



Article

# An Analysis of Children Left Unattended in Parked Motor Vehicles in Brazil

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**Abstract:** Our study investigates the incidence of children left unattended in parked motor vehicles in Brazil. These events have been widely explored in the United States but less so abroad, and never in Brazil. Over the period from 2006 to 2015, we collected data from news reports on 31 cases, including 21 fatalities. The circumstances mostly involved a caregiver, especially a parent, forgetting the child (71%), but cases also included the child being intentionally left in the vehicle (23%) or gaining access to the vehicle (3%). Children tended to be forgotten more frequently in fatal cases (86%), particularly on the way to daycare, than non-fatal incidents where circumstances were more evenly distributed between forgetting (40%) and being intentionally left behind (50%). Incidents occurred throughout the country but mostly in the southeastern region near the city of São Paulo. Additionally, the danger for children is present year-round as we observed cases in every season, albeit with a peak in the summer. This heat-related hazard is not well recognized across Brazil and we recommend increasing awareness through education. Further, given the high percentage of cases involving parents forgetting to leave their children at daycare, we recommend arrangements between daycare providers and parents to communicate when a child does not attend as expected.

**Keywords:** hyperthermia; vehicle; car; children; weather; Brazil

## 1. Introduction

Parked cars and vans may create life-threatening environments for children left unattended. On a hot day in full sun, vehicles can reach dangerously high temperatures exceeding 70 °C in response to a greenhouse effect [1–4]. Further, children are especially vulnerable to heat because of a combination of less efficient thermoregulation than an adult and the inability to adjust clothing as they are strapped into a car safety seat [4–7]. Unfortunately, deaths from heatstroke in vehicles are not uncommon, at least in the U.S. where it has been well documented. A total of 661 fatalities have been identified from 1998 to 2015, averaging about 37 per year [8].

Several studies have investigated the circumstances and characteristics of children who have died in hot cars in the U.S. [9–11]. No official database includes details that a heat-related fatality occurred in a vehicle and, therefore, all studies on this topic have used news reports in some capacity [9]. Some studies have sampled these incidents using news reports exclusively [9,11] while others have utilized official databases, like the Centers for Disease Control and Prevention WONDER (Wide-ranging Online Data for Epidemiological Research) online Database, to identify heat-related deaths in combination with news reports to determine the setting of the fatality [10]. Booth et al. (2010) found strong correspondence in identified cases when comparing the above methods [10].

The largest and most current dataset, extending from 1998 to the present, indicates that over half the cases in the U.S. involve a caregiver forgetting a child (54%) with the remaining cases split between

the child gaining access (29%) and being intentionally left behind (17%) [8]. Deaths are most common among children under three years who account for over 80% of fatalities. These incidents occur in a wide geographic range across the contiguous U.S. but most commonly in the southern portion of the nation. The greater number of deaths in southern states is likely related to the greater frequency of hot days, which increases the likelihood for high cabin temperatures. Indeed, a study in Austin, TX noted that even in winter, cabin temperatures could reach dangerous levels [4]. Finally, most fatalities (70%) occur in the summer months [10,11].

Aside from a small study in Italy [12], there is a lack of vehicular heatstroke research examining incidents outside of the U.S. and no published research on non-fatal incidents. Our study aims to investigate the incidence, circumstances, and geography of both fatal and non-fatal cases of children left unattended in parked motor vehicles in Brazil. We selected Brazil for several reasons. First, it is the largest country in South America, and the fifth largest in the world based on population. Additionally, much of it lies in the tropics where temperatures remain high throughout the year, increasing the hazard for children in hot vehicles. Finally, there appears to be little recognition of the dangers that hot cars pose to children via public health messaging from governmental agencies or non-governmental child advocacy groups.

