Violent death in Mexican children: Could fatalities be prevented?

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\textbf{Abstract:} A retrospective case-series study with forensic autopsies practiced for a 5-year period. From 3,089 autopsies practiced, 89 cases (2.9\%) were children under 10 years of age. Mechanical agents had the highest frequency (\(n = 64, 71.9\%\)), and traumatic brain injury was the leading cause of death. Natural death cases (biological agents) were the second major cause of death in our study (\(n = 16; 18\%\)), and tuberculosis was the main cause of this group (\(n = 7; 100\%\) males). One case was HIV positive. Children dead by natural causes endured mild-to-severe cases of malnutrition. Forensic data must be considered for a better understanding of fatalities occurred in children.

\textbf{Subjects:} Social Sciences; Criminology and Criminal Justice; Victims and Victimology; Health and Social Care; Public Health Policy and Practice; Preventative Medicine

\textbf{Keywords:} infant mortality rate; neglect; traumatic brain injury; infectious diseases; violence prevention; sudden unexpected infant death

\section{1. Introduction}

Violent death in childhood is a public health problem worldwide, and it is always a dramatic event for both family and society. Infant mortality rate (IMR) is defined by the World Health Organization (WHO) as the number of deaths of infants under the age of 1 year per 1,000 live births, while under-5 mortality rate (U5MR) is defined as the number of deaths of children under 5 years of age.
per 1,000 live births (WHO, 2017). Both rates could be directly related to the educational level and socioeconomic status of a country (Ko et al., 2014).

In the United States, the Surveillance for Violent Deaths of the National Violent Death Reporting System (NVDRS) for 17 States in 2013 reported 201 cases of violent deaths in children under the age of 10, from a total of 19,251 cases (1.04%) (Lyons, Fowler, Jack, Betz, & Blair, 2016). In Mexico, the U5MR is double than that in the United States (Mexico, 13.4; USA, 6.6); despite these alarming numbers, Mexico has not designed a reporting system for violent deaths of children or a special program focused on prevention (Inter-agency Group for Child Mortality Estimation, 2019).

In daily practice, a medical examiner performing a forensic autopsy on a child must determine whether the death was accidental or intentional and if the child was subject to any kind of abuse. In the Mexican criminal justice system, medical examiners are subordinated to the Attorney General. A forensic autopsy is ordered by the attorney when a death is the result of violence or in cases of sudden death. Under certain circumstances, a forensic autopsy must be performed in some natural death cases. All autopsy indications are very similar worldwide (González-Angulo, Moreno-González, Vilegas-Castrejón, Cantú, & Jiménez-Navarro, 1983; Malicier, 2001). All indications imply a cautious examination, but special attention is required while performing pediatric autopsies. These autopsies might reveal violent causes but also reveal several conditions related to death, such as maltreatment and neglect (Zhu et al., 2000).

In such a context, the manner of death could be classified as natural or violent, depending on the primary cause. Natural death is caused by inner pathology, whereas violent death occurs by the action of an external agent and, in turn, could be primarily classified as accidental (non-intentional), suicidal and homicidal. Indeed, the main objective of a forensic autopsy is to determine the cause and manner of death (natural or violent) and therefore to identify the causal agent. While infectious diseases are considered as causes of natural death (with exception to biological agents used for war purposes), etiological agents implicated in violent death can be classified as mechanical (active or passive forces that produce a fatal injury to the body, e.g. blunt and sharp force injuries, firearm injuries, hanging, asphyxia), physical (any form of energy that shocks the body, e.g. electricity, temperature, radioactivity) and chemical (any toxic substance that impairs an organic function or has a caustic effect on tissues, e.g. drug overdose, poisoning, pollutants, acids, chemical weapons) (Beauthier, 2007; Dolinak, Matshes, & Lew, 2005).

It must be considered that all violent deaths of children under 10 years of age should raise suspicion of homicide. On the other hand, some natural death cases such as sudden infant death syndrome (SIDS) require special attention. Cases of SIDS could be considered by the medical examiner as an exclusion diagnosis in every case of an apparent natural death. To diagnose SIDS accurately, the presence of physical injuries, mechanical airway obstruction, poisoning, drug overdose or side effects must be discarded (Centers for Disease Control and Prevention [CDC], 2019; Seske, Ralston, Muglia, & Greenberg, 2016). To accomplish this goal, the cause of death should be determined using all possible diagnostic tools, being that SIDS is often misdiagnosed in cases of asphyxia or drug toxicity. Some authors estimate that 10-20% of the cases of SIDS might result from filicide when diagnosis is not accurate owing to a deficient examination (Eze, Akang, & Odesanmi, 2011; Levene & Bacon, 2004).

