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Automobile Fires in the U.S.: 2006-2010 Estimates

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Keywords: fire statistics, automobile fires, fire risk

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ABSTRACT

Automobile fires account for the majority of vehicle fires and vehicle fire deaths. It is necessary to address automobile fires if major reductions are to be seen in the overall vehicle fire problem. Any efforts to evaluate the merits of proposed fire safety improvements require an understanding of how many fires and deaths are presently occurring and how many might be prevented with the proposed improvements. In this paper, data from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) fire department survey were used to estimate the frequency and associated losses of automobile fires attended by local U.S. fire departments, and the major factors in these fires and losses. The risk of automobile fires, associated deaths overall and from fires resulting from collision or overturn per billion kilometers driven are also included. The majority of automobile fires resulted from mechanical or electrical problems, but three out of every five automobile fire deaths resulted from fires started by collision or overturn.

KEYWORDS: automobile fires, fire statistics, fire risk

INTRODUCTION

During 2006-2010, U.S. fire departments responded to an average of 152,300 automobile fires per year, resulting in annual averages of 209 civilian deaths, 764 civilian injuries, and $536 million (US) in direct property damage. Table 1 shows that automobiles accounted for two-thirds (68%) of reported road vehicle fires and 63% of the associated deaths. In addition to automobiles, road vehicle fires include other types of passenger road vehicles, such as buses, recreational vehicles and motorcycles, and freight road transport vehicles, such as trucks.

Overall, automobile fires accounted for 10% of all reported U.S. fires (excluding those handled by private, state or federal firefighting agencies) and 6% of the associated fire deaths. During this period, there were 1.4 fire deaths per 1,000 reported automobile fires. With almost 131 million automobiles registered in the U.S. during 2010 [1], these vehicles are essential to getting people where they need to go. In most years, more people are killed by automobile fires than by non-residential structure fires. [2] While progress has been made, there is more to do. It is necessary to understand the causes and circumstances of these fires in order to develop sound strategies to prevent these fires and losses. These factors, as well as fire and loss rates based on distance travelled, fire department response times, and automobile fire and fire death trends are discussed. Data issues and limitations are also addressed.

METHODOLOGY

This paper focuses on automobile fires reported to local (municipal or county) fire departments in the U.S. National estimates of fires and associated losses were calculated using the detailed data and data classification system from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) [3] and the National Fire Protection Association's (NFPA's) fire department experience survey following the general procedures described by Hall and Harwood. [4] Fire departments

throughout the U.S. use NFIRS to document their incidents. Generally, state fire authorities administer the NFIRS program for their state, providing training, support and quality control. States set their own reporting requirements, ranging from mandatory for all incidents, to mandatory for incidents meeting a loss threshold to completely voluntary. Participation in NFIRS is voluntary at the federal level. Note that fires that are reported to federal, state or private firefighting organizations are not captured in NFIRS. Fires that are handled without fire department assistance are also not captured.

Table 1. Road vehicle fires reported in the U.S., by vehicle type: 2006-2010 annual averages

Vehicle type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions US)	
Passenger road vehicles	202,800	(91%)	277	(84%)	1,077	(88%)	$776	(76%)
Automobile, passenger car, ambulance, race car or taxi-cab	152,300	(68%)	209	(63%)	764	(63%)	$536	(52%)
Unclassified passenger road vehicle	41,200	(18%)	56	(17%)	173	(14%)	$144	(14%)
Motor home, camper mounted on pickup	2,700	(1%)	5	(2%)	60	(5%)	$45	(4%)
Bus, school bus or trackless trolley	2,100	(1%)	0	(0%)	22	(2%)	$29	(3%)
Motorcycle or trail bike	1,600	(1%)	3	(1%)	19	(2%)	$5	(0%)
Off-road recreational vehicle	1,300	(1%)	1	(0%)	10	(1%)	$4	(0%)
Towable travel trailer	1,300	(1%)	3	(1%)	23	(2%)	$11	(1%)
Collapsible camper trailer	200	(0%)	0	(0%)	4	(0%)	$1	(0%)
Portable building or manufactured home	200	(0%)	0	(0%)	2	(0%)	$2	(0%)
Freight road vehicles	20,500	(9%)	52	(16%)	144	(12%)	$250	(24%)
Semi-trailer, with or without tractor	5,900	(3%)	23	(7%)	38	(3%)	$92	(9%)
General use truck	4,600	(2%)	7	(2%)	32	(3%)	$39	(4%)
Unclassified freight road vehicle	4,600	(2%)	10	(3%)	30	(2%)	$68	(7%)
Pickup truck or hauling rig	3,000	(1%)	6	(2%)	23	(2%)	$14	(1%)
Garbage, waste or refuse truck	1,700	(1%)	0	(0%)	9	(1%)	$18	(2%)
Tank truck for flammable or combustible liquid	400	(0%)	4	(1%)	10	(1%)	$13	(1%)
Tank truck for nonflammable cargo	300	(0%)	2	(1%)	1	(0%)	$4	(0%)
Tank truck for compressed or LP-gas	100	(0%)	0	(0%)	1	(0%)	$1	(0%)
Total	223,300	(100%)	329	(100%)	1,221	(100%)	$1,025	(100%)

