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Smoke Detector Nuisance Alarms: A Field Study in a Native American Community

Fires are the leading cause of unintentional death in the home for Native Americans. Although smoke detectors can reduce the risk of residential fire death by 40 percent or more, many detectors are disconnected because of frequent nuisance alarms.

Exceedingly high fire-related death rates make fires the leading cause of unintentional death in the home for Native Americans.[1] The fire death rate for Native Americans in the Aberdeen, South Dakota, Area of the Indian Health Service (IHS), for example, is six times greater than the rate in the United States for all races.[2] And the rate of nonfatal injuries due to residential fires may be as high as eight times the mortality rate.[3]

By providing early warning of a fire, a smoke detector can reduce the risk

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of residential fire death by 40 percent or more.[4] In fact, the U.S. Fire Administration has referred to smoke detectors as "potentially the most cost-effective tool we have for reducing deaths from fires."[5] This is especially true for rural communities, where volunteer fire departments and low population density can lead to long delays in firefighter response times.

However, one serious problem can reduce the efficacy of smoke detectors: disconnecting the devices because of frequent nuisance alarms. A nationwide survey of smoke detectors conducted by the Consumer Product Safety Commission (CPSC) found that 20 percent of smoke detectors installed in homes were inoperable. One-third of these had missing batteries or had been disconnected as a result of nuisance alarms.[6] Unfortunately, the situation was much worse at Arizona's Fort McDowell Indian Reservation, where a home survey found 51 percent of detectors inoperable. Fifty-six percent of these had been disconnected because of nuisance alarms.[7]

In 1995, we undertook a study to determine the rates of smoke detector usage and operability, and the factors associated with nuisance alarms in a Native American community within the Aberdeen Area IHS. The resulting recommendations for reducing nuisance alarms should increase the proportion of operable smoke detectors.

Our methods

We obtained approval to conduct this investigation from the Devils Lake Sioux Tribal Council and Tribal Health Administration.

The Devils Lake Sioux Reservation encompasses 274,322 acres in Benson County, North Dakota. The Bureau of Indian Affairs (BIA) estimates that 4,707 Native Americans live on the reservation. We chose St. Michaels District, one of four communities within the reservation, as the site for our study because it has diverse housing types and various economic strata.

The tribal sanitarian and a community health representative (CHR) surveyed St. Michaels to prepare a map of homes that included at least one enrolled Native American. We identified 240 such homes. We then verified home occupancy by consulting with community members, the BIA realty office, and township farm and home directories.

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We identified 112 smoke detectors in the 80 households that had detectors. Forty-four, or 48 percent, of these detectors weren't operable.

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The surveys were conducted from April 1 to June 30, 1995. A systematic sample consisted of unannounced visits to every other household for face-to-face interviews with the most knowledgeable adult present. When residents refused to be interviewed or weren't home after two visits, we visited the next-highest numbered household. In households in which at least one smoke detector had ever been present, we conducted full surveys. For households in which a smoke detector had never been installed, we conducted abbreviated surveys.

The survey included 26 questions, as well as physical measurements and visual observations. A nuisance alarm was defined as a smoke detector that sounded when there was no fire. Information collected during the interview included such characteristics as the size of the home, the occupants' ownership status, household demographics, the number and operability of smoke alarms, and a history of each detector's nuisance alarms.

We also measured the distances from the smoke detectors to ceiling/wall junctions and to potential nuisance sources such as stoves, bathrooms, and fireplaces. We visually inspected smoke alarms to determine their condition; their type, either photoelectric or ionization; their power source, whether battery, AC, or a combination; and the model.

We also noted whether the power source was connected. To assess detector operability, we replicated the procedures used in the CPSC national study.[8] Alarms were tested by pressing test buttons, where present, and by

TABLE 1

Characteristics of Surveyed Homes with Smoke Detectors (N=80)

Characteristic	Number	Percent
Home ownership		
HUD rental or mutual help	55	68.8
Private	25	31.3
Home type		
Single-family home	66	82.5
Mobile home	13	16.3
Apartment unit	1	1.3
Age of home in years		
0 to 14	29	36.3
15 to 29	37	46.3
More than 30	14	17.5
Area of main floor in square feet		
0 to 949	22	27.5
950 to 1199	40	50.0
More than 1,200	18	22.5
Heat source		
Natural gas	50	62.5
Electricity	16	20.0
Other	14	17.5
Primary cooking appliance		
Gas stove	41	51.3
Electric stove	38	47.5
Toaster oven/microwave	1	1.3
Households with a fireplace or wood stove	12	15.0
Households with at least one cigarette smoker	58	72.5
Households with at least one child under age 6	42	52.5
Households with at least one person over age 65	18	22.5
Annual household income[1]		
Less than $15,000 per year[2]	53	66.3
More than $15,000 per year	26	32.5

1. One respondent refused.
2. Poverty level for a family of four.

spraying them with a smoke-simulating aerosol.

