

# SMOKE ALARMS – PILOT STUDY OF NUISANCE ALARMS ASSOCIATED WITH COOKING (ABRIDGED)

Arthur Lee (engineer) and Danny Pineda (student intern)<sup>1</sup>  
US Consumer Product Safety Commission, Bethesda, Maryland

**ABSTRACT** ● **Objective** To measure the rate of nuisance alarming for residential smoke alarms with different smoke-detecting sensors with respect to distance from the main cooking source (kitchen stove), cooking method, food cooked, and mealtime in actual household settings. ● **Design** Exploratory split-split plot. ● **Setting** Kitchens in nine various-aged residences in the Washington, DC area between March 2008 and November 2008. ● **Participants** Nine households that volunteered to be part of the study. ● **Intervention** Groups of smoke alarms were installed at selected distances from the kitchen stove for approximately 30 days. Each group of smoke alarms consisted of an ionization, a photoelectric, and a dual-sensor smoke alarm from one of two different manufacturers. An automated data capture system monitored and recorded alarm status; occupants recorded their cooking events in a logbook. ● **Main outcome measures** Information that quantified the number and rate of nuisance alarms for different smoke-detecting technologies to determine their sensitivity to installed location relative to the kitchen stove and to various cooking routines, such as cooking methods, foods prepared, and mealtimes. ● **Results** For smoke alarms 5 feet from the stove, nuisance alarms occurred during 8.7% (41/469) of cooking events for ionization, 11.3% (53/469) for dual-sensor, and 3.0% (14/469) for photoelectric smoke alarms. At 10 ft. from the stove, nuisance alarms occurred during 4.9% (23/469) of cooking events for ionization, 8.7% (41/469) for dual-sensor, and 6.0% (28/469) for photoelectric smoke alarms. At 20 feet from the stove, nuisance alarms occurred during 1.1% (5/469) of cooking events for ionization, 1.1% (5/469) for dual-sensor, and 0.9% (4/469) for photoelectric smoke alarms. ● **Conclusions** Regardless of the smoke alarm type, placing the smoke alarm more than 10 ft. to 15 ft. from the stove considerably reduced the number of nuisance alarms. Smoke alarms placed 20 ft. from the cooking source rarely resulted in nuisance alarms. For a smoke alarm located closer than 10 ft. to 15 ft. to a cooking appliance, a photoelectric type smoke alarm produced the fewest nuisance alarms. The type of food prepared and the cooking method used influenced whether a smoke alarm activated (e.g., sautéing, pan frying, and stir frying produced many more nuisance alarms than other cooking methods). The rate of nuisance alarms during preparation of dinner was higher than during other mealtimes.

In 2005, there were an estimated 375,100 unintentional residential structure fires resulting in 2,630 deaths, 12,820 injuries and \$6.22 billion in property loss.[1] Based on a telephone survey conducted in 2004, 96% of all homes have at least one smoke alarm. Overall, three-quarters of all U.S. homes have at least one working smoke alarm. Yet from 2000-2004, smoke alarms were not operating or were intentionally disabled in almost half (46%) of the reported home fires.[2] Nearly 20% of the smoke alarms installed in U.S. homes have been disabled due to dead or missing batteries.[3,4,5,6,7,8,9,10,11] Nuisance alarms are reported to be the leading cause of residential occupants disabling their smoke alarms.[3, 4,5,6,7,8,9,10,11] According to the National Fire Protection Association (NFPA), the most commonly reported reason for occupants disabling a smoke alarm is nuisance alarms associated with cooking.