NFPA's survey solicits summary data about major categories of fires and other incidents from all local U.S. fire departments protecting populations of at least 50,000 and a random sample, stratified by population, of smaller departments. Because a statistical sample is used, it is possible to estimate the total number of reported fires and losses. Estimated total vehicle fires and losses from each year's NFPA survey are divided by the total vehicle fires and losses in NFIRS to create scaling ratios. NFIRS query results are multiplied by these scaling results to estimate the frequency of specific factors associated with vehicle fires or losses. The same approach is used with residential and non-residential structure fires, and outside or unclassified fires. Separate ratios are calculated for fires, civilian deaths, civilian injuries, and direct property damage.

Query criteria

In this analysis, automobile fires were identified by using the entire range of NFIRS vehicle fire incident types (130-139) and mobile property type 11 - automobile, passenger car, ambulance, race

car or taxi-cab. Unclassified passenger road vehicles and pick-up trucks or hauling rigs were excluded. Only data originally collected in Version 5.0 of NFIRS were analyzed. Fires in which mutual aid was given were excluded. Vehicle fires inside structures that involved the structure are considered structure fires and not included here. Only casualties caused by the fire are considered fire casualties. Trauma-only casualties should, by NFIRS and NFPA definition, be excluded. Over the five-year period of 2006-2010, *raw* NFIRS data contained a *total* of 446,926 automobile fires that meet these criteria, with 884 civilian deaths, 1,754 civilian injuries, and $1,371,288,438 in direct property damage.

Handling unknown or missing data in NFIRS

For NFIRS fields other than incident type and property use, unknown or missing data were allocated proportionally. A proportional share of vehicle fires in which the mobile property involved in ignition as coded as none were treated as unknown and included in the estimates. "None" was also treated as unknown in the factor contributing to ignition field

Distance data

Data from the U.S. National Highway Traffic Safety Administration (NHTSA) were used to calculate event rates based on kilometers driven. [5] Because the data on kilometers (converted from miles) driven in 2009 were not shown separately for automobiles, annual averages for 2006-2008 were used in calculations involving distance travelled. Risk relative to exposure is useful for setting priorities and tracking progress.

CAUSES AND CIRCUMSTANCES OF AUTOMOBILE FIRES

A number of factors influence the outcome of a fire. The location of the fire can affect the likelihood of prompt discovery, fire department notification and timely fire department response. Some types of fires have a higher risk of death than others. The area of the vehicle where the fire originates also matters.

Where do automobile fires occur?

Roughly three-quarters (71%) of automobile fires and associated deaths (76%) occurred on highways, streets or parking areas. While only 17% of the fires occurred on highways or divided highways, Figure 1 shows that these fires caused 41% of the associated deaths.

