Preventing Pediatric Vehicular Heatstrokes: Overcoming Prospective Memory Failure

The Sofia Foundation for Children's Safety was founded in 2017 to help prevent the avoidable tragedy of pediatric vehicular heatstroke.

ABSTRACT

This paper seeks to increase awareness and prevent the avoidable occurrence of children dying from hyperthermia when caregivers unknowingly leave them in a vehicle. Pediatric vehicular heatstroke (PVH) frequently are a result of prospective memory (PM) failures, rather than neglectful caregiving. Parents who have inadvertently left a child in a car often report experiences of 'false memories' where they vividly remember dropping the child off as they intended. In this paper, we explain how PM failures, false memories, and other contributing factors lead to pediatric vehicular heatstrokes. Since the vast majority of PVH tragedies happen to caring and attentive parents, this paper argues that all caregivers should take safety precautions to prevent hot car deaths. The Bag in the Back campaign has been developed to offer guidelines for preventing PVH. This campaign is reviewed and can be used by pediatricians, daycare providers, and others to mobilize caregivers to take action in preventing PVH deaths and injuries.

INTRODUCTION

Pediatric vehicular heatstroke (PVH) is one of the leading causes of nontraffic, non-crash vehicular child fatalities in the United States.[1] They have increased dramatically since car seats were moved to the back seat, which prevents air bag injuries but removes the visual reminder that a child is in the car.[2] On average, there are 38 PVH fatalities in stationary vehicles for young children in the U.S. each year, for a total of 742 child fatalities on record between 1998–2017 and thousands of non-fatal injuries.[3] Just over half of the children involved in these hot car fatalities were unknowingly left by a parent or other caregiver. During Covid-19, however, the number of child fatalities of vehicle hypothermia have been the lowest since 1998, with a particularly large decline in children who were unknowingly left behind in cars (62% less compared to previous years).[4] Experts have presented multiple reasons for the sudden drop in PVH figures; the global and nation wide lockdowns of 2020 changed patterns of our daily routines; people stayed stationary and were driving around 14% less which significantly contributed to the annual decrease in pediatric vehicular heatstroke deaths in the United States.[5] However, despite these figures being at an all time low, researchers estimate that once society and the economy open up again and home restrictions are being lifted, people will return back to their daily routines – such as driving to work or school – and PVH fatalities will increase.

Therefore, there is now a sense of urgency for health-care professionals, parents and legislators to recognize this type of motor vehicle injury or fatality in both public and private discourse and further contribute to the prevention of PVH deaths. A major barrier to preventing these avoidable deaths, however, is the public's misunderstanding about how common memory failures, rather than neglectful parenting, lead to most instances of PVH. Even very good parents can mistakenly leave a child behind in a car.[6]

The Bag in the Back[7] campaign is designed to educate parents, caregivers, doctors, and the general public about pediatric vehicular heatstroke. The campaign seeks to explain how prospective memory failures, the development of false memories of drop-off, and other contributing factors make it possible for caregivers to unknowingly leave a child in the car. The Bag in the Back campaign offers suggestions for how physicians and daycare providers can talk with parents about preventing PVH.

THE SCIENCE BEHIND VEHICULAR HEATSTROKES

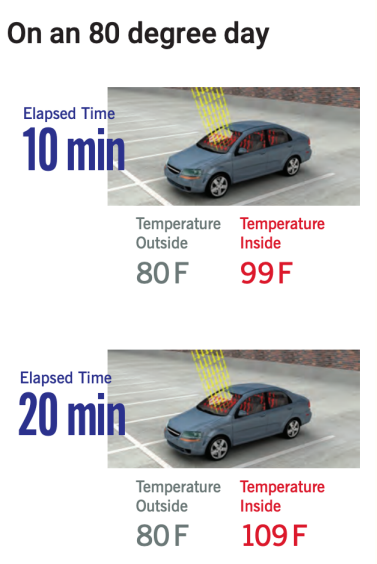
Pediatric vehicular heatstroke is a particular risk in geographical locations with prolonged periods of hot weather.[8] However, PVH has occurred in almost all states including those in the far north; an outdoor temperature in the mid-60s is sufficient to heat the car to over 110 degrees.[9][10]

