



**Oregon Office of State Fire Marshal**  
**Oregon Waking Up to Smoke Alarms**  
**2010**

**Prepared by the Waking Up to Smoke Alarms Committee**  
**report to the Oregon State Fire Marshal**  
**September 2010**

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    Address risk to the young and physically challenged \_\_\_\_\_ 10

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# Report by the “Waking Up to Smoke Alarms” Committee

September 2010

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## BACKGROUND

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In 2009 information was shared among members of the Oregon fire service that indicated smoke alarms were ineffective in reliably waking children. A report from an eastern state news organization demonstrated this concern using real-time smoke alarm activations with sleeping children varying in age from quite young to late teens.

To further research this issue, Oregon State Fire Marshal Randy Simpson convened a study committee to review current research and provide recommendations. The committee assembled additional documentation including statistical information developed by the National Fire Protection Association (NFPA). The Fire and Life Safety Section of the International Association of Fire Chiefs was also contacted for comment.

This report summarizes the committee’s findings and recommendations on this issue.

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## MEMBERSHIP

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<b>Member</b>	<b>Representing</b>
Cindy Kettering	City of Bend Fire Department
Debbie McDermott	McMinnville Fire Department and Oregon Fire Marshals Association
Colleen Olson	Oregon Office of State Fire Marshal, Community Education
Joe Parrott	Salem Fire Department
Anita Phillips	Oregon Office of State Fire Marshal, License and Permits Services
Kari Shanklin	Clackamas Fire District #1
Joel Stein	Keizer Fire District
Jim Walker	Oregon Office of State Fire Marshal, Chief Deputy State Fire Marshal
Tari Glocar (Retired in 2009)	Oregon Office of State Fire Marshal, Community Education

## FINDINGS

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A paper by Dorothy Bruck, et al, from the Victoria University School of Psychology (Melbourne, AU) described the results of studies of this concern.<sup>1</sup> Three studies were conducted in all.

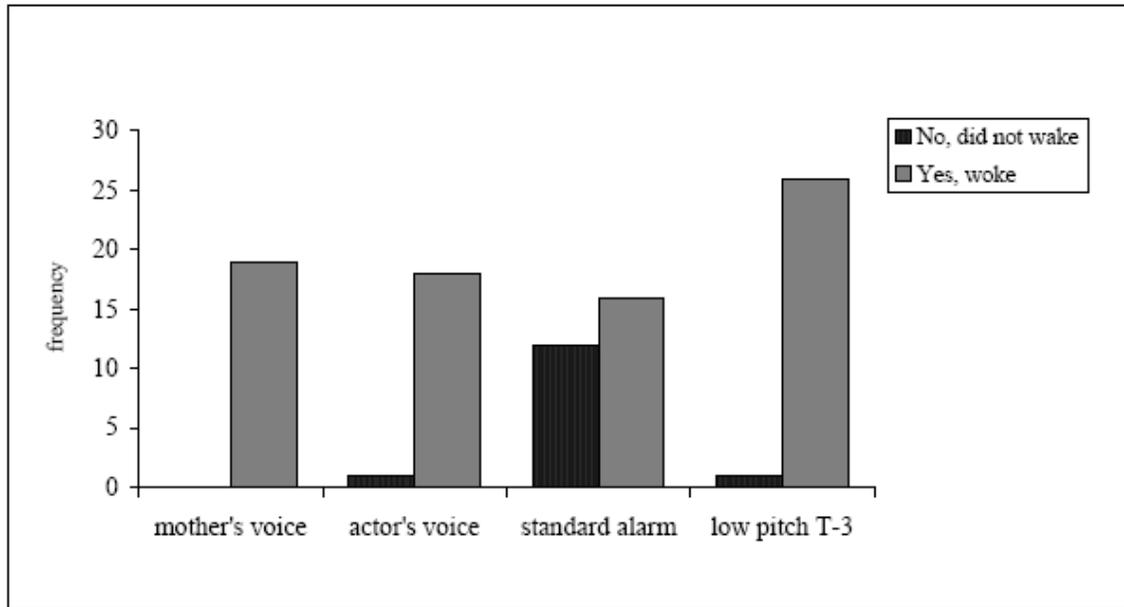
**Study 1:** The mother's voice signal was pre-recorded in each home using a script and included the child's name at the rate of about once every six seconds. If two children being tested shared a bedroom, both names were included (order counterbalanced). The message said that there was a fire, they were to wake up now, and quickly go outside. The actor's voice signal was a female voice saying danger, there is a fire, they must wake up now and go and investigate. Both voice signals conveyed urgency, although the actor's voice was typically more urgent. All messages lasted 30 seconds and were looped to make a 3-minute continuous recording. The female actor's voice was acoustically tested and found to be a complex sound within the frequency range from 315 Hz to 2500 Hz. The children were told that a signal could go off on any one or more of the three nights of the study.