The number of disabled smoke alarms could very well be on the rise as more families cook at home mainly because of the increasing population in the United States. In 2005, it was reported that most Americans cooked dinner at home most nights of the week.[12] Approximately 43% of Americans cooked six to seven nights a week. Household size also affects the frequency of cooking. The larger the household size, the higher the tendency to cook. If the household consisted of only two people, at least one meal a day was cooked 72.1% of the time. The percentage rose with each additional person; 89.4% of households with six or more people cooked at least once a day.[13]

What is a nuisance alarm? A nuisance alarm is an

unwanted activation of a smoke alarm in response to a stimulus that is not the result of a potentially hazardous fire. During a nuisance alarm, the smoke alarm sensor operates, and it is usually a true indication of the present state of the sensor. Even though the smoke alarm is alarming to a non-hazardous source, the smoke alarm is detecting particles that may not be visible to the occupant and, therefore, the occupant may perceive the alarm activation as inconvenient, annoying, or vexatious.

In this pilot study, CPSC staff examined the rate of nuisance alarms for different smoke detecting technologies in smoke alarms and how it may relate to the distance from the cooking source and to various cooking routines, such as cooking methods, foods cooked, and mealtimes.

## METHODS

The study used stand alone battery operated smoke alarms from two different manufacturers, and three different types of smoke alarms (ionization, photoelectric, and dual sensor).

From March to November 2008, three groups of smoke alarms were installed at distances of 5 ft., 10 ft., and 20 ft. from the main cooking appliance in nine different test homes for 30 days (The last home was tested for 60 days with additional smoke alarm locations at 3 ft, 7.5 ft., and 15 ft.) Each group of smoke alarms consisted of an ionization, a photoelectric, and a dual-sensor smoke alarm. For each of the first eight homes, nine smoke alarms from one manufacturer (either manufacturer A or manufacturer B) were used for the entire suite of smoke alarms installed in a home. For the ninth

<sup>1</sup>The views expressed in this report are those of the CPSC staff and have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission. This document was prepared in the authors' official capacities and may be freely copied.

home, thirty-six smoke alarms from both manufacturers were used. The sound transducers of all the test smoke alarms were disabled during the test period to prevent occupants from hearing the alarms, but the signals were fed to a data acquisition system that recorded the time and date of all activations.

Eight of the homes were single family homes and one home was an attached townhouse. The average age of the homes was about 30 years old. The newest home was 8 years old, and the oldest home was 82 years old. Six homes used natural gas for the range/oven, and three homes used electric ranges/ovens. All the homes had freestanding range/ovens. None of the homes in the study used a mixed supply for their oven and stove (e.g., gas range with electric oven). Seven homes contained exhaust hoods that could exhaust cooking fumes to the outside. One home had a recirculating exhaust hood; and the other home did not have any exhaust hood, but there was a window adjacent to the stove.

Participants were required to keep a daily log of their cooking behaviors, including times of cooking, cooking methods used, and foods that were cooked.

For all of the homes included in the study, there were at least two occupants living in the home; the number of occupants for all homes ranged from two to six. The occupants included children 12 years old and younger, adults between 30 and 50 years old, and adults over the age of 50 years.

There were a total of 358 cooking events recorded for the nine homes. For the first eight homes, the number of cooking events was similar between manufacturers (123 cooking events with manufacturer A and 124 cooking events with manufacturer B). Home 9 had 111 cooking events. To normalize the cooking events, home 9, which contained smoke alarm from manufacturers A and B, the number of cooking events was doubled to 222.

Analysis for all homes indicated that the number of nuisance alarms was highest for smoke alarms at a distance of 5 feet from the cooking appliance, with dual-sensor smoke alarms causing the most nuisance alarms 11.3% (53/469). Nuisance alarms occurred during 8.7% (41/469) of cooking events for ionization and 3.0% (14/469) for photoelectric smoke alarms 5 feet from the stove. A decline to infrequent nuisance alarms was observed at 20 feet for all smoke alarm types, 1.1% (5/469) nuisance alarms for ionization, 1.1% (5/469) for dual-sensor, and 0.9% (4/469) for photoelectric smoke alarms. At 10 ft. from the stove, nuisance alarms occurred during 4.9% (23/469) of cooking events for ionization, 8.7% (41/469) for dual-sensor, and 6.0% (28/469) for photoelectric smoke alarms. The ionization and dual-sensor smoke alarms showed declines in activations as the distance from the cooking appliance increased, as might be

expected; but the photoelectric smoke alarms showed an unexpected slight increase in activations at a distance of 10 ft., before declining at 20 ft. This was attributed to data from home 9, which may have been caused by more frequent exhaust fan usage (8.7% homes 1 to 8, 48% home 9) than the other homes and/or a higher percentage (21.4% homes 1 to 8, 50.8% home 9) of sautéing, pan and stir frying cooking events.