Studies have found that – on days when temperatures exceeded 86 °F – the temperatures inside of vehicles quickly reached 134 to 154 degrees Fahrenheit. On average, in the first 10 minutes, the temperature inside a vehicle rises by 19 degrees and can rise more than 40 degrees during a 60-minute period. When the outside temperature is 90 °F, a child left in a vehicle can die in as little as 10 minutes.

Two factors make children more prone to hyperthermia than adults: children have a greater surface area to body mass ratio than adults and their thermoregulation is less efficient than adults'. A child's body heat rises three to five times faster than an adult's and a child's organs begin to shut down when the child's temperature reaches 104 °F.[11] Fatal body temperature for a child is 107 °F. Even though PVH death is still relatively rare, other problems, such as vital organ damage and brain swelling can occur rather quickly, resulting in grave injuries.

WHAT IS PROSPECTIVE MEMORY FAILURE?

Researchers and scientists have long studied how memory is formed, stored, and recalled. In neuropsychology, memory has been broadly divided into two categories; retrospective memory (RM) and prospective memory (PR).[12] Retrospective memory is the memory we store of people, times, contexts, words and events etc. encountered or experienced in the past. In contrast, prospective memory involves remembering something or remembering to do something after a delay, such as stopping by the pharmacy on the way home from work. Both of these memory formations are linked, however, when people are asked to think or describe memory loss in their own lives they commonly refer to and think about retrospective memory. RM-type of forgetting includes details, such as someone's address or a phone number or other facts. Multiple studies indicate, however, that most common memory failures in everyday life are errors in prospective memory.[13]



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The distinctive feature of a prospective memory failure is an error in the use of stored information to plan and execute an action set to take place in the future.[14] Prospective memory failures are nothing new; the human mind experiences various PM-related memory errors and disruptions on a daily basis. Some common examples of PM failures include, planning to call a friend at lunchtime, but instead going straight to the cafeteria as you normally do; not remembering to take your medication prior to going to bed because you had to stop to clean up a spill; and not interrupting an otherwise routine drive home to stop at the grocery store as you planned.

What usually contributes to PM failures are errors in multitasking, ongoing habitual activity (being on 'autopilot'), and the absence of a reminder cue (e.g., seeing a child in the rearview mirror, a drop-off reminder from a phone, or a sound of a child on the backseat). Successful performance of prospective memory requires multiple cognitive operations including: forming, organizing and initiating the plan; retaining the memory of the intention over a delay period; performing the intention at the right time; and then remembering that the intended action took place. The essence of a PM failure therefore is the loss of awareness to 'remember to remember' at just the right time[15] Most prospective memory failures are relatively harmless or minor annoyances, but it is crucial to increase awareness that sometimes these memory failures can create potentially hazardous conditions.

The vast majority of parents do not understand that a common prospective memory failure could lead to them inadvertently leaving a child in a hot car. However, over twenty-five percent of US parents with children under three years of age acknowledge that at some point, they have lost awareness of the presence of a child in the back seat of the car.[16] While driving a child, it is common for parents to think about other people and situations, especially when their child is quiet or sleeping. In the case of PVH, as thoughts shift during the drive, a prospective memory failure leads the parent to miss the planned action of dropping off their child.

In PVH, when asked to recount the events of their day, parents often report changes in their normal routines. Changes like taking a new route to work, getting an unexpected phone call, or not normally being the one to drop off the child can cause inattentional blindness (i.e., not perceiving something that is in plain sight) and the memory failure leads to the parent losing hold of the plan to drop off the child. This scientific anomaly of PM failure also explains why parents, who have unwillingly left their child in a car, went about their routine activities as the habit memory suppressed the prospective memory.[17] When the brain creates a 'false memory', parents can become oblivious to the fact that their child remains in the hot car all day.