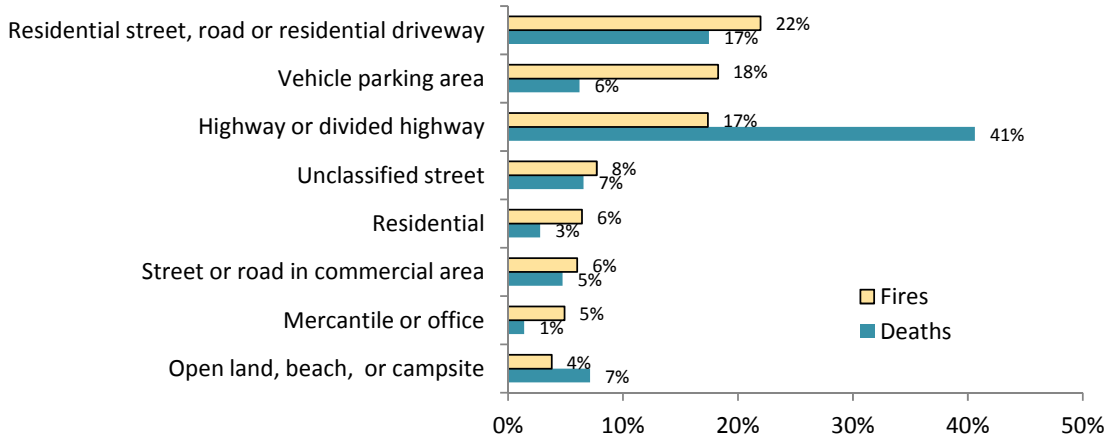

Figure 1. Automobile fires, by leading location where fire occurred: 2006-2010

Table 2 and Figure 2 show the major causes of automobile fires. These causes were pulled from three NFIRS fields: cause of ignition, factors contributing to ignition, and heat source. The major casual

factors describe specific scenarios. Because the field for factor contributing to ignition allows multiple entries and calculations were done separately for each field, double-counting is possible.

What are the leading causes of automobile fires?
Some type of a mechanical failure or malfunction was a factor on almost half (45%) of automobile fires and 11% of the associated deaths. Mechanical failures may be due to leaks or breaks, worn out parts, backfires, or similar issues. Electrical failures or malfunctions were factors in one-quarter (24%) of the fires, but only 1% of the deaths.

Table 2. Automobile fires, by major causal factors: 2006-2010 annual averages

Causal Factor	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions US)	
Mechanical failure or malfunction	69,100	(45%)	22	(11%)	217	(28%)	$201	(38%)
Electrical failure or malfunction	35,800	(24%)	2	(1%)	113	(15%)	$105	(20%)
Intentional	15,900	(10%)	23	(11%)	44	(6%)	$112	(21%)
Exposure fire	8,200	(5%)	3	(1%)	14	(2%)	$47	(9%)
Collision or overturn	5,700	(4%)	125	(60%)	144	(19%)	$38	(7%)
Smoking materials	2,700	(2%)	8	(4%)	31	(4%)	$11	(2%)

While collisions or overturns were factors in only 4% of the automobile fires, these incidents caused three of every five (60%) automobile fire deaths. More than half (57%) of the automobile collision fire deaths resulted from fires on highways or divided highways, suggesting that these situations are more likely to occur where travel speeds are higher.

