Vision 20/20

The Smoke Alarm Problem

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About Vision 20/20

Started in 2006, Vision 20/20 is a collaborative project that brings together national fire safety organizations and experts to help address the gaps in fire prevention. With funding from the Department of Homeland Security Fire Prevention and Safety Grant program, as well as additional funding from private sources, Vision 20/20 has become a focal point working on identifying problems in the effective delivery of fire prevention and safety and developing strategies to address these issues.

Since its inception, Vision 20/20 has helped to foster discussion and innovation through a series of seminars and symposiums that bring together fire safety practitioners to share information and knowledge. In addition, Vision 20/20 has been instrumental in helping to develop effective strategies used in Community Risk Reduction programs across the nation.

Vision 20/20 is led by a Steering Committee that represents a number of national organizations focused on different aspects of fire prevention and safety. This diversity plays a major role in the success of Vision 20/20's efforts, programs and projects. More information, including reports, videos and presentations, is available at Vision 20/20's web site www.strategicfire.org and Vision 20/20 can be followed on Facebook at www.facebook.com/strategicfire and Twitter @strategicfire.

About this Study

This study was generated from a desire to better understand the scope and nature of smoke alarm use in the United States. It is influenced by national reports on the topic, and combined with experience from the many field programs on community risk reduction efforts undertaken as part of the Vision 20/20 Project. When 2/3 of people dying in home fires do so where smoke alarms are either not present or not working, we clearly have a problem-a problem with getting homeowners to install enough smoke alarms to adequately protect their homes, and to maintain them in working order. This is a problem that was identified as a priority in the original Vision 20/20 plan in 2008.

In order to move forward with specific actions to improve the number of homes with working smoke alarms, we first needed a better understanding on the nature and the scope of their use. This report considers the previous and relevant research on the issues, and provides impetus for that action, as well as an underlying call for additional study to more fully understand why people do not have working smoke alarms.

We are grateful to the author and the team of subject matter experts for their effort and expertise in producing this report and to the Maine State Fire Marshal's Office for providing time and expertise to produce it.

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Smoke Alarms in Our Homes: An Overview

This research review and analysis was undertaken in order to understand the status of smoke alarm use in United States homes. They have been done within the context of the overall fire problem in the U.S., which some misconstrue as being minor because significant progress has been made over the last four decades. The fire death rate in the U.S. is still far higher than some other industrialized nations, and nearly double that of England.[1] So we know that more progress is possible. And significant portions of the national economy are related to fire losses, direct and indirect. When combined with the cost of fire protection, approximately two percent of the gross national product is tied up with the nation's fire problem.[2]

The fire fatality rate per 100 fires has been twice as high in homes without smoke alarms as it is in those with the devices.[3] However, alarm use, operability and effectiveness *are limited* by consumer action, inaction and, perhaps, due to ambiguity perpetuated by the fire and life safety community, laws and regulations, and the signaling industry itself. Since the installation of the devices in homes skyrocketed between 1977 and the 1990s, we have learned that installation alone doesn't mean they are working. The only way to optimize the value of these devices is to make certain they are working.

According to a report from the NFPA, "In telephone surveys done for NFPA [National Fire Protection Association] in 2004, 2008, and 2010, 96% of all households reported having at least one smoke alarm."[4] This considerable percentage is consistent with the findings of other recent national surveys.[5] The findings suggest that American homeowners are becoming aware of and understanding the value of these home safety devices and installing them in their homes.

However, some researchers have questioned the validity of surveys that rely on self-reporting.[6] They examine the potential for sampling bias and the doubts raised as to the accuracy of responses obtained in telephone surveys. Other survey research raises the valid question of whether or not people have really understood what proper use, operation and maintenance of the product really entails.

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[1] *Fire Death Rate Trends: An International Perspective.* US Fire Administration Topical Fire Report Series Vol. 12, Issue 8. July 2011. p. 1-2

[2] J. Hall, *The Total Cost of Fire in the United States.* Quincy, MA: Fire Analysis and Research Division, National Fire Protection Association. March 2013. p. 30

[3] M. Ahrens, *Smoke Alarms in U.S. Home Fires.* Quincy, MA: Fire Analysis and Research Division, National Fire Protection Association, September 2011.

[4] Ibid. p. 1

[5] The American Community Survey Conducted by the Census Bureau (2011) found a similar percentage range as did the U.S. CDC through its Behavioral Risk Surveillance System (BRFSS, 1995).

[6] A. Robertson, F. Rivara, B. Ebel, J. Lymp, and D. Christakis "Validation of parent self reported home safety practices," *Injury Prevention* 11 (June 2005); R. Stepnitz, W. Shields, E. McDonald, and A. Gielen "Validity of smoke alarm self-report measures and reasons for over-reporting," *Injury Prevention* (April 2012); P. Hatfield, A. Staresinic, C. Sorkness, N. Peterson, J. Schirmer, and M. Katcher "Validating self reported home safety practices in a culturally diverse non-inner city population," *Injury Prevention* (November 2005); [6] M. Douglas, S Mallonee, and G. Istre "Estimating the Proportion of Homes With Functional Smoke Alarms: A Comparison of Telephone Survey and Household Survey Results," *American Journal of Public Health* 89 (July 1999).

Nuisance alarms due to poor placement, disabling and problems with the type (ionization versus photoelectric) can only partially explain a more complex problem. They certainly don't appear to explain, in totality at least, the complete absence of any smoke alarm in a home, nor do they explain an insufficient number (or inadequate placement) of smoke alarms. Literature on smoke alarms reveals a very complex usage picture. Perhaps what is more telling in the findings of many well-done studies is not what is stated directly but rather what is inferred.

Unfortunately many of these inferences can't be quantified. However, when studied in the context of time, 1970 to present, they are actually quite informative. It is important to understand that the considerable number of studies on smoke alarm technology, use, operation, and maintenance, and the shortcomings of these devices examined in this analysis were conducted at the same time that fire safety messages, product marketing, codes, statutes and policies were changing. This raises important questions. Was it all simply too much for some consumers to absorb? If so, how has that impacted home fire safety?

The changes over the past few decades dealt with everything from proper placement, number of devices needed, and types of devices to power sources and much more. In its sincere frustration over inadequate smoke alarm protection in homes, the fire and life safety community's collective effort to fix the problem (combined with highly technical reports from various institutes and the influence of corporate interests) may have contributed, over time, to consumer confusion.

In this analysis I have explored the growing presence of smoke alarms in U.S. homes beginning in 1977, and their presence and operability since. I have also reviewed what has motivated consumer purchasing of smoke alarms, as well as maintenance and operation, appropriate or not. Motivation to purchase is tied to statutes, regulations and messaging, something I have analyzed from both the consumption and non-consumption perspective. In the end, this analysis leads to many additional questions, which is part of the overall smoke alarm "problem." We need to understand more.

Perhaps most important, despite all we know about the success of this device, we still have yet to see its full potential realized. According to U.S. Fire Administration reports, two thirds of the people who die annually in fires do so where smoke alarms are either not present or not working. To improve smoke alarm protection, the fire service will have to assess the communities they serve for risk and actually go and see how these devices are being used or misused.