QUICK FACTS

- Research shows that 60% of adults have experienced different types of memory distortions
- A vast majority of the parents aren't taking action to prevent leaving a child unknowingly in the car
- Over 50% PVH fatalities happened to children unknowingly left by a parent or a caregiver
- Pediatric vehicular heatstroke is one of the leading causes of nontraffic non-crash child fatalities in the United States

FALSE MEMORIES

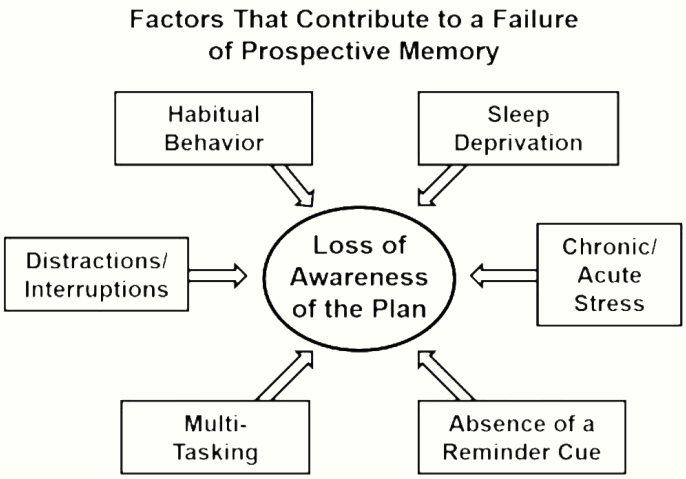
False memories have intrigued cognitive psychologists for nearly a century. Multiple types of research show that a high number of people create false memories in associative memory tests in both clinical and non-clinical environments.

In a clinical environment, the Deese–Roediger–McDermott[18][19][20] (DRM) paradigm is most commonly used when studying false memories. In this approach, people are given a list of words that share a common theme such as 'school' (e.g. desk, education, locker, learning, recess, etc.). The list, however, lacks a word that is common and semantically related to the theme, such as 'teacher'. When people are queried as to which words were on the list, a high percentage of people falsely 'recall' that the word 'teacher' was on the list. Hence, the assumption that 'teacher' was on the list becomes a false memory.[21] Based on some reports in similarly conducted studies, up to 70% of the participants will recall or recognize the 'false' word with the same probability as the words which appeared in the middle of the study list.[22]

In a non-clinical setting, false memories have been reported by people in multiple different settings from everyday tasks to worklife and childcare**.** For example, a person who realizes at lunchtime that they do not have their lunch bag at work even though they can clearly picture themselves grabbing it off the kitchen counter at home, has created a false memory. Or, a person who imagines sending a quick email to a friend and then later when the friend asks why there was no reply, the person feels puzzled because they clearly 'remember' sending it. In a survey conducted in 2018 by the Sofia Foundation, 93% of adults report having had these types of false memory formations at some point in their lives.[23] Although most people have experienced the strange feeling of a false memory, many do not realize how this common phenomenon can put them at risk to misremember the drop off of a child.

People may be at particular risk for developing false memories of dropping their child off when their normal routines change, when the order of performing a task changes, or when the task gets interrupted by something that does not usually happen. Even simple interruptions such as a road accident, a phone call, or an unusual stop can cause a person's brain to lose hold of the planned action (drop-off). Afterwards, it is extremely easy for the brain to check off the missing step as completed because the imagined event is mistaken for an actual event. In terms of pediatric vehicular heatstroke, parents and caretakers have universally reported being certain they had taken the child to the target location, typically home or daycare. The DRM paradigm helps to clinically explain how these false memories can occur to anyone and all of us are vulnerable to them. Therefore, parents who forget children in cars because of an assumption that they took the child to daycare becomes a false but seemingly very real memory.