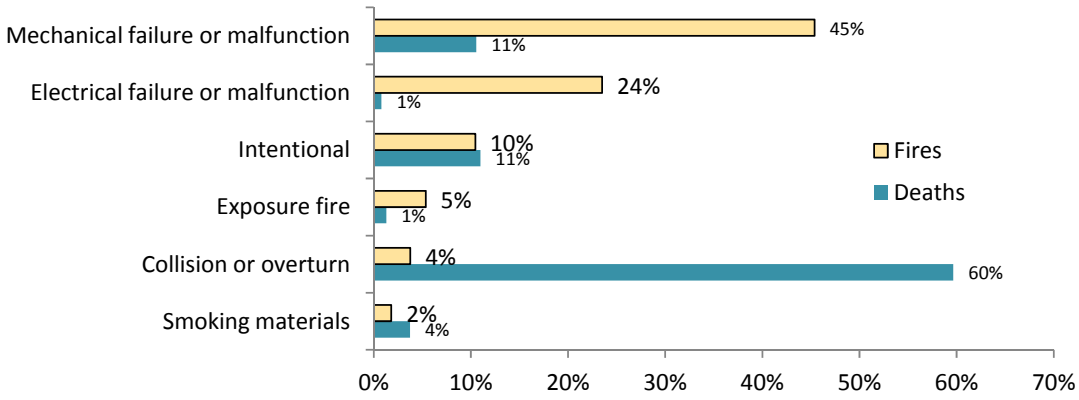

Figure 2. Automobile fires, by major causal factors: 2006-2010

Ten percent of automobile fires were intentional; these incidents caused 11% of the deaths. Intentional fires are excluded from the remainder of the analysis of causal factors. Because the NFIRS field "cause of ignition," includes unintentional, equipment or heat source failure, and act of nature as separate code choices, the term "non-intentional" will be used to describe all fires that were not intentionally set. During 2006-2010, fire departments responded to an estimated annual average of 136,400 non-intentional automobile fires, resulting in an average of 186 civilian deaths, 720 civilian injuries, and $424 million (US) in direct property damage per year.

How is the area of fire origin related to the cause of non-intentional automobile fires?
Table 3 and Figure 3 show that two-thirds (69%) of the non-intentional automobile fires began in the engine or running gear area, resulting in two of every five (39%) deaths. Because of their dominant share, leading factors are very similar to overall automobile fires.

Figure 4 shows the leading causal factors for non-intentional automobile fires that started in: the engine area, running gear or wheel area; the passenger area; and the fuel tank or fuel line. Figure 5 shows comparable data for automobile fire deaths. Collisions or overturns ranked first among the causal factors for deaths resulting from fires in all three areas.

Table 3. Non-intentional automobile fires, by area of origin: 2006-2010 annual averages

Area of Origin	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions US)	
Vehicle engine area, running gear or wheel area	93,600	(69%)	72	(39%)	368	(51%)	$265	(62%)
Passenger area of vehicle	16,600	(12%)	31	(16%)	132	(18%)	$64	(15%)
Unclassified vehicle area	9,100	(7%)	39	(21%)	54	(7%)	$32	(7%)
Cargo or trunk area of vehicle	4,100	(3%)	3	(2%)	40	(6%)	$13	(3%)
Exterior surface of vehicle	3,500	(3%)	3	(2%)	19	(3%)	$11	(3%)
Unclassified area of origin	2,600	(2%)	3	(1%)	5	(1%)	$7	(2%)
Vehicle fuel tank or fuel line	2,100	(2%)	29	(15%)	72	(10%)	$10	(2%)
Other known area	4,600	(3%)	7	(4%)	30	(4%)	$23	(5%)
Total	136,400	(100%)	186	(100%)	720	(100%)	$424	(100%)

Mechanical failures or malfunctions caused three of every five (60%) of the fires beginning in the engine or running gear areas. Electrical failures or malfunctions were factors in one-quarter (24%) of the fires in these areas.

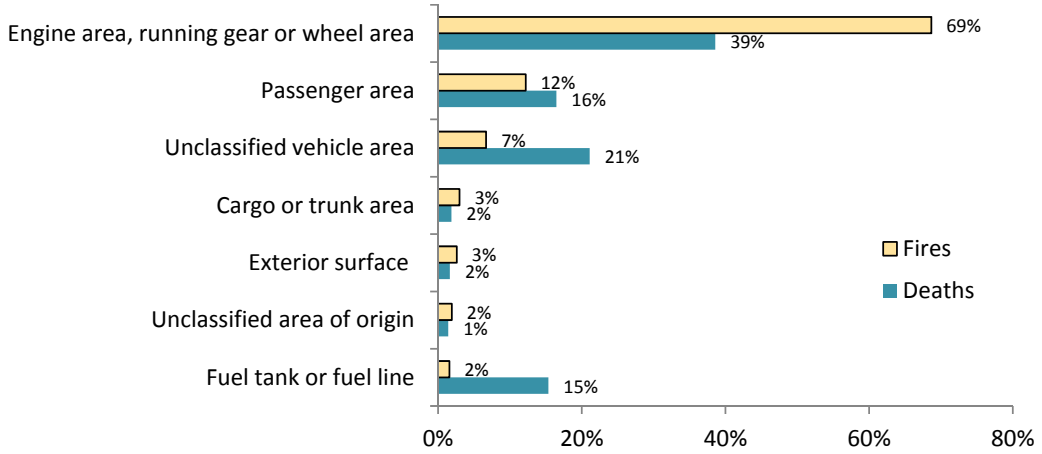

Figure 3. Non-intentional automobile fires by leading areas of origin: 2006-2010

The 12% of non-intentional automobile fires that began in the passenger area caused 16% of the fatalities. Electrical failures or malfunctions were factors in half (49%) of the fires originating in the passenger area, and mechanical failures or malfunctions were factors in 15%. Smoking materials started 8% of the passenger area fires.