Regarding death caused by infectious diseases in children, it is frequently associated with neglect or abuse, and these autopsies should be analyzed carefully. Even deaths that were classified as natural could have a background of neglect not just from family or custodians but also from medical malpractice (Jena, Chandra, & Seabury, 2013).

Due to the lack of information on basic features of forensic autopsies performed on Mexican children, the main purpose of this study is to determine the causes of death of children under 10 years old when a forensic autopsy was required. Moreover, the study compares our results with...
data reported by official agencies and literature, answering the following research questions: Which are the more frequent etiological agents involved in violent child death in Mexico? Is there a particular victim profile related to these cases? Are the official agencies properly considering data obtained from forensic cases to elaborate statistics? Is it possible to elaborate a program focused on the prevention of these cases?

2. Materials and methods
A retrospective case-series study was conducted based on reports of forensic autopsies practiced during a 5-year period, from January 2003 to December 2007, at the Institute of Forensic Medicine (Universidad Veracruzana) in Boca del Río, Mexico. The jurisdiction of medical examiner includes four portside counties (Veracruz, Boca del Río, Medellín and Alvarado) with a population of 801,295 inhabitants living on the borders of the Gulf of Mexico (Instituto Nacional de Estadística y Geografía, 2019a, 2019b). The autopsies of children under 10 years of age were included in the study. The performing of these autopsies was based on the standard protocol of postmortem examination used at the Institute of Forensic Medicine that includes a detailed external recognition of the corpse, an internal exam for describing gross pathology of every organ and collecting samples of organs and tissues for histological, toxicological and complementary studies. Variables collected for this study included age, gender, place where the corpse was collected, cause and manner of death determined by medical examiner following the autopsy protocol. Coroners on duty participated in death scene investigation. Corpses were carefully examined searching for evidence of older and more recent injuries suggestive of physical and sexual abuse. When available, medical records and X-ray images, computed tomography or magnetic resonance imaging studies were also examined. In all cases, parents or guardians were interviewed on the clinical background to be analyzed for consistency with forensic findings. After a full review of autopsy reports by the authors, it was decided to exclude cases in which examination and any other data were not congruent with causes of death.

3. Results
During the period from January 2003 to December 2007, a total of 3,089 autopsies were performed. We found 89 cases of children under 10 years of age, representing an incidence of 2.9% of all autopsies carried out during the study period. In these autopsies (Figure 1), about 82% of forensic autopsies were considered as violent death, but only one of those cases (1.4%) was qualified as homicide. On the other hand, the cause of death was considered “natural” in 18% of the reviewed cases (n = 16). The average frequency of deceased children that underwent an autopsy in this forensic jurisdiction was 17.8 cases per year.

3.1. Violent deaths
Etiology implicated in deceases appears in Table 1. Mechanical agents caused 87.6% of all violent deaths in children. Almost 83% of the group pertaining to violent deaths were male. Mechanical
agents affected children from 6 months to 9 years of age (average three and a half years of age). After the analysis of the scene, interviews with parents and autopsy results, it was considered by the court that all cases in this category occurred non-intentionally, except one. In terms of death caused by mechanical agents (n = 64, 71.9%), the most frequent event was head trauma with skull fracture associated with fatal brain injury (n = 49; and none of these cases were related to abusive head trauma), followed by suffocation (n = 11) and drowning (n = 3) (Figure 2). One case of murder occurred when a 6-year-old child and his parents were killed; the child died stabbed in the thorax. Thirty-seven children died at home environment, 23 children were sent from the hospital to a coroner as a result of a car accident or an accident at home and 4 children died instantaneously on the street as a result of car accidents. The skull–brain trauma affected all children of this category. It was observed that skull–brain injuries, in children able to walk, were consequences of falling out from stairs, high walls or trees. Car accidents were the most frequent cause of skull fracture. In younger children, epidural hematomas and skull fractures were common findings. In all cases, different degrees of cerebral edema were found. Suffocation was the cause of death of 11 children; of these children, seven were under 1 year of age.