Let us begin by looking at the device where it counts: in the home. It is in the home after all, where the brunt of the nation's fire burden is borne. How many alarms are not working may never really be known, but why they fail or why householders fail to obtain them can best be assessed through routine home visits, continued collection of information and careful review of the findings. In that way we can attempt to determine if the problem lies in multiple and perhaps ambiguous or conflicting messages leading to poor or inadequate placement and use, actual device problems, and/or simply the fact that consumers do not come in contact with the device daily or weekly. Which one, or more likely, which combination of reasons, best explains the problem can only be understood through direct and repeated observation. These home visits are increasing in communities across the nation as more in the fire service understand the value of reaching people in their homes. A preliminary understanding of the scope of the smoke alarm

problem has been compiled for the Vision 20/20 Project by TriData (www.strategicfire.org). Gathered during home safety visits across the nation, this data indicates smoke alarm use is actually far lower than phone surveys have indicated.

Some simple market analysis has also been conducted regarding smoke alarms for the Vision 20/20 Project by a marketing firm (Salter Mitchell – www.strategicfire.org). This analysis indicates that people do in fact understand the importance of alarms but often fail to act on that knowledge. The graphic below provides an example of the discord regarding smoke alarms when compared with research that stipulates 96% of homes have them.

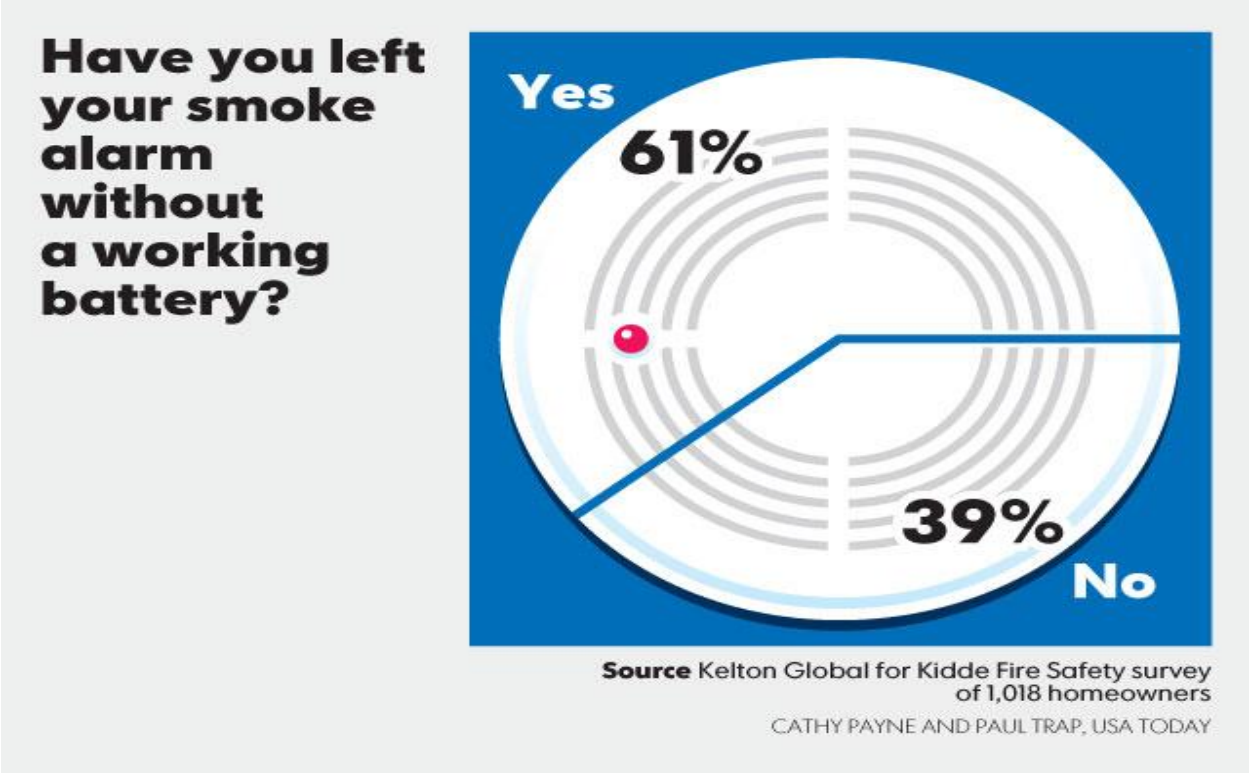

FIGURE 1 JULY /AUGUST 2012, USA TODAY

To the general consumer a smoke alarm is a home device, some might call it an appliance, which detects smoke and warns us of a fire. Among home devices and appliances it joins a long list of items ranging from air conditioners to telephones, and televisions to water heaters. The universe of home devices and appliances can be categorized a number of ways including use by room, general purpose, and even cost. To consider why they may or may not be used and maintained or why they get disabled, we need to look at the utility of the smoke alarm and its proximity to our daily home routines in contrast to other home devices and appliances.

As a *home safety* device, the smoke alarm is likely considered important, if not key. A recent gap analysis conducted by AARP regarding home safety found that 98% of all participants (ages

18-49 and 50 plus) said a working smoke alarm on every floor is important or very important.[7] Generally speaking, most surveys indicate that people do believe they are important and are aware of the device's life-saving capacities, regardless of the participants' socioeconomic or demographic background.[8] In our daily lives, however, smoke alarms are a distant device and at best we will come in contact with them only when testing them or when the alarm goes off for some other reason. That contact yields the gratification of knowing something that *can* save our lives is there and working.

Smoke alarms would likely rank low, however, in terms of both proximity and utility, if compared to other common home devices and appliances. By proximity, I'm simply referring to how close we come to our smoke alarms in our daily routines, and how frequently. Because they are high on a wall or on the ceiling, they are not proximate. Unless we happen to be cleaning or testing the device, we don't have a routine need to look at or touch a smoke alarm. (Ironically, it just might be that a nuisance alarm, an issue that has brought about a great deal of focus on smoke alarm use and operability, may bring many of us in direct contact with our smoke alarm more often than testing or cleaning.) In contrast, we are constantly using other appliances, such as the toaster, microwave, or TV. This frequent use may explain why more people are likely to upgrade or replace home entertainment products than they are to replace a smoke alarm. They are also more likely to replace their home furnace, heater or air conditioner if they fear it won't work the next day than they are to replace a smoke alarm.[9]

Utility refers to consumer preference based on what yields the greatest amount of satisfaction. Through this lens it is easy to understand why home entertainment products, air conditioners and heaters come in ahead of smoke alarms when it comes to ranking them in terms of replacement.

In essence then, all these other devices are literally closer to us and they are close to us often because we routinely utilize them and see a need to do so. Proximity and utility are tied more tightly together for many home devices and appliances than for smoke alarms. Again, this does not mean the people surveyed did not see smoke alarms as being of great value. But value is often being brought to participants' attention during a survey asking them about smoke alarms and other home devices. In other words, they're being reminded of what it says on the back of the smoke alarm box (if they installed it themselves) or what fire and life safety advocates have been telling them for years as reiterated during part of the survey asking them about this

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[7] A working smoke detector on every level was essentially compared in importance to fire extinguishers, lighted stairways, deadbolts, handrails, and grab bars in a bathroom. *Bulletin Poll: Home Safety*, AARP Research and Strategic Analysis. Washington, DC, 2012.