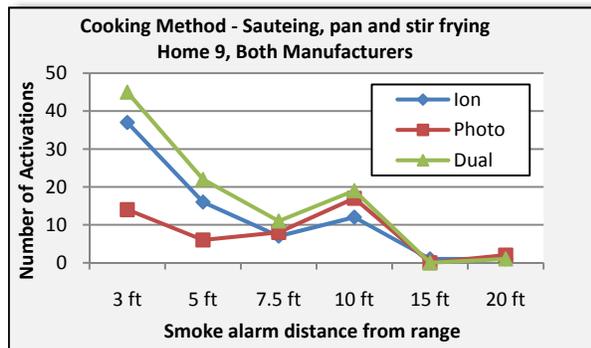
Dinnertime had the most cooking events (49%, 176/358), and breakfast time had the second most cooking events (30%, 108/358). Lunchtime had the fewest cooking events (12%, 43/358), as expected since, in eight of the nine homes tested, both parents worked outside the home. The number of cooking events at dinnertime was 176 and 221 normalized. At dinnertime, the dual-sensor smoke alarms had the highest percentage (16.7% 37/221) of activations at 5 ft., followed by the ionization (12.7% 28/221) and the photoelectric smoke alarms (5.9% 13/221). At 10 feet, the percentage of activations decreased for the ionization and dual-sensor smoke alarms (7.7% 17/221 and 13.6% 30/221, respectively), but increased for the photoelectric smoke alarms (10.9% 24/221). At 20 ft., the percentage of activations was similar for all smoke alarm types (~ 2%).

The cooking method played as important a role in the number of smoke alarm activations as did the locations of the smoke alarms. The analysis of cooking methods was conducted using data from home 9, since it contained smoke alarms from both manufacturers A and B and provided the greatest detail in the cooking log. The cooking methods from home 9 were divided into four categories: frying, toasting, baking, and boiling. Stove frying included sautéing, pan frying, and stir frying using a pan, pot, or wok on the stove. This type of cooking typically consisted of browning meats or vegetables using enough oils to coat the cooking surface. Toasting consisted of using a toaster or toaster oven to heat items, such as bread products or small portions of meat, placed in these portable appliances. Baking consisted of cooking in the main oven. Boiling included boiling, simmering, and steaming a large amount of liquid for cooking. This included items such as pasta, soups, vegetables, and shell fish. The microwave oven was used to reheat foods, but there were no records of using the microwave oven to cook meals. There were 189 identified cooking methods in the 111 cooking events.

For home 9, the photoelectric smoke alarms had the fewest activations (37%, 70/189) for all cooking methods. The ionization (65.1%, 123/189) and dual-sensor (63.5%, 120/189) smoke alarms had similar numbers of activations. Pan and stir frying were associated with more activations (219) than other cooking methods (82 – boiling, simmering, 61 – baking, and 58 – toasting).