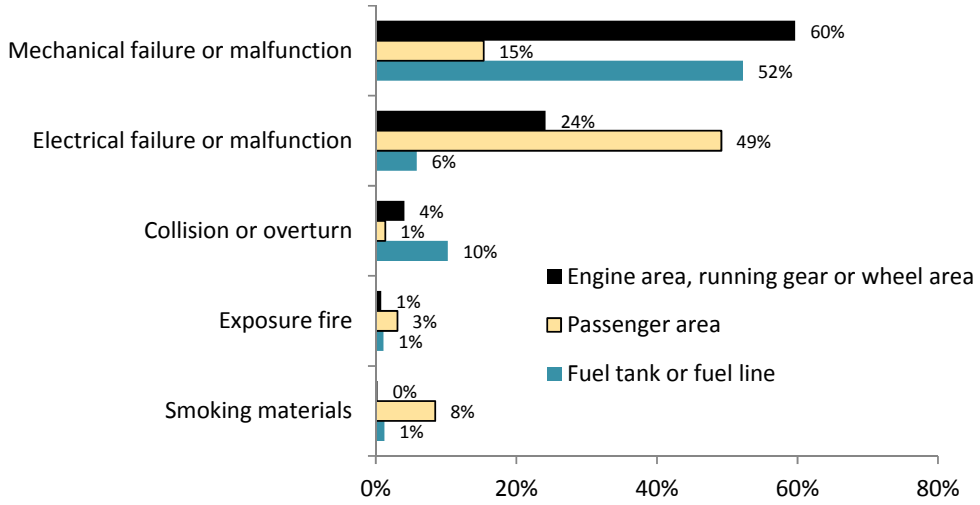

Figure 4. Non-intentional automobile fires, by major causal factors and area of origin: 2006-2010

Only 2% of automobile fires originated in the fuel tank or fuel line, but these fires caused 15% of the associated deaths. Mechanical failures or malfunctions were factors in half (52% of these fires) and one in five (19%) of these deaths. Leaks or breaks dominated the mechanical failure or malfunction category, accounting for one-third (32%) of the fires originating in the fuel tank or fuel line.

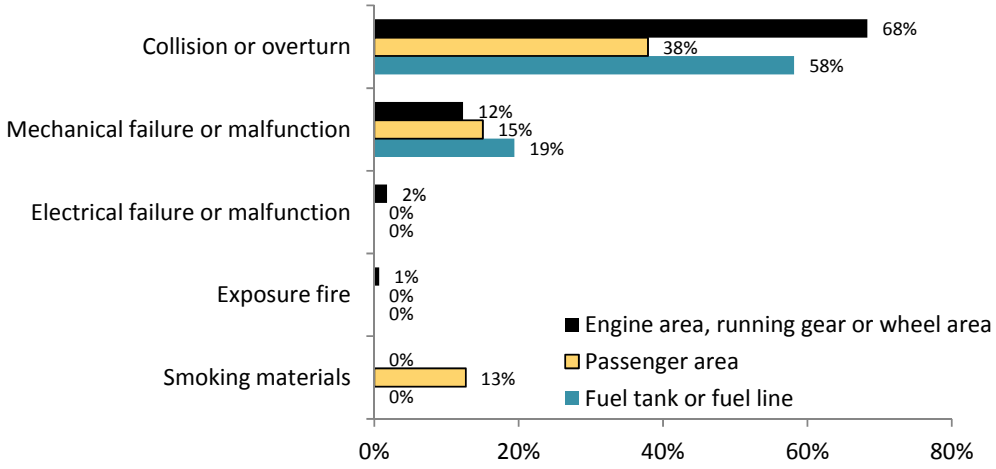

Figure 5. Non-intentional automobile fire deaths, by major causal factors and areas of origin: 2006-2010

FIRE DEPARTMENT RESPONSE TIME TO AUTOMOBILE FIRES

The time between fire occurrence and the arrival of help can play a role in the outcome. Unfortunately, most vehicles do not have a mechanism to record when a fire starts. Some fires, particularly those in rural areas, are not discovered immediately. Figure 6 shows that the response time calculated as the time elapsed between the time the alarm was received by the fire department and the time the first responding unit arrived on scene. This was calculated for all automobile fires (both intentional and non-intentional) reported in 2006-2010.