Each full survey took approximately 45 minutes to complete. In homes without detectors, abbreviated surveys addressing home ownership and home type took less than 5 minutes to fill out.

During the statistical analysis of the survey results, Epi Info Version 6 statistical software was used to calculate Mantel-Haenszel chi-squares and Fisher exact tests for statistical significance ($p<0.05$).[9] We omitted photoelectric detectors from the statistical analyses of nuisance alarms because there were only three in the sample, and none had produced a nuisance alarm. We also omitted seven smoke detectors from certain analyses because they were in basements physically separated from cooking and steam nuisance sources.

The results

To obtain a 50 percent sample of the 240 homes, we visited 173 homes. Residents couldn't be contacted at 51 of the homes, and 2 respondents refused to participate. We completed full surveys in 80 homes that had at least one smoke detector and abbreviated surveys in 40 homes that had never had a smoke detector. Of the 120 homes surveyed, 66 were Housing and Urban Development (HUD) rental or mutual-help homes, and the remaining 54 were privately owned. There were 96 single-family dwellings, 23 mobile homes, and 1 apartment unit.

Of the 120 households surveyed, 40, or 33 percent, didn't have even one smoke detector. HUD homes were much more likely than privately owned homes to possess a smoke detector—83 percent versus 46 percent, respectively. Only 57 percent of mobile homes had smoke detectors, compared with 69 percent of single-family dwellings.

Table 1 summarizes the characteristics of the 80 households that had one or more smoke detectors. Natural gas was the primary heating source in 63 percent of the homes. Only 12, or 15 percent, of the homes had a fireplace or wood stove. In 73 percent of the homes, there was at least one cigarette smoker. Sixty-six percent of the households had incomes below the poverty level for a family of four, which is currently $15,000 per year. Twenty-three percent had at least one person over age 65 staying in the home on a regular basis, and 53 percent had at least one child under 6 years old. This is significant because young children and the elderly suffer the highest rates of death from residential fires.

In the 80 households that had detectors, we identified 112 smoke detectors (see Table 2). Most homes—71 percent—had a single smoke detector. In multilevel homes, only 9 percent had working smoke detectors on floors other than the first floor. Of the 112 detectors, 106 were ionization detectors, 3 were photoelectric, and 3 were of unknown detection source. Fifty-two de-

TABLE 2

Smoke Detector Characteristics of 112 Detectors in 80 Households

Characteristic	Number	Percent
Number of smoke detectors per household		
Homes with one smoke detector	57	71.3
Homes with two or more smoke detectors	23	28.8
Type of detection source		
Ionization	106	94.6
Photoelectric	3	2.7
Unknown	3	2.7
Type of power used to supply detector		
Battery	52	46.4
Electric	49	43.8
Electric with battery backup	11	9.8
Smoke detector placement		
Ceiling	67	59.8
Wall	43	38.4
Other	1	0.9
Smoke detector operability		
Homes in which none of the installed detectors were operable	30	37.5
Homes in which at least one detector was operable	50	62.5
Homes in which at least one detector was inoperable	36	45.0
Reasons for smoke detector inoperability (N=44)		
Battery removed or disconnected because of nuisance alarms	21	47.7
Electrical power disconnected because of nuisance alarms	10	22.7
Detector removed from premises because of nuisance alarms	7	15.9
Battery was removed for other reasons	3	6.8
Battery was dead	3	6.8

TABLE 3

Nuisance Alarms Among 109 Ionization Detectors in 80 Households

Characteristic	Number	Percent
Households reporting nuisance alarms	63	78.8
Ionization detectors with reported nuisance alarms	73	67.0
Number of nuisance alarms per detector in past 12 months		
1 to 3	18	24.7
4 to 24	21	28.8
More than 25	31	42.5
Unsure	3	4.1
Nuisance alarm causes (N=73)		
Cooking	56	76.7
Steam from bathroom	13	17.8
Fireplace/wood stove	3	4.1
Cigarettes	4	5.5
Chirping	1	1.4
Other	3	4.1
Unknown	5	6.8
Type of cooking cited for cooking-generated nuisance alarms (N=56)		
Frying	43	76.8
Baking	20	35.7
Boiling	5	8.9
Toaster/toaster oven	5	8.9
Other	5	8.9
Unknown	1	1.8

tectors, or 46 percent, were battery-powered; 49, or 44 percent, were hard-wired to an alternating current source; and 11, or 10 percent, were electrical with battery backup.