Table 1. Medico-legal autopsies: distribution by cause of death, sex and age group

| Agents                | N  | Male/female | Age rank (years) |
|-----------------------|----|-------------|------------------|
|                       |    |             | <1               | 1–4 | 5–9 |
| 1. Mechanical         | 64 | 42/7        | 18               | 13  | 18  |
| 1.1. Head trauma      | 49 | 7/4         | 7                | 4   | -   |
| 1.2. Suffocation      | 11 | 3/0         | -                | -   | -   |
| 1.3. Drowning         | 3  | 3/0         | -                | -   | 3   |
| 1.4. Stabbing injuries| 1  | 1/0         | -                | -   | 1   |
| 2. Physical           | 3  | 3/0         | -                | -   | 3   |
| 2.1. Burns            | 3  | 3/0         | -                | -   | 3   |
| 3. Chemical           | 6  | 2/4         | 2                | 4   | -   |
| 3.1. Prescription drugs| 6  | 2/4         | 2                | 4   | -   |
| 4. Biological         | 16 | 7/0         | -                | -   | 7   |
| 4.1. Tuberculosis     | 7  | 7/0         | -                | -   | 7   |
| 4.2. Bacterial pneumonia| 5  | 3/2         | 1                | 4   | -   |
| 4.3. Diarrhea         | 4  | 3/1         | 1                | 3   | -   |
| Total                 | 89 | 71/18       | 29               | 28  | 32  |

*Number of cases.

Figure 2. Frequency of violent death by mechanical agents in children.
age; the death of these children was the result of suffocation with bedding, aspiration of milk, vomit or choking. We have no certainty if these events happened by any degree of neglect or by accident because the district attorney did not follow any legal proceeding against parents or caregivers. A decision was made to consider these cases as accidents. In addition, CDC (2019) classifies sudden unexpected infant death into three categories: SIDS, unknown and accidental suffocation and strangulation in bed. Suffocation cases reported by our study belong to the third category of the CDC classification. Four children from 2 to 4 years of age died by choking, and all these events occurred at home environment. Physical agents were not a frequent cause of death (3.4%), but accidental burns were the cause of death of two 5-year-old children and in one 8-year-old boy. Agents of chemical nature like prescription drug poisoning \( (n = 1) \) and the accidental ingestion of toxic chemicals caused six deaths (6.7%) in children between 1 to 4 years of age. Five of these deaths happened in hospital in the first hour of arrival and one more at home (Figure 3).

### 3.2. Natural deaths

In the period studied, there were no reports of SIDS. Medical examiners determined that the cause of death was associated with infectious agents in 16 cases (18%). Age of these children was between 8 months and 4 years of age (average 3.6 years old). A total of 81% of children were sent from the hospital. Of these cases, most children had died before arriving at the hospital or they died in the first minutes after arrival without an admission registered, and for these reasons, they were referred to medico-legal autopsy. Except in the cases of bacterial pneumonia, all other children had two or more pathological conditions, and malnutrition was the most frequent one. Pulmonary tuberculosis (TB) \( (n = 7) \), bacterial pneumonia \( (n = 5) \) and acute diarrhea \( (n = 4) \) were the most important causes of death in this group (Figure 4). Pulmonary TB affected male children between 3 and 6 years old; six referred from the hospital and one directly from home. One child...
with TB and malnutrition was also HIV positive. Children with bacterial pneumonia were on average 3.1 years old (3–6-year range). Four cases came referred from hospital and one collected from home; 60% were male. All children with acute diarrhea were dehydrated, and 75% of them were sent by the medical staff of the hospital with no previous admission to be examined by the coroner as they declared the absence of vital signs during the initial clinical exam.

