errors. Retrospective autopsy review potentially offers more detailed and accurate information. Statistics Canada data indicate that the percentage of deaths subjected to autopsy in 1991 was 16.9% and had declined to a national average of 5.7% in 2007. In Manitoba, the autopsy rate was considerably higher, at 10.5%, although comparisons for the pediatric population are not available.⁶ Manitoba has highly centralized health care. The death investigation system is coordinated by the Office of the Chief Medical Examiner (OCME). In Manitoba, all child deaths (non-natural and natural deaths of individuals <19 years of age) are

reportable to the OCME. Manitoba has Canada's oldest multidisciplinary child death review committee, formed in 1992 through the Provincial Advisory Committee on Child Abuse.

Because of the centralized death investigation system, it is possible to analyze all childhood deaths retrospectively. During the study period, almost all autopsies were performed in two university-affiliated hospitals in Winnipeg and a small proportion in a third hospital in Brandon. More than 95% of the pediatric autopsies were done at a single centre in Winnipeg. Most were performed by pathologists with broad forensic experience, often in consultation with a neuropathologist. The goals of analyzing all non-natural childhood deaths in Manitoba for the 22-year period are to document temporal trends that might be influenced by changes in society and to highlight preventable causes of death.

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Conflict of Interest: None to declare.

METHODS

This is a retrospective study of deaths among children aged 0-18 years inclusive residing in the Province of Manitoba from 1989 to 2010. The study was approved by the Research Ethics Board of the University of Manitoba (protocol H2009:338). Databases used included the pediatric autopsy records and files of the OCME. Most autopsy records were located at the Health Sciences Centre, where >95% of child medicolegal autopsies have been conducted.

The OCME records were used to enumerate the manner of childhood death, which is a legal designation of natural, accident, suicide, homicide and undetermined. The cause of death is a biological consideration that comprises a multitude of diseases as well as external causes (including accidental trauma, poisoning, intentional self-harm and assaults). Information included year of death, age at time of injury/death, sex, manner of death (homicide, suicide, accidental, undetermined), cause of death, body regions affected by trauma (head, neck, chest, abdomen, pelvis, upper limbs, lower limbs) and survival time between the event and death. The age grouping was 0-1 years, 2-4 years, 5-9 years, 10-14 years and 15-18 years (rounded to the nearest integer). Causes were categorized as trauma due to motor vehicle/traffic/pedestrian accidents, blunt or sharp force assault or falling; and poisoning, choking, hanging, drowning, environmental exposure, burns or smoke inhalation sustained in (mainly house) fires, animal attack, gunshot and electrocution. Deaths due to natural causes or the complications of medical management were excluded. The location of the event that led to death (not the location of death) was divided into four geographic regions: 1) Winnipeg Metropolitan Region, 2) smaller urban centres (>5,000 population) in southern and central Manitoba (Brandon, Steinbach, Portage la Prairie, Winkler, Selkirk, Dauphin, Morden), 3) rural south and central Manitoba and 4) northern Manitoba corresponding to health authority regions (Norman, Burntwood, Churchill) located north of the major lakes. During the study period, the population of Manitoba gradually increased from 1.104 million to 1.236 million, and the percentage of children 0-19 years gradually declined from 29.4% to 26.0%. Using population data from 1995 and 2010, the regional population and the percentage of children within each region were determined. There was no significant change in the regional distributions between the two census periods. In 2010, approximately 55% of the population were located within the Winnipeg Metropolitan Region, 29% in rural regions and the remainder in scattered small cities and towns (>5,000 population).

Data acquisition was done by manual review of autopsy reports. Mortality, population and demographic data were extracted from the Canadian Socioeconomic Information Management (CANSIM) database available online from Statistics Canada. Data from the autopsy reports, OCME reports and CANSIM were entered into a statistical database (JMP 10.0.1; SAS Institute Inc., Cary, NC) for comparisons. Note that CANSIM data for children are reported in 5-year aggregates to the end of the 19th year. OCME data are summarized in decades (to the end of the 19th year), as well as in the aggregate period to the end of the 17th year; the latter are used unless otherwise stated. Data are reported as mean $\pm$ standard error of mean.

RESULTS

Demographic factors

During the 22-year period analyzed, 990 autopsies were performed for non-natural childhood deaths (≤ 18 years of age). This represents approximately 22% of the total childhood deaths. During the entire period, there were 234 autopsies in the 0-1 year group, 204 in the 2-4 years group, 127 in the 5-9 years group, 164 in the 10-14 years group and 261 in the 15-18 years group. There were 581 males and 409 females; over the years, the annual proportion of males ranged from 42% to 69%.