Forty-four, or 48 percent, of the 112 detectors were inoperable. In 86 percent of the cases, they'd been disconnected or their batteries had been removed as a result of nuisance alarms. In only three instances, the batteries had been removed for reasons other than nuisance alarms, such as for use in other devices. Another three detectors were inoperable because their batteries were dead. Among detectors experiencing nuisance alarms, battery-powered detectors were much more likely to be disconnected than electrical ones—78 percent versus 21 percent.

Combining the households that had never had any detectors with the multi-level dwellings that had fewer detectors than floors, households in which the wall detectors were improperly installed less than 4 inches or more than 12 inches from the ceiling/wall junction, and the homes with one or more inoperable detectors yields 104 households with absent or inadequate smoke detector coverage. That's 87 percent of the 120 households surveyed.

Nuisance alarms

There were only three photoelectric detectors in our survey, none of which had nuisance alarms. One trailer home had two of these detectors, each of which was paired with an ionization detector that was installed within 6 inches of it. Both of the ionization detectors sounded cooking nuisance alarms. In another home, the photoelectric detector was located 6 feet closer to the stove than an ionization detector, which had frequent nuisance alarms from cooking.

Because all the nuisance alarms occurred in the 109 ionization detectors, the following discussion refers only to those. Seventy-nine percent of households reported that one or more of their ionization smoke detectors suffered from nuisance alarms (see Table 3). These alarms occurred among 73, or 67 percent, of the detectors. In fact, some respondents stated that they had had hundreds of nuisance alarms in the previous year. Forty-nine percent of the respondents who reported nui-

Inspecting, Testing, and Maintaining Fire Alarm Systems Ensures Reliability

by Merton W. Bunker, Jr., P.E.

According to a recent NFPA study, 93 percent of homes in the United States had residential smoke detectors in 1994.[1] However, the detectors in 19 percent of all homes in the United States don't work, and nearly half the fire deaths recorded in the United States in 1994 occurred in homes that had smoke detectors. Failure of the power source accounted for 69 percent of the residential smoke detector failures reported in 1993, and most of the remainder were attributed to incorrect installations.

The number of operational detectors in nonresidential occupancies, which include places of public assembly, stores, offices, and educational facilities, is also declining, despite the fact that recent technological advances have produced larger, more intelligent, and more reliable fire alarm systems that need less maintenance than the systems of the past.

As the number of elements in any system increases, the likelihood of failure increases, even in systems whose components are individually reliable. Although new quality manufacturing practices have made fire alarm system components more reliable now than they were a few years ago, fire alarm systems still fail because they contain many devices installed over a large area—and because humans are involved. In fact, the number of unwanted alarms is on the rise.[2]

Since 1980, the number of fire department calls attributed to false alarms in the United States has nearly doubled to an all-time high of 1,646,500 in 1993.[3,4] Of these, 670,000 were directly attributable to fire alarm system malfunction. While this may be a small fraction of the total calls made, the hours the fire service has spent responding to unwanted alarms is significant—and so is the loss of life resulting from these unnecessary calls. From 1984 to 1993, 11 firefighters died while responding to false alarms.[5]

Lost productivity must also be considered part of the cost of malfunctioning alarm systems. Every evacuation that results from an unwanted alarm forces employees out of their work areas. The time spent away from work may only be a few minutes, but minutes multiply into hours very quickly when large numbers of people are affected.

Other costs, such as the psychological factor, may not be readily apparent. When inundated with frequent unwanted alarms, people tend to ignore them. And once occupants have learned this behavior, they may not evacuate the premises when a real fire triggers an alarm.