[8] "A Detector in Every Other Home Summary Report. FEMA, FA 54, (Washington, DC, 1981); R. Stepnitz, W. Shields, E. McDonald, and A. Gielen "Validity of smoke alarm self-report measures and reasons for over-reporting," *Injury Prevention* (April 2012); A. Robertson, F. Rivara, B. Ebel, J. Lymp, and D. Christakis "Validation of parent self reported home safety practices," *Injury Prevention* 11 (June 2005)

[9] UTC Fire and Security, *One in Four U.S. Homes Need Updated Safety Equipment; Families at Risk Due to Aging Smoke Alarms, a* survey conducted by Qualtrics for Kidde, a United Technologies Company. http://www.utcfireandsecurity.com/Newsroom/Pages/One-in-Four-U-S--Homes-Need-Updated-Safety-Equipment;-Families-at-Risk-Due-to-Aging-Smoke-Alarms.aspx. (May 2012).

knowledge. (The role of messaging and smoke alarm usage is explored in more detail later in this article.)

When contrasting smoke alarms to other home devices and appliances, what is too often left out of the discussion are the external costs and benefits associated with smoke alarms that make them a rather unique home device. People who install and maintain their smoke alarms are conferring a benefit upon their neighbors who also do, or don't. Early notification of a fire can lead to not only saving lives and reducing injury but also reducing property loss and contents in the building of origin as well as those around it. Conversely, those failing to install, maintain or those disabling their smoke alarms may confer costs upon their neighbors should a fire start, go undetected and spread from the building of origin to another.[10]

The purpose for this overview was to set aside all the presumptions we might have had based on national surveys and look instead at our own communities' use of the devices. In home visits we can truly see how proximity and utility are, or might be affecting smoke alarm use by a typical resident and how smoke alarms fit in the broader scheme of home life. In the process of conducting a home visit, we can learn a lot about those we serve in general. Proximity and utility may be important factors in the critical and pressing problem of failure to install and maintain smoke alarms, or disabling them.

Ultimately, more research is needed to provide us with quantifiable data that helps us understand why people don't own alarms, or why they disable them or allow them to fall into misuse. Until then we can act on reasonable assumptions and some well-documented experience, notably in the United Kingdom, that home safety visits are an effective way to assess the percentage of homes with working smoke alarms, and concurrently correct the situation in homes without them to the extent that resources (funding) allow it.

[10] W. Baumol and A. Blinder, *Economics: Principles and Policy*, 8th ed. (Fort Worth: The Dryden Press, 1999), 272 – 273.

Skyrocketing Presence Yet Troubling Operability

There is broad consensus among fire and life safety advocates that smoke alarms are present in most homes across the United States. There is also widespread agreement in the field that these devices have a demonstrated history of saving lives. The latter concept is proven with data, but the former requires more attention, as does the actual operability of present smoke alarms (versus the stated operability).

Numerous surveys conducted by and for a variety of fire and life safety advocacy organizations corroborate the claim that the use of smoke alarms "skyrocketed" between the latter 1970s and 1990s.[11] In a study conducted for the Federal Emergency Management Agency (FEMA) and the National Fire Data Center, detector/alarm ownership jumped from 22% to 50% in just three years between 1977 and 1980.[12] Since that time surveys have generally indicated that 95-97% of U.S. households have at least one smoke alarm. This growth of 46% since 1980 is celebrated as a considerable success story considering the life-saving capacity of these devices. It is critical to remember, however, that presence does not necessarily mean the smoke alarm is working. When broken down in terms of smoke alarms being both present and working, phone survey data indicate that 20% of homes with alarms have non-working alarms. When you subtract the 20% from 96% it appears as if approximately 77% of homes have an alarm that works.[13] It still begs the question: are they present, do they work, and what kind of alarms are they?

Those participating in the FEMA survey were asked what kind of detector they owned with the choice being photoelectric, ionization or other. The distribution of responses between photoelectric and ionization was virtually equal. However, sales data for the same time frame revealed a strong preference for ionization by a "wide margin," suggesting many surveyed answered incorrectly.[14] This particular question may also reflect that respondents simply didn't know the difference or how to discern the difference. Other oddities in surveys where sales data don't appear to match responses include the stated belief by respondents that smoke alarms should be replaced more often than recommended. If people truly believe this, and are following through, it's not being reflected in the sales data.

Clearly, self-reporting phone surveys have some inherent problems despite many advantages. The advantages include the fact that they are usually less expensive and, of particular importance, they allow for timely data collection needed for difficult to reach audiences. Also, error can be minimized when certain sampling methods are employed. "The main disadvantage of telephone surveys has been the potential for sampling bias and variable estimates of

[11] **M. Ahrens, Smoke Alarms in U.S. Home Fires. NFPA (Quincy, MA, 2011), 1.**
[12] **"A Detector in Every Other Home Summary Report. FEMA, FA 54, (Washington, DC, 1981), iv.**
[13] **M. Ahrens, 2011, p. 7**
[14] **Supra note 6. p. 2**

behavioral factors caused by excluding households not accessible by telephone,"[15] according to a 1999 study in the American Journal of Public Health. Smoke alarm presence is recognized to be less likely in rural areas when compared to the population at large.[16] Studies on home safety practices and measures that employ telephone self-reporting survey methods can be subject to over-reporting the actual presence of alarms or number and location along with the alarms' functionality. This raises doubts in general about the accuracy of responses. In one study it was found that working smoke alarms were over reported by as much as 22%. [17] Another study stated that the validity of respondent-reported home safety behaviors has been seen to decrease when questions are asked over the telephone rather than in the home.[18] Another interesting twist on self-reporting is that people with smoke alarms present tend to downplay the importance of smoke alarm coverage in general.[19] Why might this occur? Some believe the limitations of self-reporting can be attributed to clarity of questions, scale of potential answers, issues of interpretation, cultural context and social conformity.[20] These national surveys using self-reporting provide a good sense of trends. No one will ever know exactly what percentage of U.S. homes have a smoke alarm or working smoke alarm at any given time, however.

The questions raised about self-reporting are of particular concern to fire safety practitioners focused on the population within their service areas. Analysis questions concerning the validity of such surveys reinforce the importance of having fire departments and other home safety advocates get out and go door-to-door to make sure they understand what *is actually happening* in their community. This is precisely why conducting a local risk assessment and visiting homes is ultimately the best way to know how many alarms are actually in homes, how many are working, and concurrently to correct the situation when they are absent and inoperable. These visits not only provide better data, they provide educational and intervention opportunities that augment a department's level of community service and perceived public value simply by being out among the people they serve.

Regardless of any problems previously mentioned with research methodology, by the late 1980s and early 1990s, advertising and public safety campaigns began addressing the great number of homes with smoke alarms where there were problems with their operation in a fire. Data collected on the estimated percentage of fire-involved homes with smoke alarms that were

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[15] M. Douglas, S Mallonee, and G. Istre "Estimating the Proportion of Homes With Functional Smoke Alarms: A Comparison of Telephone Survey and Household Survey Results," *American Journal of Public Health* 89 (July 1999): 1112.