Response time was less than five minutes in 39% of the automobile fires and 22% of the deaths. The first firefighters arrived in less than 10 minutes in 85% of the fires and 71% of the deaths. Response times of ten minutes or less were seen in 82% of the automobile fires resulting from collisions or

overturn and 64% of the associated deaths. Additional time may be spent in handling a call at a public safety answering point before the call is transmitted to the fire department.

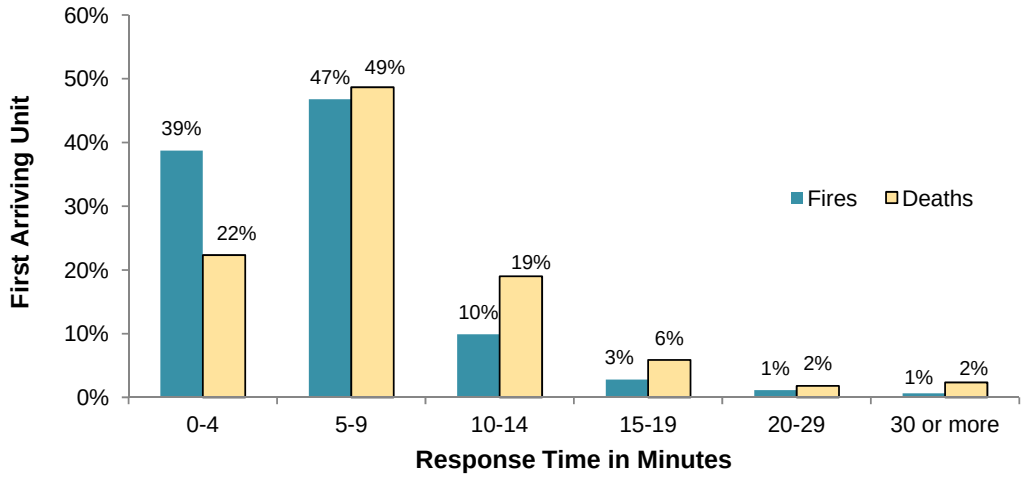

Figure 6. Reported automobile fires (all causes), by response time for first arriving unit: 2006-2010

TRENDS

While automobile fires and associated losses still occur with distressing frequency, considerable progress has been made. The trend analysis includes both intentional and non-intentional fires. Figures 6 and 7 show that after a generally consistent downward trend, the numbers of reported automobile fires and associated fire deaths respectively were 42% and 49% lower in 2010 than in 2002. In contrast, total fires and fire deaths were only 21% and 8% lower, and structure fires and associated deaths were only 7% and 1% lower. [6]