Fire alarm systems become more prone to false alarms as they age. Over the years, detectors become contaminated, suffer from sensitivity drift, and often become nests for insects. Linear beam and flame detector lenses become coated with airborne particulates. Waterflow switches may corrode and become contaminated by high mineral content in the water. And lead-acid batteries used as secondary power supplies may fail as the sulfide builds up between plates or their terminals corrode.

Fortunately, most alarm system failures can be prevented by adopting a rigorous inspection, testing, and maintenance program whose principles apply to household fire warning equipment, as well as to large commercial and industrial systems.

Testing the system

Although property owners are ultimately responsible for inspecting, maintaining, and testing their fire alarm systems, they're not obligated to do it alone. NFPA 72, *National Fire Alarm Code*, allows property owners to delegate this responsibility to a second party in the form of a written contract, copies of which must be presented to the authority having jurisdiction.

The owner or his or her designated representative should select a qualified service person or alarm service company that employs qualified personnel. Small systems using one type of equipment can be serviced by in-house personnel, who can be trained relatively inexpensively. If the system is very large or uses many different technologies, the owner may wish to subcontract maintenance service. If a central station service is used, the owner *must* contract with a listed sance alarms had subsequently disconnected the power source from the smoke detector.

Seventy-seven percent of the respondents also said that cooking was the cause of their nuisance alarms. Frying caused the majority, or 77 percent, of cooking nuisance alarms, followed by baking, which caused 36 percent. Boiling was responsible for 5 percent, toasting for 5 percent, and other cooking styles for 11 percent. The second leading cause of nuisance alarms, steam from bathrooms, was implicated in 18 percent of the alarms.

Cooking-related nuisance alarms were significantly related to the distance of the detector from the stove (see Table 4). The cooking-related nuisance rate was 68 percent for detectors less than 20 feet away, 58 percent for those 20 to 25 feet away, and 36 percent for detectors more than 25 feet from the stove. Regular reported use of a stove fan reduced the cooking-related nuisance alarm rate from 81 percent to 60 percent among detectors within 20 feet of the stove. Stove fans didn't affect the nuisance alarm rates for detectors 20 feet or more from the stove; 48 percent of alarms occurred in detectors when fans were present, and 50 percent occurred when fans weren't present.

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As might be expected, nuisance alarms caused by steam from bathrooms were related to the distance of the detectors from the bathroom door. The nuisance rate was 19 percent for detectors within 10 feet of the door. Among those located 10 feet or more from the bathroom door, none reported steam-related alarms. Use of a bathroom fan didn't decrease the nuisance alarm rate from bathroom steam.

Although 73 percent of households reported at least one cigarette smoker in residence, only 6 percent identified cigarette smoking as a cause of nuisance alarms. However, only 57 per-

company. NFPA 72 recognizes several types of qualifications, but one nationally recognized means of certification is the National Institute for Certification in Engineering Technologies (NICET) program.

Visual inspections should always be conducted before tests begin so that obvious problems can be identified and corrected. For example, smoke detectors that exhibit accumulations of dust may not meet the required functional or sensitivity tests and should be cleaned before the tests begin. Conditions that don't meet code requirements, such as detectors placed too close to the air stream of heating ventilation and air conditioning (HVAC) vents, should also be identified and corrected to ensure that the system will function as planned. Up-to-date record drawings should be used to verify that all the devices originally installed are still in place and that additional devices haven't been added since the last test.

Those conducting the tests must post the test schedules in a conspicuous location so that everyone in the facility will be aware when the system is being tested. Lobby signs, bulletin board notices, and e-mail messages are very effective. A backup plan should always include procedures to notify occupants if a real emergency occurs. Where possible, tests should be conducted when they won't interfere with the facility's daily activities.

When the occupancy type of a protected premises changes, the fire alarm system may have to be modified to reflect that change. For example, a warehouse that stores paper products is converted to a storage facility for drums of flammable liquids. The fire alarm system that was designed to detect a paper fire may not be appropriate to detect a flammable liquids fire. Older equipment should also be replaced when parts become unavailable or when repair costs become excessive.

Inspection, testing, and maintenance records should be kept for the life of the fire alarm system, as should records of unwanted alarms and their causes. One way to do this is to develop a maintenance management information system that will allow those responsible for the system to identify trends in component failures. It's also the owner's responsibility to ensure that record drawings are updated whenever the system is altered. Records should include changes to software.