4. Discussion

During 2015, INEGI reported a total of 655,688 deaths in Mexico. From these cases, 36,770 corresponded to children of 14 years old or younger (5.6%). Based on these numbers, INEGI also reported the following percentages of death by violent causes (including homicide, suicide and accidents, without specifying if autopsied or not) corresponding to 8.2% for children up to 4 years of age, 27.1% for children from 5 to 9 years of age and 36.4% for teenagers from 10 to 14 years of age. Based on 2,353,596 live births and with an incidence of 26,057 infant deaths (<1-year old), national IMR resulted in 11.07 (Instituto Nacional de Estadística y Geografía, 2019a, 2019b). Regarding the above, we found that increasing in national mortality rates associated with violent causes seems to be clearly related to the increasing age of children. Meanwhile, general mortality incidence for the State of Veracruz in 2015 was 52,354 cases, and a total of 5,597 cases belonged to our jurisdiction (10.69% of state incidence). In the State of Veracruz, infant death incidence was 1,778 cases and 163 cases for our jurisdiction (9.16%). IMR for the State of Veracruz based on 144,842 live births during 2015 was 12.27 (10.88% higher than national IMR), and for our forensic jurisdiction, IMR was almost equal to the State of Veracruz (12.24) based on 13,311 live births (Instituto Nacional de Estadística y Geografía, 2019b), and this number is 37% higher compared with Hamilton County, Ohio, one of the highest local rates in the USA (IMR 8.9) (Seske et al., 2016).

Considering a total state population of 8,127,832, our jurisdiction represents 10.48% of the State, and State population represents a 6.31% of National (121,005,816 inhabitants), our sample is representative of the State population, and in turn, the State is representative nationwide. Thus, our study sample reflects this phenomenon in Mexico. In all official data reviewed to compare the results of this study, we could not find the sources reporting the mortality figures showing deaths which diagnosis was based on the autopsy or any other variables reported in this study. Instead, INEGI reports only “percentages” of violent deaths, lacking the specificity of the US-NVDRS. In our sample, less than 3% of the total autopsies performed within 2003–2007 were children under 10 years of age (N = 8 9). We report an average incidence of 17.8 cases per year (0.31% of general mortality rate—6.98 per 1,000 inhabitants per year). Death of children under 1 year of age had an average frequency of 5.8 per year (47.38% of the jurisdiction IMR), and considering that the State and jurisdiction IMRs are higher than National, the percentage of deceased infants that underwent a forensic autopsy was higher than expected. It is alarming that an incidence of 17.8 violent deaths of children per year, in a small jurisdiction, is equal to 8.85% of the 201 cases in the 17 States of NVDRS study.

In our report, mechanical agents were the most frequent causes of death, as described in other studies (Lang, Pärna, Grijbovski, & Väli, 2010). In traumatic brain injury (TBI), males were preponderantly affected (83%). In these cases, evidence of physical mistreatment was not found; however, the fact that almost 60% of children died at home by mechanical agents suggests lack in home prevention. Several factors are involved in prevention strategies, including family education level, socioeconomic status and social deprivation. In lower-class socioeconomic groups, with greater social deprivation, the IMR is higher, and these groups also have a high accident rate (Afandi, 2012). When the cause of brain trauma is analyzed, in Latin American countries, it is primarily associated with falls, while in the United States and other developed countries, it is related to car accidents. About this notion, a study from Peru showed that TBI (80.1%) and traffic accidents (10.4%) were the leading causes of death in children (Guillén-Pinto et al., 2013). In Australia, pediatric head injury was associated with motor vehicle accidents in 77% of cases, and sports and recreational injuries accounted for 26% (Amaranath et al., 2014). In children receiving intensive care in the United Kingdom, accidents involving vehicles had the highest mortality rate
(23% for vehicle occupants, 12% for pedestrians) compared to cyclists (8%) and falls (3%); TBI was an isolated injury in two-thirds of admissions (Parslow, Morris, Tasker, Forsyth, & Hawley, 2005). According to the records from discharges of patients with TBI in hospitals from Sweden, the average incidence rate of TBI was 12/100,000; main causes were traffic accidents (60%) and falls (22%) (Emanuelson & Von Wendt, 1997). In a 5-year study in Arizona, 62% of deaths were due to medical conditions and 8% were considered preventable (253/2,983); in contrast, 91% (852/934) of unintentional injury deaths were considered preventable (Rimsza, Schackner, Bowen, & Marshall, 2002). In our study, as described in other Latin American countries, falls were the leading cause of brain injury in children. We only analyzed children who died of brain damage, but those who survive these injuries may have different types of sequelae (Keightley et al., 2014).