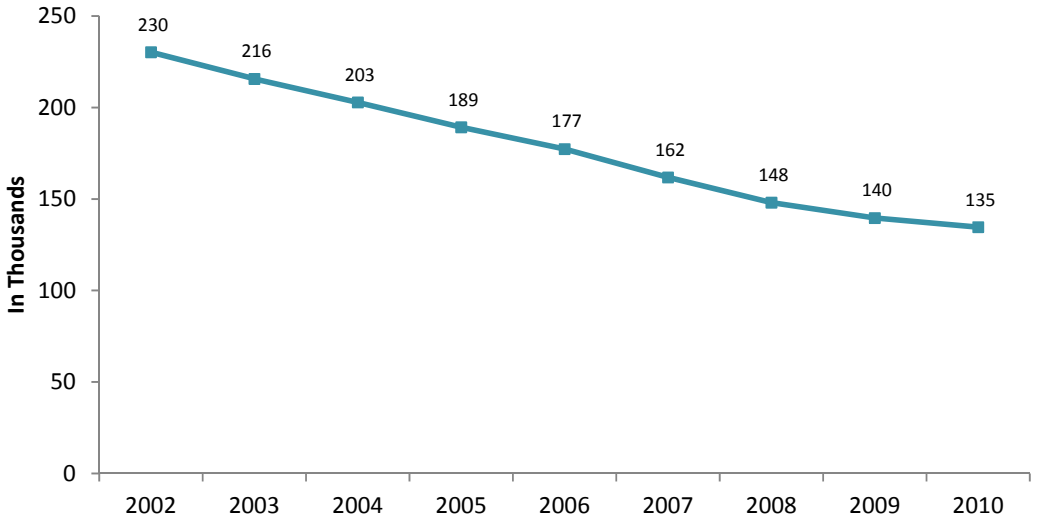

Figure 6. Reported automobile fires (all causes) by year

Despite the decreases in automobile fire deaths, Figure 7 shows that in recent years, automobile fires have killed more people per year than were killed in non-residential structure fires. [2]

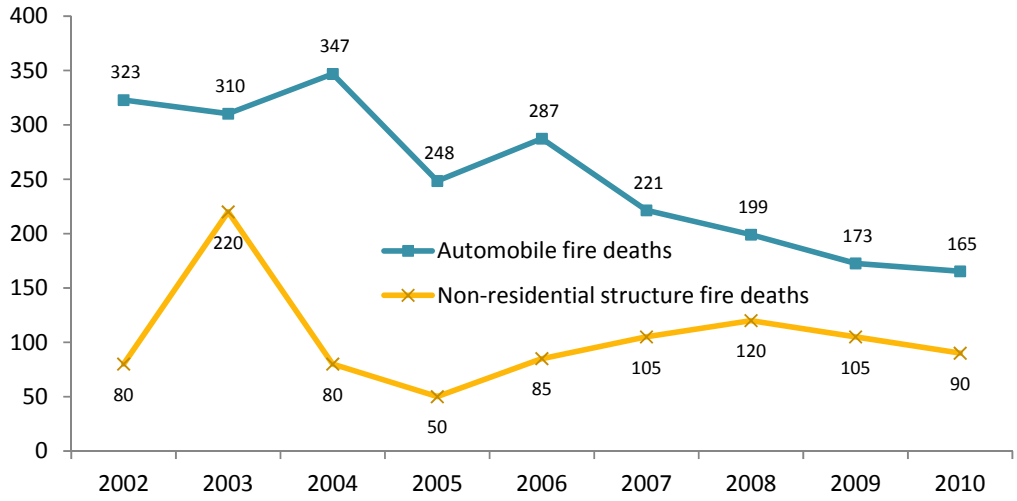

Figure 7. Reported automobile and non-residential fire deaths by year

RISK BASED ON DISTANCE TRAVELLED

Although automobile fires accounted for 11% of reported US fires and 7% of fire deaths during 2006-2010, the risk of such an event is low in terms of the distances driven. The Federal Highway Administration published data on distances travelled. [7] Data specifically for automobiles was provided through 2008. In later years, the vehicle groupings were modified. From 2006-2008, U.S. automobiles were driven an average of 2,666 billion kilometers (1,657 million miles).

Based on 2006-2008 NHTSA data with the 2006-2010 automobile fire estimates, for every billion kilometers driven, there were

- 57 automobile fires,
- 0.08 automobile fire deaths,
- 35 non-intentional fires that began in the engine or running gear area,
- six non-intentional fires that began in the passenger area,
- two fires resting from collision or overturn, and
- 0.05 deaths from fires resulting from collision or overturn.

DATA LIMITATIONS AND ISSUES

Unknown or missing data are assumed to resemble known data.

The fire statistics in this analysis are estimates. In scaling up based on the NFIRS data and in allocating unknown data proportionally, it is assumed fires that had unknown or missing data or were not reported to NFIRS would resemble the fires with reported, usable available data. Table 4 shows that the proportion of unknown or missing data varies considerably by field.

For less common events, smaller numbers can result in more volatility/

The lack of complete data becomes a more serious issue when numbers are smaller. Automobile fire deaths and injuries are much less common than automobile fires. Fires caused by collisions or overturns are much less common than those caused by mechanical or electrical failures or malfunctions. The general patterns have been consistent over time but some volatility is likely due to the smaller numbers involved.