[16] M. Ahrens, U.S. Experience with Smoke Alarms and Other Fire Detection/Alarm Equipment. NFPA (Quincy, MA, 2004), 4. Meuller, Sidman, Alter, Perkins and Grossman, "Randomized controlled trial of ionization and photoelectric smoke alarm functionality," *Injury Prevention* (November 2007): 1.

[17] A. Robertson, F. Rivara, B. Ebel, J. Lymp, and D. Christakis "Validation of parent self reported home safety practices," *Injury Prevention* 11 (June 2005): 209.

[18] Ibid. 212

[19] R. Stepnitz, W. Shields, E. McDonald, and A. Gielen "Validity of smoke alarm self-report measures and reasons for over-reporting," *Injury Prevention* (April 2012): 301

[20] P. Hatfield, A. Staresinic, C. Sorkness, N. Peterson, J. Schirmer, and M. Katcher "Validating self reported home safety practices in a culturally diverse non-inner city population," *Injury Prevention* (November 2005): 52.

operational showed a decline from 1980 through to 1985 and then a recovery. But as of 2001 they had not reached the level of operability measured in 1980. It was in 1985, in fact, that the decline in operating smoke alarms in fires exceeded the estimated rise in smoke alarms present across the U.S.[21] With trends indicating rising installations continuing from 1977 to the 1990s and data indicating declining or flat operability during a fire, focus then turned to operability issues and in particular what was causing the decline.

With the growth in smoke alarm usage from 1977, forward, came an increase in reported nuisance alarms and the onset of disconnection in response. Despite studies indicating that people considered the smoke alarm to be an extremely important home safety device, it appeared that, for many, the nuisance "outweighs the benefits of smoke alarm protection."[22] The issue led the U.S. Consumer Products Safety Commission (CPSC) to conduct a study to determine exactly why alarms failed in fires.[23] This study focused on the findings of the often cited *Smoke Detector Operability Survey*, which concluded that a "high percentage of inoperative smoke detectors in households had dead batteries, or missing or disconnected batteries or AC power sources" and went on to conclude the chief culprit was the nuisance alarm.[24]

The nuisance alarm issue, regardless of cause, led to numerous studies focused on overall coverage of smoke alarms (number per floor), placement in general, and considerable in-depth analysis of ionization technology as opposed to photoelectric. This makes sense when you consider that by this time, regardless of changing requirements of codes, most alarms purchased and installed in the early years (1977 – 1980s), were ionization single-station, battery-powered smoke alarms, as sales data and numerous studies indicate. (Later in this report I discuss what drove that consumption pattern.) It is important to note that the product initially preferred by the consumer had some problems relative to the home environment. People do overcook food and otherwise behave in ways that can lead to nuisance alarms. This has, of course, influenced subsequent code development, the messages promulgated by the fire and life safety community, and the industry itself.

It also needs to be stated that all smoke alarms require proper installation (placement and coverage), maintenance and testing. These are things that, given the utility and proximity of the device in our daily life, make such activities more difficult or at least different from most of the other products we find in the typical home. It's a safe assumption that more people will fix the TV before the smoke alarm. And, this was the way it was, and has been from the start. Nuisance alarms were not the only problems leading to inoperability documented through data collection.

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[21] M. Ahrens, U.S. Experience with Smoke Alarms and Other Fire Detection/Alarm Equipment. NFPA (Quincy, MA, 2004), pp. 17 – 20.
[22] Ahrens, 2011. p. 15.
[23] L. Smith, "Fire Incident Study National Smoke Detector Project," U.S. Consumer Products Safety Commission, Bethesda, MD. 1995. iii
[24] C. Smith, "Smoke Detector Operability Survey Report on Findings," Consumer Product Safety Commission, 1994. pp. 24-25

Failing to test alarms or replace batteries, and improper installation also lead to the product not being effective.[25]

Finally, before leaving the discussion on presence and operability, let's not forget those who simply do not install them at all. This is a device that surveys show is recognized by a vast majority of people, regardless of socioeconomic or demographic background, to be a very important home safety device. Yet there are households that don't even have one working alarm.

In the FEMA study cited earlier, a question was posed to determine why people had failed to purchase smoke alarms. Half of respondents claimed they had no interest, another 25% found no need to have one and another 25% stated "other" while 10% stated it was too expensive. Remember, that was 1981. Today, the estimated percentage of homes without a smoke alarm is approximately 4%[26] and, as previously stated, most people believe the device is important. Perhaps being unaware of smoke alarms and their value or simply having too many other issues of concern might be contributing factors to the estimated 4%. Research suggests that those without smoke alarms had more risks for fire injury than those with alarms.[27] Factors including income, educational attainment, age and other variables associated with high risk populations are often cited as being at play in higher risk audiences.[28]

Overall, there appears to be consensus that the device is important, yet people will disconnect them, primarily due to nuisance alarms. The literature indicates these are most frequently seen in battery-powered ionization smoke alarms. There is also the failure to put the batteries back or to remedy the nuisance problem at the outset.

To consider the problem of consumers not protecting their homes with smoke alarms let's begin by looking at why people historically bought, installed, maintained and operated them properly to begin with.

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[25] Maryland Smoke Alarm Technology Task Force Final Report, August 2012.
[26] M. Ahrens, 2011. p 7.
[27] K. Shaw, M. McCormick, S. Kustra, R. Ruddy, and R. Casey, "Correlates of Reported Smoke Detector Usage in an Inner-City Population: Participants in a Smoke Detector Give-Away Program," *American Journal of Public Health* 78 (June 1988): 651. It should be noted that nearly all (98%) respondents in this believed that smoke detectors saved lives.
[28] Socioeconomic Factors and the Incidence of Fire. FEMA, FA 170/January 1997.

The Issues of Choice: Price and Other Trigger Mechanisms

This section reviews research on smoke alarm use and operability and looks at what has driven choice to buy and use smoke alarms historically and still drives it today. There is a wide range of choice as it relates to product consumption in general and smoke alarm consumption in particular. Also important is how statutes, rules, messages and price can, and have, influenced the consumer to buy and how that ultimately influences effective use of household smoke alarms.

Recently, I viewed a popular American multinational electronic commerce company website to look for a smoke alarm and this is what I found: a lot to choose from (see Figure 2). Obviously, not all 869 choices are simple smoke alarms. There were smoke alarm testing mists, bed shaking alarm systems, detector dusters, and other products related to smoke alarm protection that also resulted from the search terms. The important takeaway is that the variety of online and offline smoke alarm products is wide ranging and may well provide too much choice for consumers. In fact, consumer product research on the downside of excessive choice has shown that consumers are 10 times more likely to buy a product if they choose from among six as opposed to 24 products.[29] If excessive choice doesn't lead to an outright failure to purchase, it can lead to taking risks by making selections based upon the use of "simplifying strategies." Price, for example becomes an easy to understand and simple criteria upon which to base and justify an otherwise complex set of choices.[30]