Analysis by geographic region showed no obvious temporal changes. During the 22-year study period, 13.4 ± 1.0 non-natural deaths subjected to autopsy per year (30% of total) were from the Winnipeg region (51% of children in Manitoba), 4.0 ± 0.5 deaths per year (9% of total) were in smaller urban centres (14% of children in Manitoba), 14.2 ± 1.3 deaths per year (32% of total) were in south and central rural regions (26% of children in Manitoba), and 13.9 ± 0.8 deaths per year (29% of total) were in northern rural regions (9% of children in Manitoba).

Manner and causes of childhood death

Within the reported administrative datasets, approximately 16% of the total childhood deaths were accident, 6% were suicide, and 3% were homicide. The overall distribution for manner of death in the autopsies (excluding natural causes) was 50.9% accident, 20.3% undetermined, 17.1% suicide and 11.7% homicide. Accurate proportions in relation to all childhood deaths could not be determined because not all natural deaths are reported to the OCME (and a minority undergo autopsy), and the administrative databases are aggregated by decade rather than a limit of ≤ 18 years. The accidental death rate increased gradually, peaking in 1999, and has generally declined since then. The suicidal death rate was quite variable but has generally increased, peaking in 2005 and showing no general evidence of decline. The homicide rate was generally low with no obvious pattern (Table 1). The manner of most deaths in the 15-18 year age group was accident (especially injury) or suicide.

Road traffic incidents represented the major cause of all accidental deaths (47.8%). The majority of those who died in traffic incidents were vehicle passengers ($n=94$) and pedestrians ($n=76$), and the minority were vehicle drivers ($n=42$) and bicycle riders ($n=32$) (Table 2). There were no specific temporal trends. A mix of head, torso and limb injuries occurred with no single region of the body accounting for the majority. Other causes of accidental deaths included drowning ($n=106$), burn/smoke inhalation ($n=66$), poisoning ($n=22$), fall from a height ($n=11$), choking on food or foreign object ($n=9$), gunshot ($n=7$) and animal attack ($n=1$).

Suicide was apparently rare in the initial years of this survey (Table 1). Suicides, especially in the 15-18 years group, then began to increase steadily, peaking at 20 in 2005 (mean $17.1 \pm 2.2\%$ of non-natural deaths per year). Almost all were due to hanging ($n=174$) (Table 2), with rare self-inflicted gunshot injuries ($n=7$) and poisoning/drug overdose ($n=4$). Prior to 2006 males accounted for the majority of suicides, but by 2006 there was approximate gender parity.

The frequency of homicides was highly variable (mean $11.7 \pm 1.3\%$ of non-natural deaths per year, range 1-18) (Table 1).

Table 1. Childhood deaths in Manitoba – Manner and mortality rate*

Year	Total postneonatal deaths 1 to 12 months†	Total deaths 0-19 y†	Total childhood mortality rate/100,000 population‡	Accident (0-18 y)	Child accident mortality rate/100,000 population	Suicide (0-18 y)	Child suicide mortality rate/100,000 population	Homicide (0-18 y)	Child homicide mortality rate/100,000 population	Undetermined manner*§	Complete autopsies on children
1989	nr	nr	–	19	1.7	0	0	1	0.1	–	20
1990	nr	nr	–	29	2.6	0	0	3	0.3	–	32
1991	45	261	23.5	28	2.5	13	1.2	4	0.4	–	36
1992	43	220	19.8	29	2.6	3	0.3	5	0.4	–	36
1993	38	234	20.9	26	2.3	13	1.2	3	0.3	–	32
1994	43	245	21.8	41	3.7	14	1.2	2	0.2	–	47
1995	42	235	20.8	37	3.3	12	1.1	4	0.4	–	47
1996	37	216	19.0	38	3.4	18	1.6	9	0.8	24	49
1997	39	246	21.7	47	4.1	14	1.2	2	0.2	30	51
1998	30	210	18.5	47	4.1	7	0.6	6	0.5	18	49
1999	36	236	20.7	55	4.8	14	1.2	16	1.4	1	51
2000	38	210	18.3	39	3.4	17	1.5	18	1.6	8	52
2001	35	206	17.9	38	3.3	13	1.1	4	0.3	17	55
2002	35	200	17.3	35	3	14	1.2	7	0.6	11	52
2003	30	213	18.3	30	2.6	12	1.0	8	0.7	15	53
2004	29	200	17.0	38	3.2	18	1.5	5	0.4	12	56
2005	27	212	18.0	28	2.4	25	2.1	11	0.9	9	61
2006	25	192	16.2	32	2.7	14	1.2	4	0.3	15	49
2007	36	221	18.5	28	2.3	13	1.1	11	0.9	16	43
2008	34	200	16.6	25	2.1	12	1.0	7	0.6	9	32
2009	26	217	17.8	22	1.8	21	1.7	11	0.9	11	45
2010	27	202	16.3	28	2.3	16	1.3	4	0.3	16	47

* Manner of death includes accident, suicide, homicide and undetermined, as recorded by the Office of the Chief Medical Examiner of Manitoba for individuals <18 years of age.