Before any system is installed, its owner should ask about the costs of inspection, testing, and maintenance, and include these in the overall cost of the system or develop a budget to handle them as they're incurred. Testing and maintenance are crucial to the life of the system. It's pointless to install a state-of-the-art system that poor maintenance practices will render useless.

NFPA 72 provides the minimum requirements for a rigorous inspection, testing, and maintenance program. Chapter 7 tabulates all test methods and frequencies for inspecting and testing fire alarm systems. Table 7-2.2, which provides the methods personnel must use to conduct tests, is segregated by components of the fire alarm system. Table 7-3.1 provides visual inspection frequencies for each system component, and Table 7-3.2 provides testing frequencies for those components.

The costs associated with a maintenance program will almost always be smaller than the costs associated with a malfunctioning alarm system. Proper maintenance of a fire alarm system will ensure that it's reliable, functions as designed, and protects people and property from the effects of fire as intended.

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1. John R. Hall, Jr., "U.S. Experience With Smoke Detectors and Other Fire Detectors: Who Has Them? How Well Do They Work? When Don't They Work?," *NFPA Journal*, Vol. 88, No. 5 (September/October 1994).

2. Michael J. Karter, Jr., *False Alarm Activity in the U.S.*, 1993, National Fire Protection Association, Quincy, Mass., 1993.

3. Ibid.

4. *Fire Department Call Statistics 1980–1993*, National Fire Protection Association, Quincy, Mass., 1993.

5. *NFPA Reports on Firefighter Fatalities, 1984–1994*, National Fire Protection Association, Quincy, Mass., 1993.

were located less than 20 feet from the stove. Bathroom steam-related nuisance alarm rates decreased from 19 percent to 0 when detectors were located at least 10 feet from the bathroom door.

Several reports affirm our study's very limited data that photoelectric detectors are less likely to sound nuisance alarms than ionization detectors.[15,16,17,18] The Texas remote system study, for example, found that ionization detectors had an estimated 10 times as many nuisance activations from all sources as photoelectric detectors.[19] This is because ionization detectors are more responsive than photoelectric detectors to particles smaller than 1 micron, such as those contained in cooking smoke. The difference also explains why photoelectric detectors are somewhat more responsive to smoldering fires, which produce larger smoke particles, while ionization detectors are somewhat

TABLE 4

Ionization Smoke Detector Location and Household Fans as Factors in Nuisance Alarms

Characteristic	Detectors with Nuisance Alarms[3] (percent)	Detectors without Nuisance Alarms[3] (percent)	Statistical Significance
Distance from stove in feet[1]			
0 to 19.9	28 (28.3)	13 (13.1)	$p<.05$
More than 20	28 (28.3)	30 (30.3)	
Reported use of kitchen fan			
Yes	36 (36.4)	33 (33.3)	NS
No	20 (20.2)	10 (10.1)	
Distance from bathroom door in feet[2]			
0 to 9.9	13 (13.1)	54 (54.5)	$p<.01$
More than 10	0 (0.0)	32 (32.3)	
Reported use of bathroom fan			
Yes	11 (11.1)	51 (51.5)	NS
No	2 (2.0)	35 (35.4)	

1. Excludes seven smoke detectors in closed basements where no stove was present.
2. Excludes five smoke detectors in closed basements where no bathroom was present.

The Navajo Nation Fire Safety Awareness Campaign

by Jenna Von Dietsch

The fact that Native Americans have a fire death rate four to five times the U.S. national average makes them perfect candidates to benefit from the expertise of NFPA's Center for High-Risk Outreach. Studies have shown that Native Americans are dealing with the same fire safety problems as people in the rest of the country—but on a larger scale. The Center is working with several groups in the Navajo Nation to decrease their fire risk through increased awareness and educational programs.

The Navajo Nation consists of 170,000 people, making it the largest Native American reserve, with Navajo reservation land in Arizona, Utah, and New Mexico. Combined geographically, the Navajo Nation works out to be about the size of West Virginia.

In 1995, there were 83 major home fires on Navajo Nation reservation land. In these, 82 homes were completely destroyed, leaving more than 400 people homeless.

Knowing that something needed to be done, Peter Flores, fire marshal of the Bureau of Indian Affairs (BIA) in New Mexico called the Center for High-Risk Outreach (then the Learn Not to Burn Foundation). Flores and Alfred Abeita, BIA Safety Branch chief, were invited to participate in several training seminars in Mississippi, where the LNTB Program was being implemented in the school system. The BIA representatives liked what they saw, and Flores asked the Center to come to the Navajo Nation.