Table 4. Incidents in which the data was unknown, undetermined, left blank, or coded as "none:" 2006-2010

Area of Origin	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage
Mobile property type (all vehicles)	6%	3%	4%	10%
Cause of automobile fire	31%	39%	25%	34%
Factor contributing to automobile fire	58%	47%	43%	59%
Heat source in automobile fire	51%	54%	40%	55%
Area of origin in non-intentional automobile fire	12%	24%	6%	13%

NFIRS describes all types of fires and has limited vehicle-specific choices.
The NFIRS data system is used to describe all types of fires. It has a limited number of code choices that specifically relate to vehicles. Individual codes, such as area of origin code 83 – engine area, running gear or wheel area, cannot be broken down further. Very specific information about specific parts (e.g., spark plug, drive-belt, catalytic converter) involved in the ignition is generally not captured or identifiable in the coded data. Nor is the information linked to police reports or service records. The national NFIRS database does not contain information about rate of speed, vehicle inspection status, last time the vehicle was serviced, after market modifications or non-standard parts.

Although estimates of alternate fuel vehicle fires are not possible, other approaches can be used.
Vehicle power source data is also not captured. This has been particularly frustrating to those interested in tracking possible fire risks associated with vehicles using alternate fuels or power sources. Even if NFIRS had that capability, it is unlikely that the meaningful data could be available on electric vehicles until more are on the road Table 5 shows the technology type used by automobiles on the road in 2009 and 2010. [8] In both years, alternate-fuel automobiles accounted for only 1% of the cars in use.

Table 5. Technology type used in car stock in the U.S. in 2009 and 2010. [8]

Technology Type (in millions)	2009	2010
Conventional automobiles	**128.74**	**126.20**
Gasoline	128.12	125.47
Diesel	0.62	0.73
Alternate fuel automobiles	**3.18**	**3.58**
Ethanol-flex fuel	1.71	1.88
100 mile electric vehicle	0.01	0.01
Electric-gasoline hybrid	1.32	1.55
Compressed natural gas	0.03	0.03
Compressed natural gas bi-fuel	0.05	0.05
Liquefied petroleum gas	0.02	0.02
Liquefied petroleum gas bi-fuel	0.03	0.03
Total automobile stock	**131.91**	**129.77**

Roughly 140,000 automobile fires were reported in 2009 and 135,000 in 2010. That translates to rates of one automobile fire for every 945 and 964 automobiles per year, respectively, or rates of 1,035-1,060 automobile fires per million automobiles. Estimates of conventional types of automobile fires or fires associated with other uses of similar technology can be used to develop likely fire scenarios.

Investigations of any fires that do occur can also provide valuable information. Laboratory tests can then be used to better predict the risks.

Even with the limitations discussed above, NFIRS provides sufficient detail to identify general problem areas that warrant further research and to provide general guidance to the public, manufacturers, and policy makers about how these fires might be prevented.

Anyone who works with databases from different organizations knows that scope, definitions, and sources vary based on the mission and priorities of each organization. Consequently, results may differ. Each year, the National Highway Traffic Safety Administration's *Traffic Safety Facts* series, contains a table indicating the number of crashes with fire involved. In 2009, they reported 6,000 passenger car crashes with fire involved, including 527 fatal crashes. [9] Overall, 0.1% of the crashes involved fire, but fire occurred at 2.9% of the fatal crashes. NHTSA's estimate of the number of fire-involved crashes (or collisions or overturns in this study) is fairly consistent with NFPA's. The victim total in their analysis is much higher because they also include people who died of trauma instead of fire-related injuries only. NHTSA estimates benefit from law enforcement detail and more information about the nature of any impacts. However, NHTSA collects far less information on circumstances specific to fires.

CONCLUSIONS

While the risk of automobile fires and associated deaths is low in terms of the distance driven and progress has been made in reducing the number of automobile fires and associated deaths, more needs to be done. Losing roughly 200 people annually to these fires is unacceptable. When an automobile burns, necessary transportation is often destroyed.

Estimates derived from NFIRS and NFPA's annual fire department survey show that the majority of automobile fires are due to mechanical or electrical problems, but three out of automobile fire deaths are due to fires that result from collisions or overturns. Research should focus on improving design to reduce the likelihood of mechanical and electrical failures over the life of the vehicle and of reducing impact-caused fires.

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