**Study 2:** In this study the signal presented was the Temporal three (T-3) pattern. The frequency of the T-3 is not specified in the standard, but the signal used in this study was the same as that used in a previous study on the perceived urgency of the signal. The T-3 signal was acoustically moderately complex, with dominant tones in the lower frequency ranges; 500 Hz, 1500Hz and 2500Hz. The children were told that a signal could go off on any one or more of three nights.

**Study 3:** This study was performed in 1999 and used a standard Australian smoke alarm bought in that year. This was a high frequency signal of approximately 4000 Hz. The children were told that an alarm would go off on two of the five nights of the study but they did not know which two nights. A subset of the total sample of children is included here, only those aged 6-10 years.

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<sup>1</sup> "The Effectiveness of Different Alarms in Waking Sleeping Children", Dorothy Bruck, Sharnie Reid, Jefon Kouzma and Michelle Ball, School of Psychology, Victoria University, Melbourne, Australia, 2004



In the paper the authors concluded, “The results of these three studies suggest that sleeping children aged 6-10 years are very likely to awaken to a voice alarm or low pitch T-3 presented at about 89 dBA during the middle third of the night, while only about half such children will awaken to a high pitch standard alarm under the same conditions. The fact that the low pitch T-3 was as effective as the voice alarms suggests that the critical factor is not the urgency of the message, its verbal content, or use of a voice in itself. The evidence suggests that responsiveness is primarily a function of the *lower frequency* of a signal. With further confirmation of this as a critical factor, specifications about signal frequency should be included in the standards for all residential alarms.”<sup>2</sup>

A separate study published in *Pediatrics*, Official Journal of the American Academy of Pediatrics in 2006<sup>3</sup> was also reviewed. The article described the study as using a randomized, non-blinded, clinical research design, a volunteer sample of healthy children 6- to 12-years-old was enrolled in the study. Children were trained how to perform a simulated self-rescue escape procedure when

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<sup>2</sup> “The Effectiveness of Different Alarms in Waking Sleeping Children”, Dorothy Bruck,

<sup>3</sup> “Comparison of a Personalized Parent Voice Smoke Alarm With a Conventional Residential Tone Smoke Alarm for Awakening Children”, Gary A. Smith, MD, DrPHa, Mark Splaingard, MD, John R. Hayes, PhDa, Huiyun Xiang, MD, PhD, MPH, Center for Injury Research and Policy, Columbus Children’s Research Institute, and bSleep Medicine Center, Columbus Children’s Hospital, Department of Pediatrics, The Ohio State University College of Medicine and Public Health, Columbus, Ohio

they heard a smoke alarm. Each child’s mother recorded a voice alarm message, “First name! First name! Wake up! Get out of bed! Leave the room!” For each child, either the voice or tone smoke alarm was randomly selected and triggered during the first cycle of stage 4 sleep, and then the other alarm was triggered during the second cycle of stage 4 sleep. Children’s sleep stage was monitored by electroencephalography, electro-oculography, and chin electromyography. The 4 main outcome measures included the number of children who awakened, the number of children who escaped, the time to awakening, and the time to escape. The following charts describe the probability of awakening and escape based on these tests.