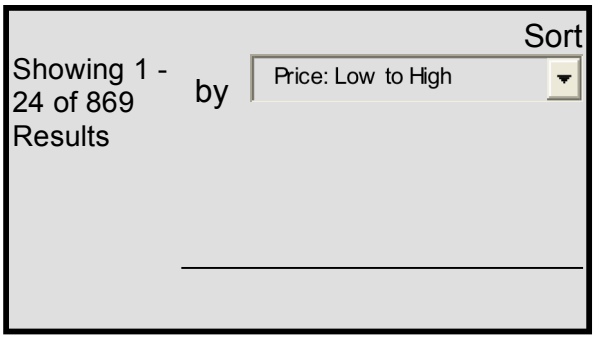

Figure 2

Too much choice, simply put, can be de-motivating, and, in the case of smoke alarms, can lead us away from considering where we're going to put the device or how many we actually need, as opposed to a single trigger, such as price. And the online market has increased access. Figure 2 illustrates this point. The drop down box allows the consumer to sort by customer review, price from low to high and vice versa, as well as new and popular rankings. Price ranking or comparison is a classic way to assist the impersonal customer to choose.[31] Using such a ranking or comparison scheme is likely based on the assumption that price might be driving consumption. The price ranking option reflects brand awareness and preference studies showing that while one brand might be preferred, another product is purchased due to lower price. In

[29] **"The Tyranny of Choice: You Choose,"** ***The Economist (December 2010): 3 www.economist.com/node/17723028***
[30] **Tori DeAngelis, "Too many choices,"** ***American Psychological Association*** **35 (June 2004): 56.**
[31] **"The Tyranny of Choice: You Choose,"** ***The Economist (December 2010): 2 www.economist.com/node/17723028***

other words price moves the customer toward a choice that may not reflect their preference or, in fact, be the best choice for them. As more and more smoke alarm manuals become available online, such options as recommended count and placement might have more influence, provided there are not too many choices. Product reviews may also impact consumer choice. The number of brands of smoke alarms isn't as wide ranging as the varying prices and technological choices consumers have. Pricing is especially powerful when the consumer's general understanding of what differentiates one product from another of the same kind (or one brand from another) is limited.

Price has certainly played a role in the growth of smoke alarm use. In the 1981 FEMA study, 10% cited "too expensive" as the reason for not purchasing.[32] In his "History of Smoke Detection" study, University of Maryland Professor James Milke, PhD, provides an historical review of the changing technology of smoke alarms since their inception, how beneficial they've been, their shortcomings, and what might help to improve them. In this study, Professor Milke states, "By the late 1970's, the price of a single station residential smoke detector had nosedived from about $50 to $8 due to fierce competition by many companies (there were still about 50 companies in the early 1980s)."[33] Adjusted to current dollars, a $50 smoke alarm would cost $178.51 today. It is understandable why the $8 dollar alarms ($28.56 in today's dollars) might stimulate demand and consumption. Professor Milke also recognizes the role changing codes and laws had when combined with dropping prices. In addition to complying with building and fire codes and standards as well as obtaining a listing from recognized testing labs, Duane Pearsall, a pioneer in home smoke detection, also worked to develop a product that was affordable in the retail market. The initial *SmokeGard* product that Pearsall put on the market in 1972 and sold for $37.88, or more than $200 in current dollars.[34]

An analysis conducted by NPD Group found that the number-one factor that leads a consumer to a smoke alarm retailer today is price, followed by the distance to the retailer. However, when it came to the product itself brand preference was number-one, followed by price.[35] According to ConsumerReports.org, the average price for a First Alert Alarm is $13 to $100 and $10 to $70 for a Kidde brand.[36] The more typical range of price that I found on online in preparing this article was $15 to $45. Let's assume that the average household smoke alarm price then is around $30. In 1978 dollars that would cost $8.40, which is approximately the cost smoke alarms dropped to in the latter 1970s, helping to increase use. Essentially, the cost of smoke alarms adjusted for inflation hasn't changed much. Certainly the variety and choice of the product has. The drop in price and increase in use in the latter 1970s took place not long after the publication of the "America Burning" report and subsequent creation of the United States Fire

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[32] FEMA, 1981 p. 14

[33] James A. Milke, PhD "History of Smoke Detection: A Profile of How the Technology and Role of Smoke Detection Has Changed," (a report formulated for Siemens Technology, Inc.), September 2010. p. 22.

[34] David A. Lucht, "Where There's SMOKE," *NFPA Journal* 107 (March/April 2013): 53 – 56.

[35] "Smoke Detectors, by the Numbers," Home Channel News www.homechannelnews.com Based on a data from NPD Group, Port Washington, NY (December 2012)

[36] "CO & Smoke Alarm Buying Guide." ConsumerReports.org www.consumerreports.org

Administration (USFA). Both events served to heighten the nation's awareness of the fire problem and the value of smoke detector protection.

Finally, in examining choice and price there are other minor attributes of smoke alarms that should be mentioned. When looking to the future of smoke alarms, the term "smart smoke detectors" is often used. Researchers believe that the success of these devices, which will essentially serve as overall environmental monitors, is going to depend on their ease of installation, cost, ease of use and even appealing design.[37] The early smoke detectors were relatively easy to install but they were not likely thought of as something we use. In fact, given the data on what happened by 1985 with regard to nuisance alarms and inoperability issues, some probably didn't want to think about them after installation at all.

Another interesting attribute contributing to the purchase of smoke alarms is the trigger mechanism. By this I mean something that creates or stimulates an impulse to purchase a smoke alarm. Price clearly can trigger a purchase, and if a primary concern, it can simplify the selection process when there are many products to choose from. In retail stores, prominence (or proximity to buyer) is a powerful trigger, bringing customers up close to a large selection of products. This trigger effect was well documented in the research NPD conducted. NPD found the clear winner in smoke alarm sales to be big box, or WHC (warehouse home center) stores as opposed to the hardware or department store.[38] Proximity, unlike price, does not necessarily influence those looking for a smoke alarm; but it may attract many who are not.

The presence of children in the home also seems to have an impact. Homes with children beat out homes without a smoke alarm present by six percent. The number of people in the home had the same effect.[39,40] In one study, homes with children under 18 years old were more likely to have alarms on all floors and in all bedrooms than homes without a family member under 18.[41]

Other triggers include laws and regulations, which almost certainly influenced the growth of smoke alarm usage from the latter 1970s to the 1990s. In predicting the presence of a smoke alarm the "most important factor in all the linear logistic models [conducted as part of this referenced study] was whether or not the home was built since 1975, the year the building codes required detectors…"[42] Some might view the passage of a law requiring smoke alarms or another event such as the NFPA's Fire Prevention Week as triggers awakening people via public

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[37] O. Baecker, "Smart Smoke Detectors for Residential Buildings – Costs, Barriers, and Success Factors," University of St. Gallen, Zurich (May 2007): 5

[38] "Smoke Detectors, by the Numbers," Home Channel News www.homechannelnews.com Based on a data from NPD Group, Port Washington, NY (December 2012)

[39] Ahrens, 2004 p. 4

[40] M. Ahrens, Smoke Alarm Presence and Performance in U.S. Home Fires, *Fire Technology* (Quincy, MA 2010): p. 3

[41] M. Green and C. Andres, "2004 – 2005 National Sample Survey of Unreported Residential Fires," CPSC (Washington, DC 2009): 79

[42] E. McLoughlin, M. Marchone, S. Hanger, P. German and S. Baker "Smoke Detector Legislation: It's effect on Owner Occupied Homes," *American Journal of Public Health* 75 (August 1985): 860

awareness campaigns to the danger of fire and leading them to purchase smoke alarms. Events too, can be and are triggers.