## 2. Methods

Our dataset of children left unattended in vehicles is based on information obtained from news reports. We utilized various combinations of keywords related to vehicles, children or baby, forgotten, hyperthermia, and death (Table 1). These keywords in Portuguese were applied in websites such as Google, Yahoo, Bing, and in the search fields of Brazilian newspapers for each region and state of the country. The first identified report was in 2006 and the last in 2015, providing a dataset that extended from 2006 to 2015. Other potential sources of data were not suitable for this study. The official DATASUS (the Brazilian Technologic Information System of the Unique Health System dataset) from the Brazilian Ministry of Health, for instance, includes cases of hyperthermia but does not specify whether the death occurred in a vehicle [13]. We recognize that the identified reports will likely underestimate the actual number of cases. Underreports may be due to a combination of a case not reaching the attention of the media, occurrence in a location without access to electronic media, or selection bias by newspapers due to space and editorial concerns [10,11]. In addition, while we attempted to consider a variety of search terms, it is possible that we missed reports due to the lack of controlled vocabulary used to characterize these events [9].

**Table 1.** Key word search in Portuguese and English for children left unattended in motor vehicles.

Portuguese	English
Insolação	Hyperthermia or heatstroke
Criança, bebê, menino, ou menina em carro	Car child, baby, boy or girl
Criança, bebê, menino, ou menina em van	Van child, baby, boy or girl
Criança, bebê, menino, ou menina em caminhonete	Truck child, baby, boy or girl
Morte	Death
Esquecido	Forgotten

Multiple sources of information were recorded for each identified report (Table S1). We documented the date, location, age, and gender of the child, circumstance of being left in the car (e.g., forgotten, intentionally left behind, or gained access), if a fatality occurred, if the child was supposed to be dropped off at a daycare, the length of time the child was in the vehicle before being discovered, and the responsible caregiver. We characterized the meteorological conditions on given days using maximum ambient air temperatures, which previous research has identified as a key component in predicting maximum daytime cabin temperatures [3]. These data were obtained from the weather observing station nearest to the incident [14]. Finally, all cases but one involved a single child.

We considered the multi-child case (i.e., Pouso Alegre, Minas Gerais, on 5 April 2015) as one incident but did account for the two children (a boy and girl) in the determination of child characteristics.

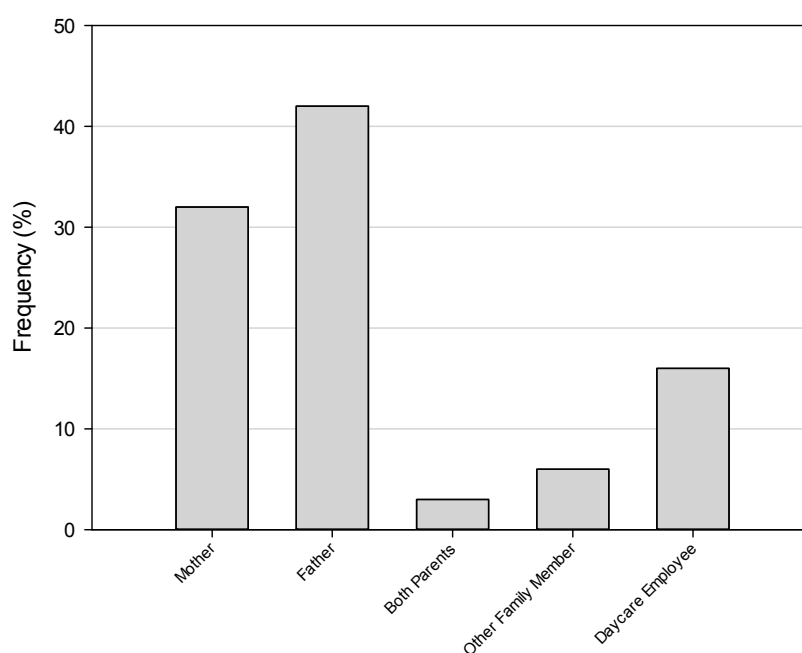
$\chi$ -Square goodness of fitness tests were used to identify whether observed differences in occurrence by season, day of the week, and by caregiver were statistically significant. For days of the week, we used six categories with one for each weekday (Monday–Friday) and one for the weekend (Saturday and Sunday). We identified five categories of caregivers in our dataset but used two categories (parents and non-parents) to assess if parents were statistically significantly more likely to leave a child unattended in a vehicle. In all cases, we assumed that the theoretical expectations were proportional to the number of nominal categories and identified significance at the 5% level.