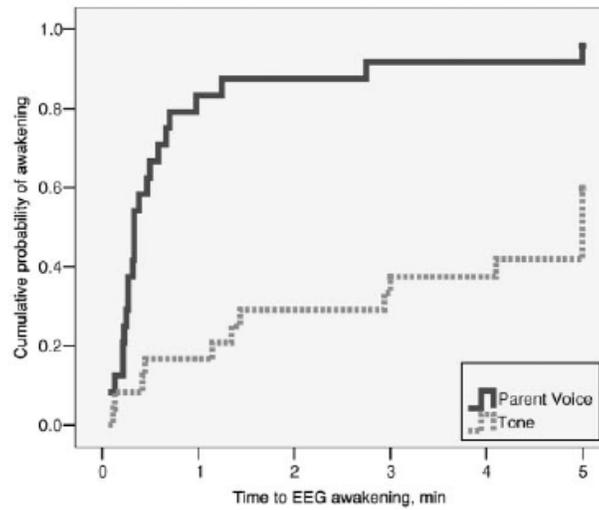


FIGURE 1  
Cumulative probability of awakening by time to awakening for parent voice smoke alarm and tone smoke alarm stimuli.

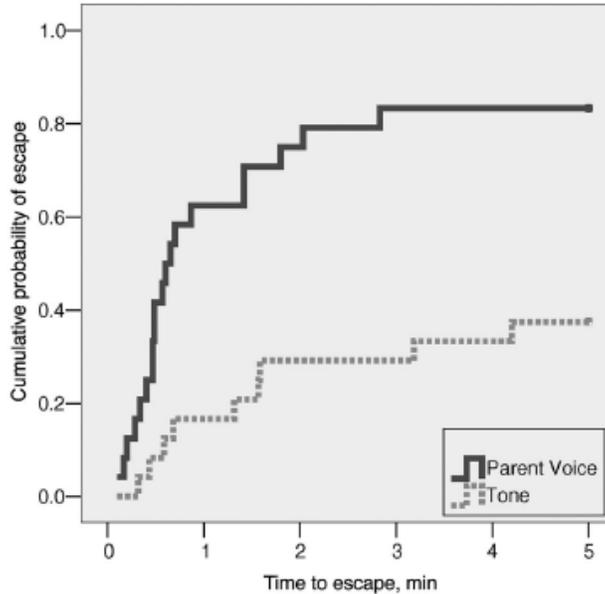


FIGURE 2  
Cumulative probability of escape by time to escape for parent voice smoke alarm and tone smoke alarm stimuli.

It concluded “To our knowledge, this study is the first to compare the ability of different types of smoke alarms to awaken children while monitoring sleep stage. The personalized parent voice smoke alarm at 100 dB successfully awakened 96% of children 6- to 12-years-old from stage 4 sleep with 83% successfully performing a simulated self-rescue escape procedure, significantly outperforming the 100-dB conventional residential tone smoke alarm. These findings suggest a clear direction for future research, as well as important fundamental changes in smoke alarm design, that address the unique developmental needs of children. The development of a more effective smoke alarm for use in homes and other locations where children sleep provides an opportunity to reduce fire-related morbidity and mortality among children.”<sup>4</sup>

A review of NFPA data and analysis was conducted to determine if the concerns expressed in these studies were contributing to higher than normal child fire death rates.

NFPA published a report, “Characteristics of Home Fire Victims”<sup>5</sup>, which evaluated fire loss and casualty data through 2005. The report concludes “The very old and the very young are at highest

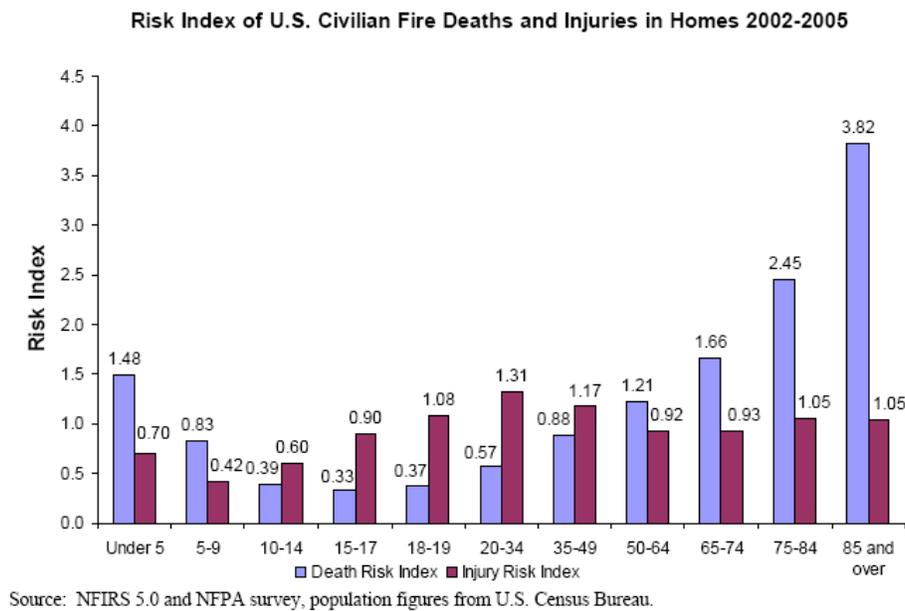
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<sup>4</sup> “Comparison of a Personalized Parent Voice Smoke Alarm With a Conventional Residential Tone Smoke Alarm for Awakening Children”