Our brains are very efficient at carrying out routine behaviors with little thought. We form memories based on the associations of previous days and the similarity of other corresponding events. It is a daily occurrence that habit memory will prevail over the prospective memory, which can lead to creating a false memory that can put all children at risk of PVH.



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MULTITASKING AND DISTRACTION AS CONTRIBUTING FACTORS

In the field of neurobiology, PM failures are often identified when the brain structures are in a mode of competing with each other. Trying to focus on more than one task at a time is commonly referred to as multitasking. However, multitasking is a myth.[24] In reality, the human brain is not capable of performing two tasks at the same time. Instead, the brain handles tasks sequentially, switching between one task and another.[25] In extreme examples, multitasking and changes in habitual patterns contribute to catastrophic memory errors, as the brain can lose its awareness rapidly.[26]

In a 2003 study, researchers noted that PM failures were most likely to occur in times of transition, typically when a person leaves one environment to go to another (e.g. when leaving from home to go to work).[27] This study reported that PM failures were at their highest rate of occurrence when people were 'preoccupied' with another action or focused on various different environmental factors.

These findings are consistent with the literature demonstrating that stress, distractions and interruptions, as well as simply processing ongoing yet intervening events, are all potential causes for errors in prospective memory. One study shows that even mild distractions contribute to memory failures[28] Forgetting one's intentions in a demanding situation can happen in a matter of seconds, and a person's awareness of an intention can be lost in response to a distracting stimulus.[29]

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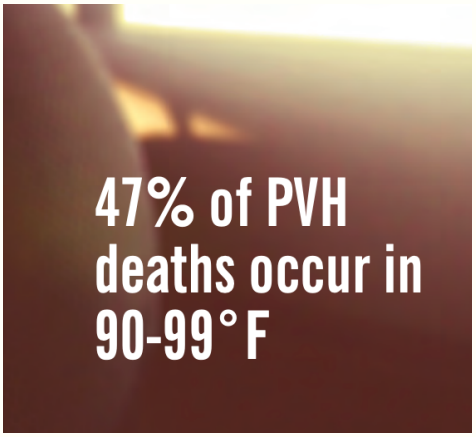
EFFECTS OF SLEEP DEPRIVATION ON PROSPECTIVE MEMORY

Multiple studies in the field of human health have shown that sleep loss impacts basic elements of cognitive function. Not getting an adequate amount of sleep increases failures to carry out intended actions, which may have severe consequences to safety-critical situations.[30] Reports show that particular elements, such as experience of attention – selectively concentrating on a discrete aspect of information – deteriorate as a result of sleep deprivation. Ultimately failures in attention can lead to a loss of awareness of future intentions.

Sleep loss and the associated complex memory processing errors can increase the occurrence of false memories. When a person is sleep-deprived the brain's ability to form accurate and real associations deteriorates and instead the mind 'fills in gaps' with the information it retrieves from similar situations in the past.[31] Differentiating with false formation of memories and natural associative processes is, therefore, not always easy, especially when fatigued.



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THE ROLE OF EDUCATION AND INFORMATION

ItTThe Bag in the Back campaign is designed to raise awareness of how prospective memory failures can lead to children dying from pediatric vehicular heatstroke. The campaign's primary goal is to provide a comprehensive but targeted approach to inform and educate the general public about PVH. When parents and caregivers realize they are at risk of experiencing a catastrophic memory failure, they are more likely to take preventive measures to make sure they do not inadvertently leave a child in the car.

By providing accurate and up-to-date information, the campaign hopes to reduce stigma around prospective memory failure and childcare, and to provide a safe space for parents and caretakers to discuss the topic of PVH freely.

Parents look to experts for guidance on safety practices, especially in areas where they may not be well-informed. Because there are many misconceptions (e.g., "I could never forget my child because she is my highest priority."), it is particularly important for safety information about PVH to be included as part of a prenatal workshops, postpartum education, and routine visits to the pediatrician's office.