Laws, regulations, and events all stimulate awareness but the most important trigger might be the door-to-door campaigns. Home safety visits and door-to-door interventions are extremely useful in increasing smoke alarm ownership and can be applied in both rural and urban environments.[43]

So the number and type of triggers impacting smoke alarm purchasing are considerable. These mechanisms are the creation of industry market and sales strategists, fire and life safety advocates and of course, public policy makers. As helpful as these mechanisms might be to stimulate purchase, they may also have a down side.

[43] **A. Jones, S. Thompson, M. Davis "Smoke Alarm Ownership and Installation: A Comparison of Rural and a Suburban Community in Geogia," *Journal of Community Health* 26 (October 2001), p. 307**

Statute, Rules and Messages: Ambiguity or Confusion?

As indicated, availability, choice and price were driving factors in the consumption of smoke alarms during the latter 1970s, as was the development of laws and regulations requiring installation. Since that time however, the laws, regulations and messages related to smoke alarms have become ambiguous.

In 1976, the first standard for certification of smoke alarms was established. Between 1973 and 1979 all the major building and fire codes in the nation required smoke alarms in homes.[44] Through the 1980s into the 1990s, the same period in which the use of smoke alarms grew to the estimated 96% mentioned earlier, changes to codes and Underwriters Laboratories (UL) standards took place, impacting both price and choice (selection). Originally, one smoke alarm (powered by the home electrical service or battery) was required in an existing home. In 1985, UL attempted to address the nuisance alarm problem with changes to alarm sensitivity requirements. As the 1980s came to a close, the building and fire codes evolved to provide greater coverage, requiring interconnected smoke alarms in all sleeping rooms, with an exception being made for existing homes. In 1997, NFPA's smoke alarm code followed with heightened coverage to all bedrooms.[45] In 1995, the 10-year-lithium-powered smoke alarm was introduced.[46] Though codes did not require either photoelectric or ionization technology specifically, both were available to the consumer during this period of time.

As the new millennium approached regulations had expanded to their current level of required coverage and interconnectivity, power source, and type. As national codes and standards change or develop and are promulgated by the code community, there is a concurrent development and growth of state and local statutes/ordinances. State statutes requiring the installation of smoke alarms delegate rulemaking authority, with few exceptions, to some state agency. This development of statutes began primarily during the early 1980s. The laws varied from state to state but generally speaking, they required at least one alarm in each apartment unit and in all *new* single-family dwellings. If a state passed such a general law and then, subsequently, the state agency then adopted the 1976 or 1981 Editions of NFPA 101, Life Safety Code, without any language amending the smoke detection in the "One- and Two-Family Dwellings" section, the result was a regulation in conflict with a statute. The law says only new homes must have them while the adopted code says they all must have them but exempts existing homes by allowing them to use battery alarms.[47] It may be that while laws and regulations can trigger

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[44] Milke, 2010. p. 20

[45] Life Safety Code, 1997 Edition. NFPA, Quincy, MA.

[46] "Home Smoke Alarms and Other Fire Detection and Alarm Equipment, White Paper by Public /Private Fire Safety Council (April 2006): pp. 9 - 10

[47] Life Safety Code, 1976 Edition, *NFPA* (Boston, MA) 101-159. This code required all newly built single-family dwellings to have at least one alarm powered by the "house electric service" and an existing home could use battery-powered units. Maine adopted the 1981 Edition of NFPA 101 but the legislation required all "new" single-family dwellings to have installed smoke alarms. By not addressing power source, the statute left that up to the Fire Marshal's Office. Note: The 1976 Life Safety Code appendix states: "detectors should be placed remotely from the cooking area."

purchase, conflict between statute and code *may* also create buyer confusion and ambiguity resulting no purchase but we don't really know this absent further focused research. The enforcing authority is also placed in an awkward position, impeding public safety education as well as code enforcement. Perhaps this explains in part what we see in the distribution of smoke alarms in existing and new construction drawn from the American Community Survey conducted by the Census Bureau.[48]

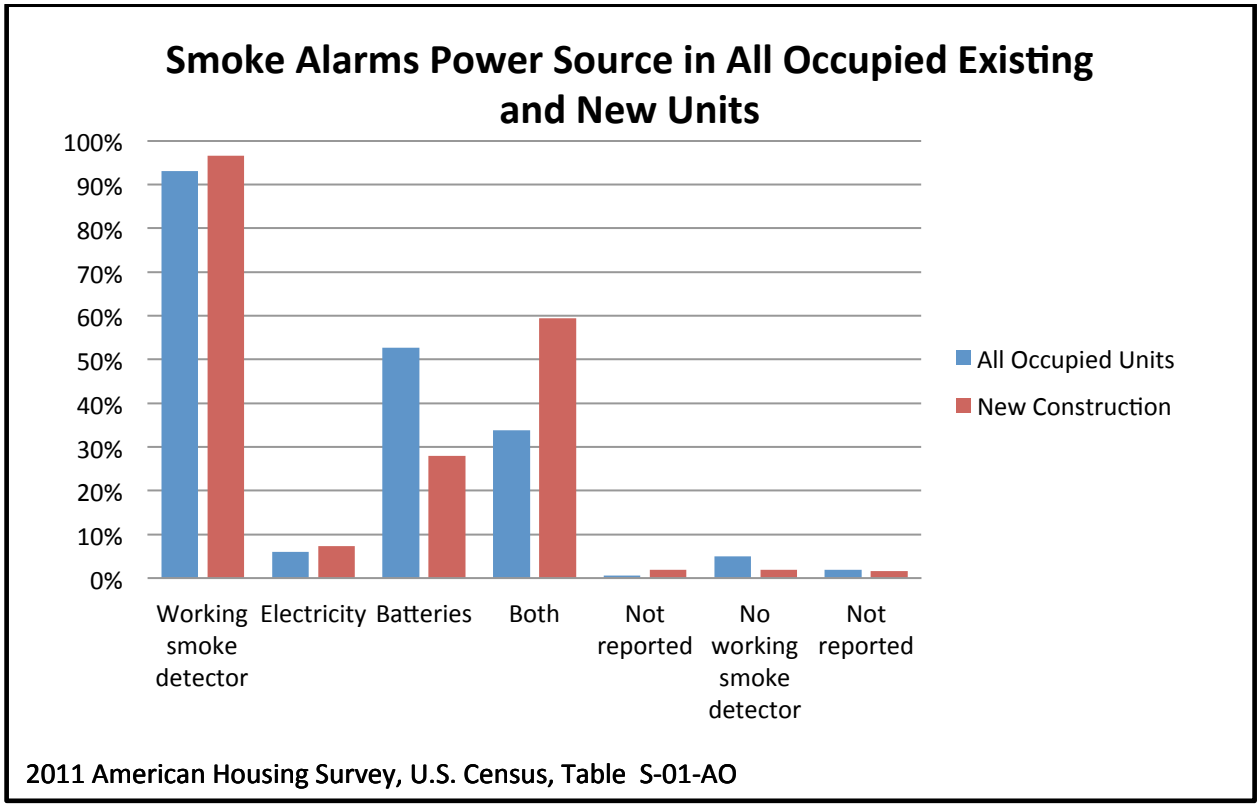

FIGURE 3 SMOKE ALARM POWER SOURCE

Data from the 2011 American Housing Survey, conducted by the U.S. Census, shows that 93% of all occupied units and 96% of new construction (built in the last four years) have working smoke alarms. However, only 60% of units are powered by the electric service of the building and battery, as required for new construction by recent code and standard organizations.[49] The 28% of new construction with battery-powered alarms is even more disturbing. Are the survey questions and/or methods resulting in under- or over-reporting, or are states and localities amending the codes as they adopt them? Or are the statutes limiting the enforcement agencies' ability to enforce the codes as written?