### 3. Results

#### 3.1. Child Characteristics and Circumstances

Between 2006 and 2015, there were 21 incidents that resulted in a fatality and 10 where the child was discovered before death. In terms of child characteristics, the majority were less than two years of age (58%; 18/31) and almost three quarters less than three years of age. There is a near balance between male (50%; 16/31) and female (47%; 15/31) children with the remaining 3% (1/31) unknown.

In analyzing the circumstances, we initially aggregated both fatal and non-fatal cases (Table 2). The vast majority of children (71%; 22/31) were forgotten with the remaining cases involving children being intentionally left behind (23%; 7/31) or gaining access to the vehicle (3%; 1/31). Of the children forgotten, 67% (12/18) involved the caregiver forgetting to drop the child off at a daycare center. We observed notable differences, however, in the partitioning of circumstances when we separated fatal and non-fatal cases. Of the fatal cases, 86% (18/21) involved the child being forgotten while there was a more even split observed between children forgotten (40%; 4/10) and intentionally left behind (50%; 5/10) among the non-fatal incidents. Finally, Figure 1 shows that over three quarters of incidents involved parents with fathers accounting for 42% (13/31), mothers 32% (10/31), and both parents 3% (1/31) of cases. The remaining incidents involved daycare employees (16%; 5/31) and other family members (6%; 2/31). We found a parent was statistically significantly more likely for be involved in leaving a child unattended ( $p = 0.001$ ) than an unrelated caregiver or other family member.



**Figure 1.** Incidents of children left unattended in motor vehicles by responsible caregiver.

**Table 2.** Incidence of children left unattended in motor vehicles by age and circumstance.

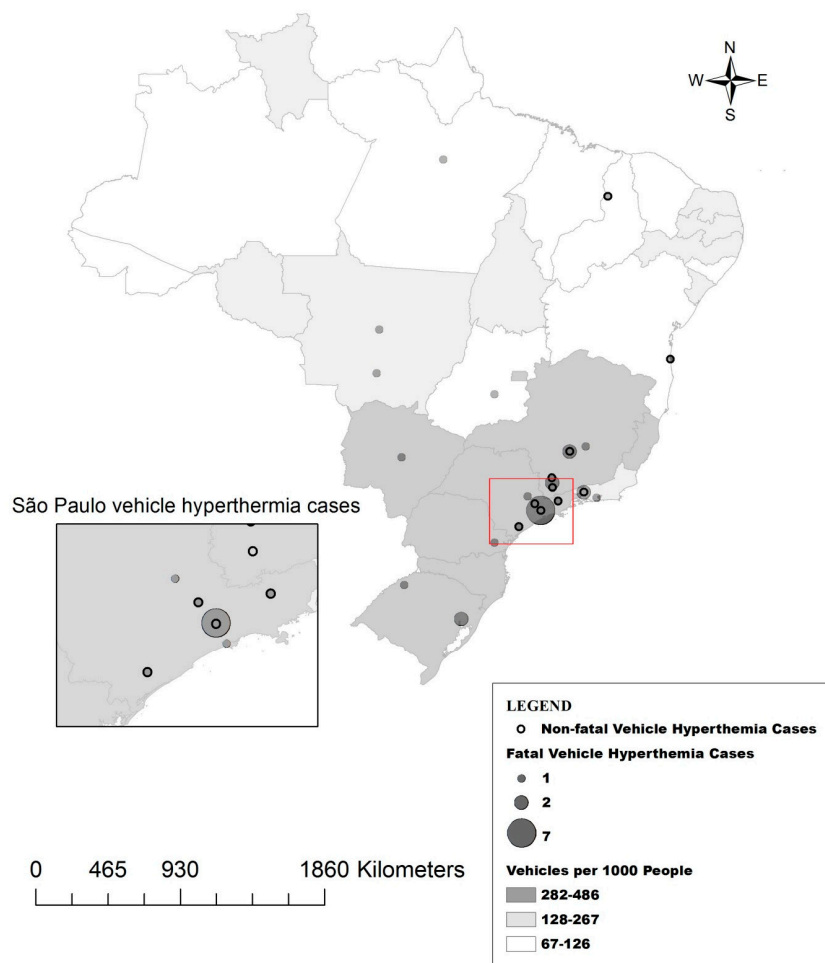
Age Interval	Circumstances				Total (%)
	Forgotten	Intentionally Left Behind	Gained Access	No Data	
Less than 1 year old	7	2	-	1	10 (32%)
From 1 to less than 2 years old	6	2	-	-	8 (26%)
From 2 to less than 3 years old	4	-	1	-	5 (16%)
From 3 to less than 4 years old	2	-	-	-	2 (7%)
More than 4 years old	3	2	-	-	5 (16%)
No data	-	1	-	-	1 (3%)
Total (%)	22 (71%)	7 (23%)	1 (3%)	1 (3%)	31 (100%)