<sup>5</sup> “Characteristics of Home Fire Victims”, Jennifer D. Flynn, Fire Analysis and Research Division, National Fire Protection Association, July 2008

risk of death from home fires. Based on 2002-2005 experience data, children under age 5 are one and a half times as likely to die in a home fire as the general public. Older adults age 65 or over are more than twice as likely to die as the general public. Risk increases with age. Adults 85 and over have nearly four times the risk of fire death as the general public. Children defined as those aged 14 or under have average risk of fire death (10% below the all-ages average), as do children defined as those under age 18 (19% below the all-ages average).”<sup>6</sup>

The report included the following chart that defines the “risk index” by age group.



The risk index for an age group is the ration of that age group’s civilian fire deaths or injuries rate per million population to the civilian fire death or injury rate per million for all age groups combined. A risk index higher than 1.00 for a specific age group means that age group is at higher risk than the general public.<sup>7</sup>

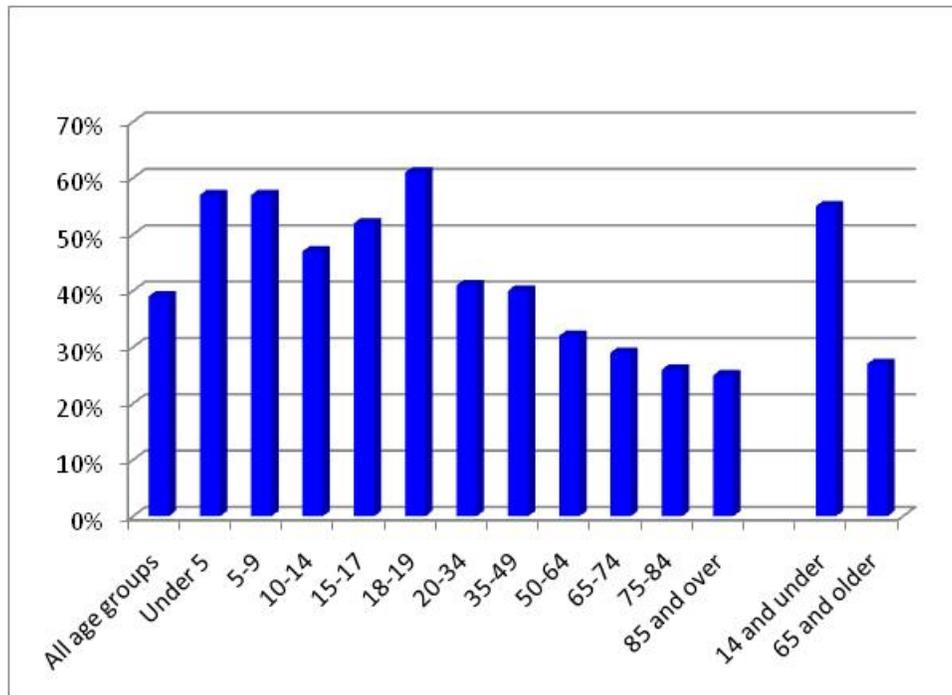
The report also evaluated fire casualties based on the activity of the victim. For the general population, 39% of home fire victims were asleep when fatally injured. The following chart shows

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<sup>6</sup> Characteristics of Home Fire Victims, page i

<sup>7</sup> Characteristics of Home Fire Victims, page 2

that percentages were higher for children than other age groups suggesting that smoke alarms may be less effective for these age groups.<sup>8</sup>



Not available is an analysis of whether there was a working smoke alarm present that operated for the fatalities included in the chart above. Further, there is no information available describing the location of the smoke alarm in relation to the victim. This analysis is essential to identifying the risk relationship between children and their sensitivity to standard smoke alarm alert signals.