[48] **U.S. Census Bureau, *American Housing Survey for the United States*, Series H-150 (Washington, DC) 2011, Table S-01-AO**

[49] **National Fire Protection Association's Life Safety Code and the International Code Council.**

Numerous studies indicate that homes built since 1980 are more likely to have AC-powered smoke alarms.[50] They find that approximately 69% of new-home smoke alarms are AC-powered, which seems comparatively consistent with what the American Housing Survey is showing for homes built recently. If we assume that the surveys accurately reflect what is happening with new construction, building code compliance doesn't appear to be as successful, or is as least static in terms of gaining compliance, because the American Housing Survey shown above was conducted more than 20 years later. It is important to remember that homes built since 1980 do not comprise the bulk of American homes as data from the U.S. Department of Housing and Urban Development found (see Figure 4).[51]

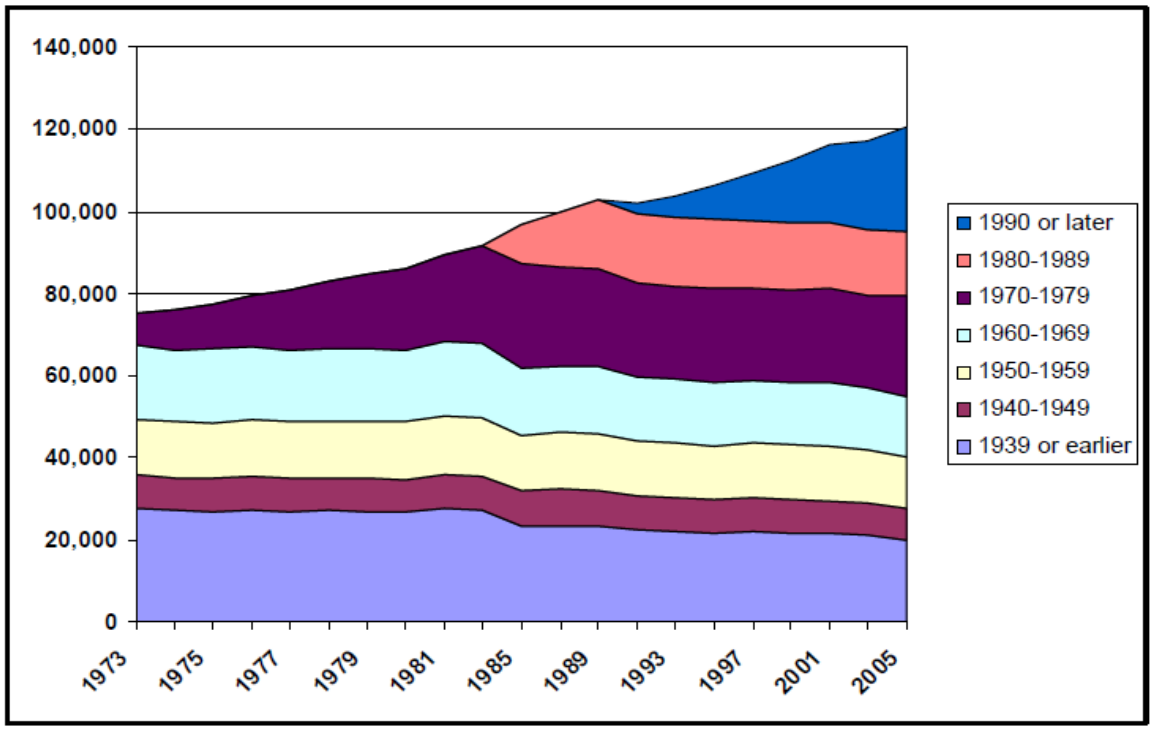

FIGURE 4 NUMBER OF YEAR-ROUND HOUSING UNITS BY YEAR BUILT

More importantly, in homes that have fires, we still see a large proportion of battery-powered alarms.[52] Precisely what impact might the incongruence between codes and statutes have had on smoke alarm use and operability is difficult to quantify, but it is worth further detailed research on a state-to-state basis. Such research might yield a clearer picture as to the degree of inconsistency between code and statute within a given state. Once that is determined conducting

[50] C. Smith "Smoke Detector Operability Survey on Findings," Bethesda, MD U.S. CPSC, October 1994, p. 9
[51] F. Eggers and A. Thackery "32 Years of Housing Data," U.S. Department of Housing and Urban Development, Office of Policy Development and Research (Washington, DC 2007) p. 11.

[52] Ahrens, M. 2011

surveys followed up by a direct observational component (visiting the homes) will reveal what is in homes in those states that have the statute-code conflict. This would also reveal how well the newer coverage and interconnectivity requirements of more recent codes are being enforced as they are added to the statutory and regulatory scheme in given states. Assuming smoke alarm codes and statutes may not have been as successful as we'd have liked due to conflict and resulting ambiguity, the question arises how this may have affected smoke alarm purchase and installation. Equally valuable is determining if the smoke alarm industry, through its messaging, along with fire and life safety organizational messaging, has influenced purchase and installation.

The amount of legislation and codes, state and local, whether in conflict or not, has had one very visible impact on the industry in the form of a voluminous amount of web page information and product guides/manuals laden with references to local and state building and fire codes. Because state statutes and codes have varied and often become ambiguous, the industry began to refer consumers to local and state codes and laws.

From the late 1970s, the industry and fire and life safety advocates have released a volume of messages, including those to install smoke alarms, test smoke alarms, every-level protection, change your smoke alarm batteries, replace your alarms, and other variations of these most basic messages. During this period and as the messages were being developed and disseminated, the problems of nuisance alarms, disconnection, and even failure to install were also being discovered. This in turn generated additional messages, and in some cases debate over the type of alarm (ionization versus photoelectric) and, in some cases, state or local legislation requiring certain types of alarms in certain places of the home.

The debate over the type of alarm can be seen in the literature of the industry and advocates as well. A number of individual state fire marshals, the National Association of State Fire Marshals (NAFSM), FEMA, the International Association of Fire Chiefs (IAFC), NFPA and other organizations have weighed in on this debate. There is broad agreement today that households need both because we don't know what kind of fire people might have. Industry response has been to create combination units, and some practitioners in the field now recommend using both types of alarms.

For a device that may not rank high in the home in terms of proximity or utility, there has been a lot of "must dos" for consumers to consider. Nothing exemplifies this more than the direction some manufacturers are taking in product development. One informative example are recent campaigns by manufacturers to provide new technologies.