Last September, Jan Stansky, a consultant to the Center, ran LNTB and public education training for BIA firefighters and preschool and elementary school teachers.

Unfortunately, it took a tragedy to build widespread support for these fire safety efforts. In January 1996, four people, a mother and her three children, died in a mobile home fire in Fort Defiance, Arizona. The blaze started in a wood stove that was used for heating. This incident reinforced the importance of fire safety education, and soon after the fire, the Navajo Nation Interagency Fire Safety Coalition was formed by the BIA's Safety Management Team. In February, Sharon Gamache, the Center's director, and Mary Nachbar, NFPA fire safety education representative, started to help the coalition plan its strategy at a meeting in Window Rock, Arizona. They also donated educational materials, including posters and radio public service announcements. Many of these materials were used at a health fair held on the reservation.

The coalition is made up of a number of groups, including the Navajo Tribal Office, the Indian Health Service, the Bureau of Indian Affairs Fire Service and Public Safety Office, the Navajo Police, the Navajo Tribal Fire Department, the Bureau of Indian Affairs Forest Service, the Parks Department, and Emergency Medical Services. Members of the coalition meet monthly, constantly reassessing their efforts.

The Center is working with this coalition to help its fire education strategy. Specifically, the coalition will implement the LNTB program. It will also work on a campaign to involve the whole Navajo Nation through public awareness and education. Proper use of wood stoves and other heating systems, smoke and carbon monoxide detectors, and other prevention subjects will be targeted.

The fire safety efforts of the coalition will gain official support when Albert Hale, president of the Navajo Nation, signs a declaration making that day the beginning of the Navajo Nation's Fire Safety Awareness Campaign. Also signing the declaration will be John Hubbard, area director of the Navajo Area Indian Health Services, and Wilson Barber, Jr., area director of the Bureau of Indian Affairs.

The coalition's long-term goals involve reducing the number of fires and fire losses. In the meantime, coalition members have already accomplished something just as important—they've recognized the problem, and they're working to rectify it.

more responsive to flaming fires, which produce smaller smoke particles.[20]

Because careless smoking is the leading cause of ignition in fatal house fires and unattended cigarettes almost always ignite smoldering fires in furniture or bedding, photoelectric detectors would be preferrable for the St. Michaels community, where 73 percent of households have one or more cigarette smokers.[21,22,23,24]

Only two smoke detectors in our study had "hush buttons," which allow a person to silence the smoke alarm for several minutes. Hush buttons are less than an ideal solution to the nuisance alarm problem for at least two important reasons. First, frequent nuisance alarms from ionization detectors will still be annoying and will eventually prompt many owners to disconnect the power source. And second, owners often find it easier to remove the battery than to repeatedly push the silencer button when smoke exposure is sustained, as it is during cooking.[25]

Our conclusions

New technology will reduce nuisance alarms by having detectors sense heat signatures before they set off an alarm.[26] Until this technology is widely available, however, we favor photoelectric detectors to reduce rates of nuisance alarms from cooking and to provide optimal protection from cigarette-related fires. Electrical detectors with battery back-up are the detectors of choice, except in communities, such as remote villages in Alaska, where alternating current electricity is nonexistent or unreliable. If ionization detectors are installed, they should be located at least 20 feet, and preferably more than 25 feet, from stoves and at least 10 feet from bathroom doors, if possible. Future studies should evaluate the cost-effectiveness of hardwired photoelectric detectors; the optimal placement of detectors to balance early warning of fires with reduced rates of nuisance alarms; and the value of regulatory, engineering, and social marketing approaches to increase the acceptance, correct installation, and maintenance of smoke detectors.

Study Limitations

Problems in recall may reduce the accuracy of responses to the number of nuisance alarms sounded in the past year, the ages of the houses and detectors, and the reasons for nuisance alarms. In addition, several factors limit the degree to which one can generalize from our results. Rates of nuisance alarms will vary among communities, depending on the types of detectors installed, the distance of the detectors from the nuisance sources, and other environmental factors, such as room size and geometry, cooking styles, ambient temperature, and humidity. Finally, the small sample size of some variables, such as mobile homes, homes whose main floors are more than 1,200 square feet, and homes with fireplaces or wood stoves, limits analysis of the impact these variables have on nuisance alarms.

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