## RECOMMENDATIONS

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Not enough is known yet to call for a major change in smoke alarm alert tones to address concerns about children not waking up to activations. However, there are several issues that should receive additional attention illustrated by the information available. The following recommendations address concerns identified by the study committee's research.

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<sup>8</sup> Characteristics of Home Fire Victims, page 55-57

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## **CONDUCT ADDITIONAL ANALYSIS OF FIRE LOSS DATA**

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Available data analysis does not demonstrate an increased risk to children from fire due to current smoke alarm alerting tones as described in the cited studies. However, fire loss data does suggest this may be a concern. More thorough analysis of available data could provide a better answer to the question.

The study committee recommends that a correlation be developed around the following analysis:

*Quantify the number of children (by age groups listed in the NFPA report) who were sleeping at the time of the fire and who had operating smoke alarms within the sleeping area.<sup>9</sup>*

This analysis should compare these age groups against other age groups to develop a risk index similar to the one listed previously in this report. This will provide a much better evaluation of whether the findings of the smoke alarm effectiveness studies translates to a real increased risk for children.

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## **ADDRESS RISK TO THE YOUNG AND PHYSICALLY CHALLENGED**

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It was clear from the committee's research that there is a very real risk to those in the population who are young or who are physically challenged. Research shows that escape times today are much shorter than escape times in the past due to the increased use of synthetic materials in household products. The concerns expressed in the findings of the smoke alarm effectiveness studies of children must be considered.

People with physical disabilities<sup>10</sup> are less able to respond quickly to the early warning of smoke alarms. Those with a hearing disability may be unable to rely on the warning sound of a conventional smoke alarm to alert them of fire. It is crucial that this audience is aware of the availability of flashing (strobe) or vibrating (tactile) smoke alarms, and the importance of proper home escape planning and practice.

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<sup>9</sup> Current practice recommends interconnected smoke alarms in all sleeping areas and on all floor levels to ensure audibility

<sup>10</sup> According to the US Census Bureau's *State and County QuickFacts* (2000), Oregon has 593,301 non-institutionalized persons with a disability, age five and older

Every home fire escape plan must be tailored to meet the needs of a given family. Parents and caregivers must know who will and who won't awaken to the sound of a smoke alarm and who are not able to escape by themselves. Parents should be aware of the concerns identified in the smoke alarm effectiveness studies. It is their responsibility to incorporate into their home escape plan how they alert children and those with physical disabilities. Local fire departments need to be sure this information is available and conduct educational outreach on these concerns as part of their regular and ongoing life safety education.

The study committee recommends that existing smoke alarm awareness programs be expanded to include:

- The importance of maintaining well placed working smoke alarms
- Greatly emphasize the responsibility of parents and caregivers to know who does not awaken to the sound of a smoke alarm or are physically challenged.
- Modify existing educational material and websites to reinforce these messages

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### **REINFORCE APPROPRIATE PLACEMENT AND INTERCONNECTION OF SMOKE ALARMS**

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63% of home fire fatalities occurred in homes without working smoke alarms. 36% occurred in homes with working smoke alarms. This, and other data, strongly suggests that additional lives can be saved through better smoke alarm placement and interconnection.

The National Smoke Detector Project found that 26% of the households surveyed had less than one alarm per floor. Additional households may have had too few smoke alarms to protect widely separated sleeping areas on the same floor. Researchers estimated that 43% of the households had less than one *working* smoke alarm per floor.

A 2000 study of 691 homes in rural Iowa found that 86% had at least one smoke alarm. The study also found that smoke alarms were not installed according to NFPA guidelines in 57% of the homes. In 85% of these cases (48% of the homes with at least one smoke alarm), a smoke alarm had not been installed on every level. The research also indicated that basements were the least likely level to have smoke alarms. Overall, only 22% of the homes were fully protected by smoke alarms according to these guidelines. Finally, homes that were poorly maintained, damaged, or cluttered

were less likely to have the full smoke alarm protection of working smoke alarms correctly installed on every level of the home.

Another explanation for people dying in fires due to the smoke alarm not activating is that the alarms may be placed incorrectly. That is, alarms may be obstructed or in a “dead air zone” where smoke particles are not able to reach the device.

The study committee recommends that public education campaigns be modified to strongly encourage placement of smoke alarms in accordance with recommended standards.