There was an obvious difference in the length of time between fatal and non-fatal cases, in which a child was left in the vehicle before being discovered. For fatal cases, on average, a child was found within 5 h of being left unattended, compared with about 2 h for non-fatal incidents. It should be noted that the average length of time for non-fatal incidents may be inflated due to a four hour incident that occurred in Divinópolis, Minas Gerais, from 7 a.m. to 11 a.m. The relatively early time of day helped to minimize the heating of the vehicle.

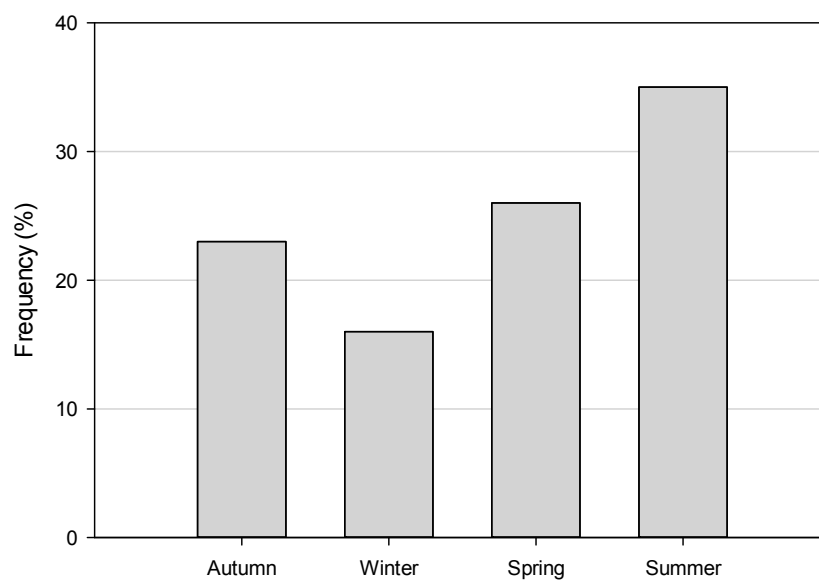
### 3.2. Spatial and Temporal Patterns

The incidence of children left unattended in vehicles is geographically diverse across Brazil (Figure 2). Yet, the greatest concentration of cases occurs in southeastern portion of the country. Indeed, 58% (18/31) of the reported cases were in the state of São Paulo, with six in the city of São Paulo. There were few reported cases in the northeastern states and none in the northwestern portion of the country, where the Amazon rainforest is located and which has a lower population density than other areas of Brazil (Figure 2). The spatial pattern does not directly correspond with climate regions where few identified incidents have occurred in the hotter northern portions of the country relative to the milder southern areas. A possible explanation may be associated with the transportation habits of the population. Grundstein et al. (2011) found a strong relationship between vehicle hyperthermia fatalities in the U.S. and the percentage of people who drive as opposed to using other modes of transportation [11]. Using vehicles per 1000 persons as a metric for car usage, we found over 80% of the deaths (25/31) occurred in the areas in the top one-third of vehicle ownership [15,16] (Figure 2).