† Total deaths represent the sum of all manners, including natural causes, as reported by Statistics Canada (CANSIM database) for each year (nr = not reported). Postneonatal deaths do not include stillbirths or deaths prior to 1 month of age (which includes mainly premature births and obstetric complications, i.e., natural). CANSIM data are aggregated by decade, therefore “0-19 y” is <20 y.

‡ Childhood mortality rates are calculated against the annual total Manitoba population as reported by Statistics Canada.

§ Recording of undetermined manner of death by the OCME was not summarized consistently prior to 1995.

|| Autopsies performed on individuals <18 years of age at the Health Sciences Centre (HSC), Winnipeg, excluding natural causes. Prior to 1994, some infant and child autopsies, including sudden infant death syndrome (i.e., predominantly natural and undetermined manner), were performed at other sites. After 1994, the pediatric autopsies were concentrated at the HSC site.

Table 2. Childhood deaths in Manitoba – Selected major causes documented at autopsy*

Year	Vehicle passenger or driver (accident)	Pedestrian-vehicle (accident)	Bicycle (accident)	Drowning (accident)	Burns or smoke inhalation (accident)	Hanging (suicide)	Child abuse (homicide)†	SIDS (undetermined)‡
1989	1	1	1	3	6	0	1	21
1990	4	6	2	3	3	0	2	24
1991	1	8	1	7	0	1	1	12
1992	3	3	2	4	1	2	2	14
1993	4	2	1	6	0	2	1	11
1994	8	3	2	5	13	3	1	12
1995	9	3	2	11	0	6	3	15
1996	9	4	4	5	4	5	5	11
1997	7	3	1	7	3	7	1	12
1998	13	5	0	9	5	4	4	8
1999	11	6	2	2	7	11	2	7
2000	10	1	0	8	4	15	6	5
2001	8	4	1	2	5	11	0	6
2002	9	2	2	2	2	12	4	3
2003	4	6	0	3	0	9	4	2
2004	4	4	1	8	2	11	3	1
2005	7	3	3	6	0	20	3	2
2006	6	2	3	1	0	12	2	5
2007	4	5	1	1	0	7	3	4
2008	0	1	1	5	5	7	1	2
2009	3	1	0	5	2	17	1	2
2010	11	3	2	3	4	12	2	4

* Autopsies performed on individuals <18 years of age at the Health Sciences Centre (HSC), Winnipeg. The manner of death is shown in parentheses.

† All are <3 years of age, the majority are blunt trauma to the head and/or blunt trauma to the abdomen.

‡ Sudden infant death syndrome reported by the Office of the Chief Medical Examiner of Manitoba. Not all autopsies were performed at the HSC. See Discussion for explanation of apparent decline. Use of the term SIDS was discontinued in 2011 and replaced by sudden unexplained infant deaths with risk factors specified (e.g., unsafe sleeping arrangements).

The largest single category of homicide was assault on infants and children <3 years old (n= 52, 0-6 per year) (Table 2). In most of these, the cause of death had been designated as “shaken baby syndrome” or “non-accidental head injury” in early years and “head injury” or “blunt force injury” in more recent years. The shift over time reflected the need to use terminology that was objective

and not prejudicial. Excluding this category, homicidal deaths were categorized according to type of force used, including blunt force trauma (n=21; e.g., beating), sharp force (n=18; e.g., stabbing), mixed sharp and blunt trauma (n=8) and gunshot wound (n=16).

The majority (75.8%) of deaths classified as undetermined were infant (0-1 years) sleep-associated deaths at home. In the early years

of this study, many had been designated as sudden infant death syndrome (SIDS). The OCME database showed the frequency of SIDS cases to be 12-34 per year (mean 22.5) from 1980 to 1990, 11-15 per year (mean 12.4) from 1991 to 1997 and 1-8 per year (mean 4.3) from 1998 to 2010 (Table 2). Note, however, that the frequency of postneonatal death had declined less slowly and seems to have stabilized at ~30 deaths per year. Increasingly utilized are the terms "sudden unexplained infant death" or "undetermined cause of death", often with a comment about unsafe sleeping circumstances (e.g., face down position in bed, sleeping in bed with parents, parental alcohol ingestion). In rare cases of infant deaths (<5), the cause was designated as asphyxiation (e.g., by smothering) and the manner as accidental.