HOW TO TALK ABOUT PVH WITH PARENTS

Parents can be educated about PVH. It is well documented that we are all at a high risk of vulnerability to memory errors and studies show that a high percentage of parents, both in the United States and elsewhere, report incidences where they have lost awareness of children in the back seat of their cars. Previous research confirms that the leading cause of death for children left unattended in motor vehicles is stroke and hyperthermia.[32]

Because the role of common memory failures are misunderstood, there is often great outrage from the public when a child is left to die in a hot car. The occurrence of PVH is seen as a result of negligence and parents and/or caretakers may be charged with crimes.[33] This often leads to perpetuating the myth that PVH only happens to 'bad' parents. As a result this topic is highly stigmatized and parents are not likely to adopt essential safety practices that could prevent leaving a child unknowingly in the car. A strong education program can be a way of disseminating information about PVH. If parents hear from trusted sources that PVH is a real risk and that it can be prevented by taking simple precautions, deaths from PVH will be reduced.

HOW DOES THE CAMPAIGN WORK?

The Bag in the Back campaign promotes a simple but smart way to avoid a preventable tragedy, encouraging parents and caregivers to develop a habit of putting a bag or a personal item in the back seat so that, every time they leave their vehicle, they are forced to open the back door to retrieve the item. In the event that a parent has lost awareness of the child through a PM failure, they are likely to see the child when they access the back seat.

WHO IS THE TARGET AUDIENCE?

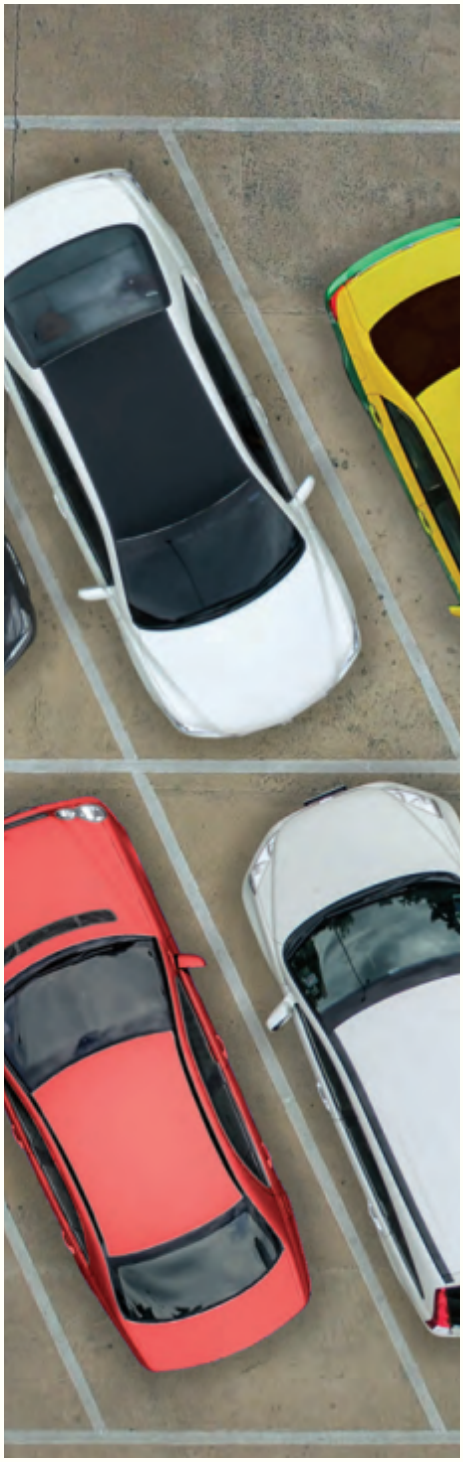
Ultimately The Bag in the Back campaign is targeting parents and caregivers of 0–12 year-old-children. However, the campaign recognizes the difficulties in getting the message to such a wide audience. Parents have reported that knowledge about PVH through public service announcements and public health campaigns is not reaching them adequately.[34] Caregivers and parents would benefit from this information coming through more personal channels. Therefore, this paper is aimed towards pediatric doctors, childcare practitioners and daycare providers who routinely share important safety information with parents. Additionally, PVH prevention measures in the workplace could be implemented through an employer's health and safety program and/or their employee wellness programs.[35]