Temporally, we investigated cases by season and day of the week. We found some variation among the seasons with the largest proportion of cases in the summer months (35%; 11/31) and least in the winter (16%; 5/16; Figure 3) but these differences were not statistically significant ( $p = 0.49$ ). Additionally, a disproportionate number of cases were observed during weekdays (Monday–Friday; 87%; 27/31), which only constitute 71% of the week (Figure 4). However, we did not find a statistically significant difference ( $p = 0.079$ ) when we compared weekdays vs. the weekend.



**Figure 2.** Locations of children left unattended in motor vehicles. The red box cover the area around the city of São Paulo, which is shown at higher resolution in the box to the left. Vehicles per 1000 people is categorized by thirds.



**Figure 3.** Incidents of children left unattended in motor vehicles by season.

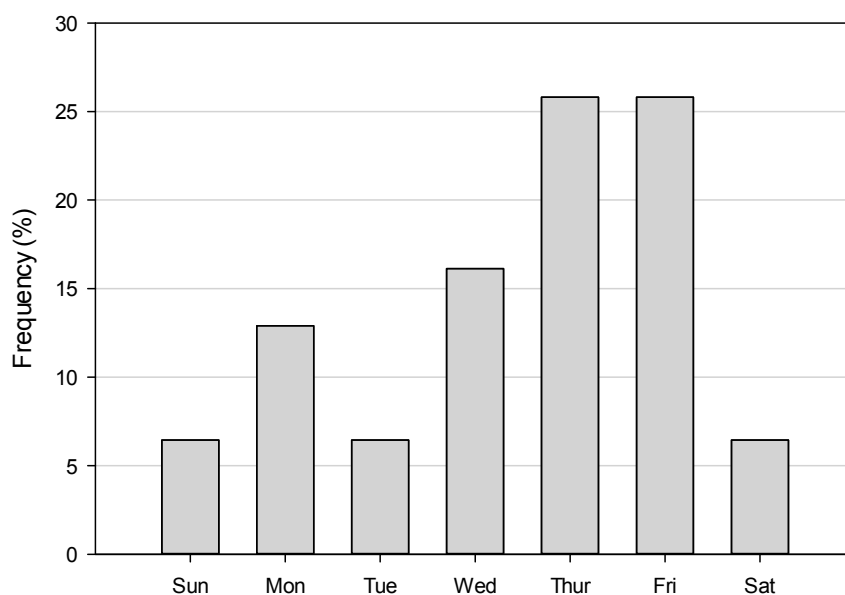


Figure 4. Incidents of children left unattended in motor vehicles by day of week.

### 3.3. Weather Conditions

We used the maximum daytime air temperature to characterize the meteorological conditions on days when a child was left unattended in a vehicle. There was no statistically significant difference observed in daytime maximum temperatures between fatal and non-fatal cases when assessed with a Student’s *t*-test ( $p = 0.31$ ). On average, the daytime maximum temperatures were  $29.9 \pm 3.8$  °C, but ranged from 16 to 36.7 °C. The two outliers (16 and 36.7 °C) occurred on days associated with non-fatal incidents. Over 75% of the cases, and all fatal incidents, occurred on days with maximum air temperatures between 26 and 34 °C (Figure 5). For perspective, typical maximum daytime temperatures in São Paulo in the summer (December–February) range from about 26–28 °C.