Survival period following fatal event

Most deaths occurred relatively soon after the event. Death was most often pronounced at the scene of the incident (847 of 990) or within hours thereafter (63 of 990), usually in a hospital emergency department following transport and attempted resuscitation. A small number of deaths occurred 1 to 7 days (n=57), 7 to 30 days (n=14) or longer (n=9) after the event. Deaths that occurred very long periods after a childhood traumatic event may not have been captured in this analysis if they were classified as natural (e.g., pneumonia after survival for years in a vegetative state following head injury) or because the individuals had become adults. Anecdotal information suggests that 1-2 autopsies per year fell into this category; more might have been missed because autopsies were not done.

DISCUSSION

We sought to analyze non-natural childhood deaths in Manitoba for the period of 1989 to 2010 using autopsy reports and the OCME database to document temporal trends and to highlight potentially preventable causes of death. The major causes of non-natural death among Manitoba children were accidental road traffic incidents, suicide by hanging, accidental drowning, accidents related to house fires, homicides through child abuse and sleep environment-related deaths in infants. The proportion of rural inhabitants in Manitoba remained fairly stable at ~30% from 1989 to 2010. As has been previously documented using administrative data from 1984-2007,^{5,7} non-natural childhood deaths occurred with disproportionate frequency in rural settings. This might reflect the socio-economic features of rural Manitoba.^{8,9} It is known that impoverished rural communities, many of which are populated by First Nations, suffer from a higher frequency of drowning,¹⁰ suicide,¹¹⁻¹³ infant mortality¹⁴ and severe trauma.¹⁵⁻¹⁷

Injury (including road traffic injuries, falls and assault) is the leading cause of deaths and hospitalizations among Canadian adolescents.^{18,19} Overall, the rate of accidental child death in Manitoba peaked in 1999, and we observed an encouraging trend with declining traffic fatalities. However, 2010 was marked by a substantial increase, suggesting that education about seatbelt use (many passenger deaths were caused by ejection from the vehicle) and driving while intoxicated remains only partially effective. The other major contributors to accidental deaths were fire-related burns or smoke inhalation and drowning. Both occurred mainly in rural communities, where at-risk housing is common and there are many unmonitored bodies of water.²⁰ Prevention remains the mainstay of reducing death and disability from accidental injuries.²¹

Across all ages, including adults, the suicide rate in Manitoba was similar to that in Canada overall for the years 2000-2008 (12.1/100,000 population).²² Across Canada during the same period, there was an overall decline in childhood and adolescent suicide, mainly due to the decreasing frequency of firearm use by males. Hanging ("suffocation") is now the leading means of suicide among Canadian adolescents, accounting for ~70%.²³ The observed increase in the number of Manitoba childhood suicides by hanging during the late 1990s, with no decline, is disturbing. The fact that alternative methods of suicide (e.g., gunshot and poisoning) did not increase suggests that factors other than adolescent depression are involved. In part this can be attributed to the relative ease with which an intoxicated child can obtain a piece of rope, shoelace or belt. One must also consider the role that mimicry plays in the social clustering of adolescent suicide.²⁴⁻²⁷ Designation of suicide as the manner of death may be incomplete, because intent cannot always be inferred from the circumstance of death. For example, some drug-related deaths were recorded as accidental or undetermined. The factors that contribute to car crashes are never fully known. With respect to hanging, there was evidence for intoxication in many cases. The very rare cases of death associated with apparent autoerotic asphyxiation were categorized as accidental.

In contrast to suicide, across all ages the mortality rate for homicide in Manitoba was more than two times that in Canada overall (3.9 vs. 1.6/100,000 population/year for 2000-2008).²² Child abuse-related homicides in Manitoba were unfortunately relatively common (1.7 cases/million/year) in comparison to those reported in a prior detailed study from Ontario (0.3 cases/million/year).²⁸ Violence against children and youth, as reported to the police, is highest in Saskatchewan and Manitoba.²⁹ The demographic factors discussed above may be contributory.

A large proportion of deaths classified as undetermined were sleep-related infant deaths. Judging by the gradual decline in postneonatal deaths overall (from ~40 annually in the 1990s to ~30 annually in the 2000s), part of the decreased incidence in SIDS might be real, the result of public education concerning a safe infant sleeping environment.³⁰ Most of the apparent decrease in SIDS is an artefact of reclassification that resulted from more careful consideration of the circumstances of death.³¹ The OCME stopped classifying infant death cases as SIDS in 2011, now officially using the term "sudden unexplained infant death". However, "no anatomical cause of death" was the most common cause in the infant deaths of undetermined manner.