CONCLUSION

In 2019, 53 children in the U.S. died in a hot car.[36] Albeit global pandemic decreased the numbers of PVH fatalities about 38%, the long term patterns of these tragedies stayed alarmingly similar; most pediatric vehicular heatstrokes tend to occur in the southern states of the United States (such as Texas and Oklahoma) and most still happen because parents either unknowingly or knowingly leave their children in stationary vehicles.[37]The unusual year of Covid-19 did not link PVH to memory loss as often as in previous years, primarily because the patterns of daily-routines changed; frequent driving decreased and schools and daycares were closed.[38]However, all vehicle hypothermia is preventable, and part of the PVH awareness campaign emphasizes that all parents are at risk at all times of leaving a child behind in the backseat of a car.

Science has proven countless times that the human brain is capable of memory failures, including skipping planned actions and creating false memories. A caregiver can easily believe their child is safe at school, home or daycare when they have, in fact, been left in the back seat of a parked vehicle. Stress, sleep deprivation, and habit memory are very capable at overriding short-term memory and forming associations with correlating and semantically close-related events and these stress-related memory loss incidents are particularly expected to increase after home restrictions are lifted.

By sharing stories and having a platform to discuss these issues, awareness can lead to the adoption of life-saving practices. The Bag in the Back is a simple and efficient way forward and can prevent countless tragedies in the future.



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APPENDIX 1.

	All				Child 3 years or younger		
	Base	# Yes	% Yes		Base	# Yes	% Yes
Told someone something	949	590	62%		512	318	62%
Taken your vitamins or medication	949	480	51%		512	257	50%
Locked your house	949	474	50%		512	240	47%
Sent an email / called someone	949	430	45%		512	219	43%
Put food in the refrigerator	949	391	41%		512	218	43%
Paid a bill	949	391	41%		512	191	37%
Brought your lunch, computer or something else you needed for work	949	365	38%		512	193	38%
Turned off the oven, a burner, the iron or other fire hazard	949	347	37%		512	169	33%
Closed the garage door	949	340	36%		512	177	35%
Removed your keys from the car	949	297	31%		512	155	30%
Removed food from the microwave	949	262	28%		512	154	30%
Removed groceries from the car	949	198	21%		512	92	18%
Locked your desk / office	949	119	13%		512	63	12%
Set the alarm on your house	949	117	12%		512	53	10%
Picked up or dropped off your child	949	37	4%		512	15	3%
Removed your child from the car	949	21	2%		512	12	2%
Removed your pet from the car	949	8	1%		512	3	1%
No, none of these	949	71	7%		512	37	7%

Survey by The Sofia Foundation 2018.

RESOURCES

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2. http://www.kidsandcars.org/wp-content/uploads/2020/01/airbag_vs_heatstroke_EN.pdf
3. https://www.noheatstroke.org/NSC-Hot-cars-report.pdf
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ADDITIONAL RESOURCES

- National Safety Council nsc.org/heatstroke
- National Highway Traffic Safety Administration:
- nhtsa.gov/heatstroke
- San Jose State University NoHeatstroke.org
- American Academy of Pediatrics HealthyChildren.org
- Safe Kids Worldwide safekids.org/take-action-prevent-heatstroke
- KidsandCars.org
- kidsandcars.org/how-kids-get-hurt/heat-stroke
- Rayrayspledge.com rayrayspledge.com/Ray-Ray-s-Call-to-Action
- Road to Zero
- nsc.org/RoadtoZero