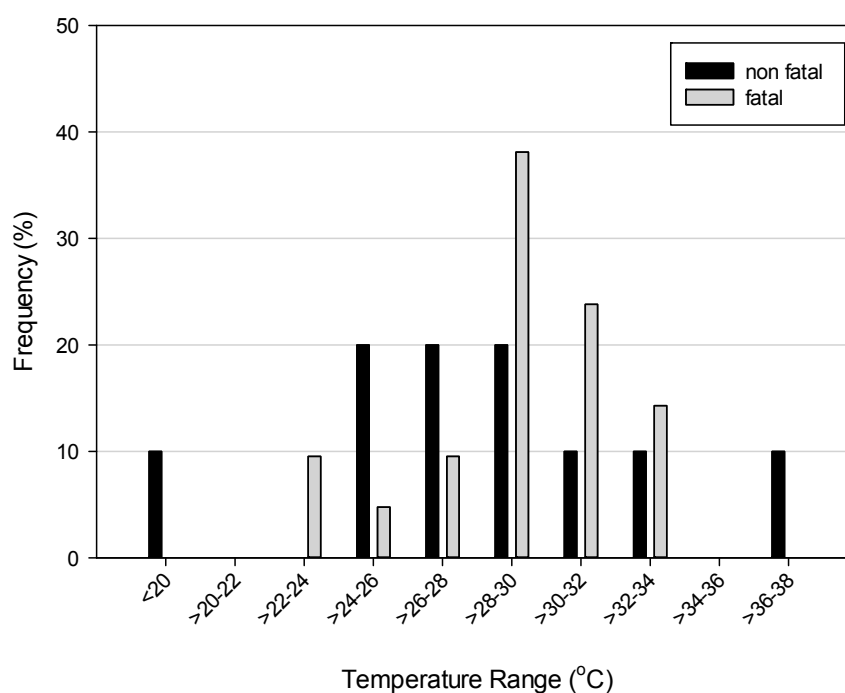


Figure 5. Histogram of maximum air temperatures for fatal and non-fatal incidents.

#### 4. Discussion

Our study identifies distinct characteristics in terms of circumstances, geographic, and temporal patterns, and weather conditions associated with cases of children left unattended in motor vehicles in Brazil. In terms of circumstances, a common profile, sometimes referred to as “forgotten baby syndrome”, involved a parent forgetting his or her child in the back seat of the car when the child was supposed to go to daycare. It is speculated that it may occur more frequently when transporting the child is a diversion from normal activity [17]. Our findings differ somewhat from data collected in the U.S. with a far greater percentage of fatal incidents occurring because they were forgotten and fewer cases involving a child being intentionally left in the vehicle or becoming trapped after gaining access. The differences may be the result of an actual difference in circumstances between Brazil and the U.S., or simply the result of the small sample size and/or selection bias among news outlets in what they chose to report.

A second key observation is that incidents occurred in a wide geographic range across the country and throughout the year. Nevertheless, the greatest frequency of reported cases was in the vicinity of São Paulo, in the southeastern portion of the country. The exact reason for this pattern may be related to the variations in transportation habits among areas, with greater frequencies of incidents in locations with more vehicles and, therefore, greater car usage. It is also possible that more cases are reported to news outlets in the more densely populated regions of the country.

Third, we found only modest seasonality in incidents in contrast to the pattern in the U.S. where 70% of fatalities occur in the summer. However, fatalities tended to occur under similar ranges of daytime maximum temperatures in Brazil ( $30 \pm 4$  °C) and the U.S. ( $32 \pm 5$  °C) [11]. The different patterns, then, can be explained by differences in climate. Much of Brazil ( $6^{\circ}\text{N}$  to  $34^{\circ}\text{S}$ ) is located in the tropics where seasonal temperatures remain high through the year and, thus, the hazard for cars reaching dangerous temperatures remains ever present. In the U.S., by contrast, the mid-latitude climates present greater seasonality in temperatures with the hottest and most hazardous conditions concentrated in the summer months. The upshot is that given the more uniformly high temperatures through the year, the hazard is not limited to only one season in Brazil. Finally, an important distinction between fatal and non-fatal cases involved the length of time the child was left in the vehicle. Clearly, the danger to the child is based on both length of exposure and the thermal conditions in the vehicle which can vary with ambient weather conditions, time of year, and time of day. In non-fatal cases, we found that much shorter exposures reduced the likelihood of a child suffering heat stroke.