Citing the statements of numerous fire and life safety organizations and even some state statutes, Kidde launched a new line of "Worry Free" smoke, carbon monoxide and combination alarms in 2012. Recognizing the problem of consumers disconnecting smoke alarms, along with changing state and local laws and regulations, there is also confusion about the life span of smoke alarms and other aspects of the device. Kidde's campaign essentially tells the customer to put up the device and don't think about it for 10 years. This particular line of Kidde alarms has everything

including voice alarms, lights, dual sensor, combination CO/smoke/heat, hush buttons, and more. The company advises its customers not to worry about pesky chirps and even guides them as to where to install various alarms by actually labeling them for specific rooms.

First Alert, has also produced products with similar messaging and technology capabilities, and has also adjusted them to make their devices more esthetically pleasing. They too, offer plenty of information directly from the fire and life safety organizations to support their product and back up their safety messages.

More recently, Nest Laboratories also developed an alarm that is a multi-criteria device incorporating a photoelectric sensor, CO sensor, heat detector and motion detector, all working in concert with one another. It connects to a smartphone application through a home's wi-fi router, linking it to other Nest Protect smoke alarms in the house as well as interconnecting with a Nest thermostat, shutting down the heating system if the CO alarm is activated. The design of this smoke alarm is a radical departure and it is too soon to know the impact that it will have upon smoke alarm adoption and the smoke alarm industry.

On one hand, offering choices helps consumers make decisions about which type of alarm will work best for them. But assuming most consumers are ignorant of the details, the potential for confusion exists and is perhaps a significant problem contributing to the lack of adequate protection.

So the question remains: are fire and life safety advocates and the smoke alarm industry offering the consumer too much information and too many options? Is there a concern that the wide variety of types, features, and price range lead a consumer to overlook the 10-year lithium-battery-powered product and choose the less expensive basic smoke alarm, or worse yet, not purchase one at all? Fire and life safety educators must consider how product choice and messages along with statutes and regulations can impact consumer usage.

Conclusion

In recent years there has been considerable discussion regarding smoke alarm performance, and what type of technology would provide the earliest alert to residents so that they could escape. It is generally accepted that photoelectric technology alerts more quickly in slow smoldering fires, while ionization technology alerts more quickly in fast moving or flaming fires. The national consensus and standards still maintain either technology would alert quickly enough to provide adequate escape of a fire. The larger problem may be revealed in the evidence that begins to tell us why two-thirds of people dying in fires are occurring in homes where smoke alarms are not present, or not operating.

All of this data can be questioned, of course, due to the overall concern about the accuracy of reporting by the fire service from the field, and the limitations on data collection that would help indicate the relationship between technology and performance in a fire. Concurrently, a preliminary analysis by TriData done with "soft" data from the field (via Vision 20/20 demonstration projects on home safety visits) indicates the number of homes with working smoke alarms may be far less than we have been previously describing (96% of home having smoking alarms). For example, in some high-risk areas, as few as 10% of homes had one working smoke alarm, revealing that 90% of homes had none that were operational.

If we focus on the issue of why people do not have working smoke alarms, the answers may be found in three distinct areas that this research review reveals, and a reasonable hypothesis constructed pointing toward solutions.

- First, the consumer confusion in the market place caused by the number of choices people have to make, and the lack of information they have to make decisions about purchasing, combined with competing messages, conflicting laws and codes, all may contribute to people feeling ambiguous about their purchase and maintenance.
- Second, there is some evidence to indicate that nuisance alarms are a factor in people disabling alarms, and could be the basis for hypothesizing as to why people don't have them as well.
- Third, the general utility of the device, while recognized as very important by the public, does not reach the same level of importance in day-to-day priorities. If the television, the heat, the electricity, or the Internet connection goes out, people will generally have them fixed as quickly as possible. The same may not be said about smoke alarms because they are not viewed as an essential part of day to day living – in other words, having the same level of consumer utility. There is nothing about smoke alarms, unlike other appliances, that would lead us to come into routine daily contact with them.

The solutions to these issues may be found in addressing the operability problems, and increasing the utility of the devices, and more focused public education efforts.

In his research on smoke alarms Professor Milke states that the device may take on additional or "increased intelligence" and "be asked to do more than simply sound an alarm." Essentially smoke detectors may someday be used to regulate overall air quality and the HVAC systems in homes.[53] If this prediction is correct, this in essence would expand the overall importance of the device and, like a thermostat that requires our daily touch and attention, bringing us closer to the device on a routine basis. In other words, linking the smoke alarm to other devices might provide it with greater utility, and therefore greater attention in the average home.

Smart home smoke alarm technology that utilizes different sensor devices might also help reduce the frequency of nuisance alarms.

In his paper, Beacker makes the point that "smart smoke detectors," with their additional communications capabilities, make it possible to automate certain tasks such as "battery and function tests" while "freeing the user from this burden."[54] In a sense, the smoke alarm in the future would free us from doing the things we've been told numerous times to do, while simultaneously, engaging us more frequently with the product, though indirectly, as a monitor of a broader home system. This smart technology is already here in various forms. As these products, which diversify to some extent the value of the smoke alarm technology, become more common it will also stress to a degree the fire and life safety advocates' role as well as the industry. As we've seen, as codes, laws, and smoke alarm products change, so do the associated messages, and with this change there will be something new to learn, implement and measure.

Despite the large volume of national data, fire and life safety advocates cannot afford to assume that 96% of any community actually has smoke alarms, nor that 77% of smoke alarms are working. This data misses a number of important local questions related to coverage, type, location and overall home safety. The only way to know for sure what is in homes it to go to homes to see what is really there. Home visits are a demonstrably effective way to truly ensure homes have the minimum adequate smoke alarm protection and that occupants know how to utilize the time afforded by that protection to escape a fire.

The fire service has added rescue, medical and haz-mat services over the years and routinely provides a range of other services in the community. They are highly regarded and trusted, and most communities have fire service personnel. Diversifying the value or number of services a smoke alarm provides may serve to remedy use and operability issues, diversifying what fire departments and fire and life safety advocates do on a routine basis will help ensure that that actually happens.

Clear and consistent messaging efforts about the value of smoke alarms, and their maintenance and operation, have demonstrated results on improving the number and operability of alarms in the past. It is logical to stipulate that focused efforts in the future would also have an impact on the number of working smoke alarms people have.

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[53] **Milke, 2010 p. 33.**
[54] **Baecker, 2007 p. 13**

In the long run, the answer to the smoke alarm problem will require that community fire and life safety advocates *and* smoke alarms to become more proximate and of more utility to us, in our homes, on a routine basis. This is because safety is a habit, and though we may not know precisely how many devices are not working, we can observe residents' use of them if we go to the home and see for ourselves. Home visits can provide insight into whether the device is simply neglected because of the lack of proximity and utility previously discussed, or because residents are confused by multiple and perhaps conflicting messages from various sources.

And finally, we are making some reasoned assumptions about why smoke alarms are not present in homes or are not working. Some focused research is needed to help answer those questions from both a human behavioral perspective and the role that the types of technology may play in contributing to problems such as nuisance alarms, or alarms that do not activate in a fire.

About the Author

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