In Mexico as other countries, when a child arrives at emergency room without vital signs or agonizing, and clinical diagnosis is not clear, a forensic autopsy should be performed. Despite intensive campaigns on prevention, the cause of death by infectious diseases accounted for 18% of forensic autopsies in our sample. Children were taken to the hospital with severe respiratory distress, and most of them died in the first hour after arrival. It is disturbing that the main cause of death in these children (3–6 years old) was associated with TB because this is a chronic disease, possibly acquired at home from an adult under the same roof. In 2016, WHO (2016) reported that 1.8 million people had died due to TB in 2015, so this is one of the top 10 causes of death worldwide. In Turkey, a study with forensic autopsies showed that 10% of cases had granulomas with caseous necrosis and tuberculosis bacilli (Ozsoy et al., 2010). In our study, TB was associated with the cause of death in almost 8% of the natural death cases.

The outlook of children mortality in our country (5–12 years) has changed dramatically and is easily appreciated if we compare data between decades. In 1979, 13,450 deaths were reported, and in 2003, only 5,190 deaths (~61.41%). However, when analyzing the causes of death, most significant decrease was infectious and malnutrition diseases (1979—34.5%; 2003—15.1%), but noninfectious diseases have increased as a cause of death in Mexican children (1979—22.1%; 2003—47.2%). It is disturbing that the percentage of accidental and intentional injuries has not changed significantly (1979—33.3%, 2003—36.5%) (Secretaría de Salud, 2005). This reveals a gap in prevention that requires not only education of actors but also effectiveness in public policies; for this reason, medical examiners should collaborate with other agencies managing mortality data.

The study limitations include that it is trying to describe a phenomenon that is occurring in an entire country, with a small population sample. As we said before, this sample was considered representative because we compared our results with others in the literature. Some of these studies that we had compared were based on smaller samples, and they were still of research interest. Otherwise, none of these studies could be considered representative. Because the full access to forensic cases is sometimes very limited, despite the sample size, all these studies should be considered valuable and representative. And in this sense, another limitation of our study is the retrospective view. Because recent forensic cases are reserved by attorney, we could not make this study in a prospective view. However, the period studied is enough to appreciate the impact of the phenomenon in our society.

Ultimately, this study answers to the research questions formulated in the beginning. First, mechanical agents are the most frequent etiological agents related to violent death in Mexican children. Remarkably, the second major cause of death found in pediatric autopsies in our country is still related to biological agents (TB). Both causes are fully preventable. Second, based on the numbers of this study, we found that the most frequent victim profile in pediatric autopsies is a male child, from 1 to 9 years of age, and dead by head trauma in domestic or street environment. Third, official agencies are not considering forensic data for the statistics reported, and they lack information that is valuable for a better understanding of violent death of children. Finally, as these cases are mostly preventable, Mexican government agencies should consider elaborating a prevention program based on the etiology (mechanical in most cases), regarding deaths caused
by biological agents that are fully preventable. An effective public strategy could lead to a lower number of violent deaths in Mexican children.

For this reason, we conclude that a valuable goal worldwide must be to decrease IMR by violent and infectious causes in childhood by creating effective programs against violence and promoting infectious disease prevention. Thus, we thoroughly encourage all agencies responsible for managing this information in Mexico (e.g. INEGI or Secretaría de Salud) to include more detailed forensic data to mortality statistics. Violence prevention in Mexico needs focus on education and awareness of parents and caregivers, giving access to health facilities and services, keeping ergonomics and safety of the home environment, providing early diagnosis and treatment of infectious diseases and preventing malnutrition in childhood since this is one of the most at-risk groups around the globe.

Acknowledgments
The authors acknowledge the facilities provided by the Attorney General of the State of Veracruz (FGEV) and by Coroner’s Office (SEMEFO) of Boca del Río, Ver. The authors also thank to Sharon Rendon for kindly reviewing and proofreading this paper, helping us to improve the presentation of this work.

Funding
The authors received no direct funding for this research.

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Conflict of interest
The authors declare that they have no conflict of interest.

Ethical approval
This article does not contain any studies with human participants or animals performed by any of the authors.

Citation information
Cite this article as: Violent death in Mexican children: Could fatalities be prevented?, Noé López-Amador, Ana L. Calderón-Garcidueñas, Rubén Ruiz-Ramos & Octavio Carvajal-Zarrabal, Cogent Social Sciences (2019), 5: 1662588.

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