#### 5. Implications and Limitations

Our study, the first of its kind for Brazil, documents 31 cases of children left unattended in a parked vehicle. Unlike other childhood injuries, vehicle-related hyperthermia is highly preventable and the results from this study point toward a number of possible mitigation measures. First, there appears to be no widespread public health messaging about the dangers of leaving children unattended in hot vehicles from governmental or private sector health organizations. A first step would be to raise awareness through education. In the U.S., a variety of messages have been developed by governmental agencies (e.g., National Weather Service, the National Highway Traffic Safety Administration, the Georgia Department of Early Care and Learning) and child safety advocacy groups (e.g., Safe Kids and KidsAndCars.org) [18–22] (Table 3). These messages should be coupled with recommended actions for parents and caregivers such as reminders to check the back seat (e.g., putting a handbag, brief case, or cell phone in the back seat for retrieval when the car is parked; keeping a large stuffed animal in the front passenger seat as a visual reminder that there is a child in the car; or the use of other passive reminders like stickers or key chains), keep the vehicle locked at all times to prevent children from gaining access, and for bystanders to call emergency services if a child is observed unattended in a vehicle [22]. Additionally, based upon our small sample, many of these deaths occur when a parent forgets to leave a child at daycare. Here, an important complement to the above suggestions would be the development and implementation of an arrival/absence confirmation with day providers [23].



This would create a two-way conversation between the childcare provider and parent, to ensure that a parent would be notified in the event their child did not arrive at daycare.

**Table 3.** Public safety messages related to children unattended in hot vehicles.

Message	Source	Portuguese Translation
Look before you lock	KidsAndCars.org; Texas Department of Family and Protective Services	Olhe antes de trancar
Look again	Georgia Department of Early Care and Learning (DCAL)	Olhe de novo
Never leave a child alone in a car, not even for a minute	Safe kids USA	Nunca deixe uma criança sozinha no carro, nem mesmo que por um minuto
ACT A: Avoid heatstroke C: Create reminders T: Take action	Safe kids USA	ECT E: Evite insolação C: Crie lembretes T: Tome atitude
Where's baby?	National Highway Traffic Safety Administration	Onde está o bebê?
Beat the heat, check the back seat	National Weather Service	Combata o calor, confira o banco traseiro

We recognize a number of limitations in our study. As mentioned earlier, our dataset likely under samples the actual number of cases because we only included data from online news reports. Additionally, some caution must be used in interpreting the results of our limited sample of fatal and non-fatal cases. Nevertheless, the very consistent findings among the included incidents provide confidence in our broader conclusions surrounding the circumstance of occurrence. Lastly, we only have data on when the child was found in the car, not the length of time before he or she died from hyperthermia. It is possible the child died well before being identified which would inflate the variable we use for fatal cases.

While our study clearly identifies vehicle-related hyperthermia as a hazard in Brazil, there are a number of areas where this work can be further developed. First, a larger database would provide a better sample size and possibly more representative information. In the absence of official governmental data on vehicle-related hyperthermia, we plan to continue to build upon our existing dataset and develop an information clearinghouse, perhaps in conjunction with an existing one such as available at [noheatstroke.org](http://noheatstroke.org) [8]. Second, studies of perceptions of the risk for vehicle hyperthermia among Brazilian parents and caregivers may help guide public safety campaigns. We proposed some suggested public safety messages which are used in the U.S. but information from the above study might identify messages and mitigation measures that are most effective among different populations in Brazil such as working parents.

## 6. Conclusions

This research is the first to identify the heat-related hazards for children left unattended in parked motor vehicles in Brazil. From 2006 to 2015, at least 21 children have died from heat stroke under these circumstances. We recommend a variety of mitigation measures, including increased awareness through education and policies at daycare centers that communicate with parents if their child does not arrive as expected.

**Supplementary Materials:** The following are available online at [www.mdpi.com/1660-4601/13/7/649/s1](http://www.mdpi.com/1660-4601/13/7/649/s1), Table S1: Dataset of children left unattended in parked motor vehicles in Brazil, 2006–2015.



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**Author Contributions:** Driely Costa and Andrew Grundstein conceived and designed the experiments; Driely Costa collected the data; Driely Costa and Andrew Grundstein analyzed the data and wrote the paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

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