Unlike administrative datasets, this autopsy database report lacks the direct links to socio-economic status, racial and ethnic factors, and prior health service utilization. However, it offers the view of a longer time span, which makes temporal trends more obvious. It also provides more detail about injury types and survival. The data presented here mirror data held in administrative databases, such as the Canadian Vital Statistics system at Statistics Canada and that of the Manitoba Centre for Health Policy.^{8,32,33} These data supplement such administrative databases. For example, the Canadian Hospitals Injury Reporting and Prevention Program is known to underreport fatal injuries.³⁴ Administrative databases may be limited by inaccurate coding and may not be able to determine specific causes of death.³⁵ Linkage between the medical examiner's autopsy records and administrative data are likely to yield a more

complete view of the circumstances of death for population research.³⁶ Statistics Canada recently initiated a Canadian Coroner and Medical Examiner Database to incorporate detailed data from reported deaths, including autopsy information. However, data have been reported only for 2006-2008, and information from Manitoba has not yet been incorporated.³⁷

Because this was a 22-year data analysis, we were forced to use multiple resources to gather information. For most of the medical datasets, the definition of the end of childhood is the 18th birthday, but the population datasets were clustered by decade. This can lead to a slight discrepancy in the proportions calculated. Had we included autopsies on individuals in their 18th and 19th years, the proportion of deaths related to traffic accidents and violence would likely have increased. Regardless of these uncertainties, the temporal features are not altered.

Non-natural deaths remain a major problem among Manitoba children, particularly in rural areas. In the ideal world, accidental deaths (road traffic, drowning, fire-related) should be preventable by education and reasonable safety measures. Reduced numbers of infant deaths through improved education about safe sleeping conditions should also be feasible. Because the majority of deaths occur at the scene or within the first few hours, improved hospital care would not be expected to play a major role in reducing non-natural childhood deaths, although we cannot comment on the outcomes of severe non-fatal insults. Given that these non-natural deaths are more likely in rural and impoverished communities, improved societal support might be expected to achieve positive results; however, the contributing socio-economic factors are difficult to modify. Linkage between autopsy and administrative databases should amplify the value of both and, it is hoped, would offer a tool for social change.

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RÉSUMÉ

OBJECTIF : Notre analyse de tous les décès d'enfants de causes non naturelles au Manitoba sur une période de 22 ans (1989-2010) vise à faire ressortir les causes de décès évitables et à décrire les tendances temporelles qui pourraient être influencées par les changements sociétaux.

MÉTHODE : Nous avons interrogé la base de données des autopsies pédiatriques de 1989 à 2010 du Centre des sciences de la santé de

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Winnipeg et les dossiers du Bureau du médecin légiste en chef pour obtenir tous les décès de causes non naturelles d'enfants de ≤ 18 ans. Les dossiers ont été examinés en détail. Les données recueillies incluaient le profil démographique, le mode de décès, les causes et les circonstances ayant conduit au décès, ainsi que la durée de survie après l'événement.

RÉSULTATS : Sur la période d'étude de 22 ans, le nombre total de décès d'enfants de causes non naturelles suivis d'une autopsie au Manitoba était de 581 pour les garçons et de 409 pour les filles pour une population d'environ 1,23 million d'habitants (estimation de 2010). Ceci représente 22,1 % des décès d'enfants au Manitoba sur la période de l'étude. Une proportion plus élevée d'enfants vivant dans les communautés rurales et nordiques est décédée de causes non naturelles. Les accidents de la route ont représenté la majorité des accidents, lesquels ont atteint un sommet en 1999. Pour les suicides, qui ont atteint un sommet en 2005, les pendaisons dans le groupe des 15 à 18 ans ont représenté presque la totalité des cas. Pour les homicides, les décès résultant de la maltraitance d'enfants de < 3 ans étaient la cause la plus fréquente. Pour toutes les causes de décès, la plupart des sujets ont été trouvés morts sur les lieux ou sont décédés peu après.

CONCLUSIONS : La plupart des décès d'enfants de causes non naturelles au Manitoba pourraient être évités par la sensibilisation aux stratégies de prévention et par le redressement des iniquités sociales. L'amélioration du transport à l'hôpital à partir des endroits éloignés aurait sans doute peu d'impact sur la survie.

MOTS CLÉS : épidémiologie; traumatismes; mort; adolescent; pendaison; accidentel