Variable	All Homes	Homes 1 to 8	Home 9
Cooking events	358 (normalized 469)	247	111
Ionization alarms (5,10,20 ft)	8.7% (41), 4.9% (23), 1.1% (5)	8.5% (21), 4% (10), 1.2% (3)	9% (20), 5.9% (13), 0.9% (2)
Photoelectric alarms (5,10,20 ft)	3% (14), 6% (28), 0.9% (41)	2% (5), 1.2% (3), 0.8% (2)	4.1% (9), 11.3% (25), 0.9% (2)
Dual alarms (5,10,20 ft)	11.3% (53), 8.7% (41), 1.1% (5)	8.5% (21), 7.3% (18), 0.4% (1)	14.4% (32), 10.4% (23), 1.8% (4)
Cooking events per mealtime (dinner, lunch, breakfast)	221, 53, 149 (normalized)	131, 33, 67 (normalized)	90, 20, 82 (normalized)
Dinner activations (5, 10, 20 ft)	35.3% (78), 32.1% (71), 6.3% (14)	26% (34), 19.9% (26), 4.6% (6),	53.7% (44), 54.9% (45), 9.8% (8)
Lunch activations (5, 10, 20 ft)	15.1% (8), 1.9% (1), 0% (0)	21.2%, (7), 3% (1),0% (0),	5% (1), 0% (0), 0% (0)
Breakfast activations (5, 10, 20 ft)	14.1% (21) 13.4% (20), 0% (0)	7.5% (5), 6% (4), 0% (0),	19.5% (16), 19.5% (16), 0% (0)

For sautéing, pan and stir frying method in home 9, the dual-sensor and ionization smoke alarms at 3 ft. had 37 and 45 activations, respectively. The photoelectric smoke alarms had the least activations (14) at 3 ft. For all smoke alarm types, the number of activations decreased at 5 ft. (16 – ion, 6 – photo, 22 – dual) compared to the number of activations at 3 ft. At 10 ft., the number of activations increased (12 – ion, 17 – photo, 19 – dual) from 7.5 ft. (7 – ion, 8 – photo, 11 – dual) before dropping to 2 or less activations at 15 ft. and 20 ft.



## LIMITATIONS

In this investigation, the number of homes was limited, and the homes were not selected randomly (i.e., the study was limited to CPSC employees or their acquaintances). The homes do not represent a statistical sample nor were they representative of homes in the U.S. in general, but they do offer some insight into the frequency of nuisance alarms for a variety of cooking behaviors.

CPSC staff identified and tested only two manufacturers that produce and sell all three types of smoke alarms (ionization, photoelectric, and dual-sensor) and the data does not necessarily represent a statistical sample of all smoke alarms sold in the U.S.

Cooking behavior can vary greatly between homes for many reasons, such as ethnic background, age of the occupants, household size, availability of food type, and geographical location. Cooking behavior may vary seasonally due to weather, changes in activity, and availability of foods, these variations were not explored under this evaluation.

The test objectives did not include determining the propensity of an occupant to disable a smoke alarm. To discourage evaluation participants from disabling a smoke alarm due to frequent nuisance alarms, the sound transducers for the smoke alarms were disabled during the test duration.

## DISCUSSION

From the CPSC staff tests, any smoke alarm placed too close to a cooking source caused nuisance alarms. The type of food cooked and the cooking method used influenced the number of nuisance alarms. Sautéing, pan frying, and stir frying produced many more nuisance alarms than other cooking methods, mostly attributed to the higher frequency of cooking. This type of cooking typically uses high heat and oils that can cause small water and oil droplets to travel extended distances. Baking produced a higher percentage of nuisance alarms. However, all smoke alarm types that were less than 10 ft. to 15 ft. from the cooking appliance were susceptible to nuisance alarms, regardless of the cooking method used.

Dinnertime produced almost twice the number of smoke alarm activations as other meal times. This was expected

since, typically, there are greater amounts of food cooked and cooking times tend to be longer than other mealtimes.

Regardless of the smoke alarm type, placing the smoke alarm at least 10 ft. to 15 ft. from the main cooking appliance reduced the number of nuisance alarms. For the CPSC staff test, smoke alarms placed closer than 10 ft. to 15 ft. to a cooking appliance, photoelectric smoke alarms produced the fewest number of nuisance alarms, and photoelectric types also had the least variation in performance for the two manufacturers tested. For these tests, the performance of dual-sensor and ionization smoke alarms varied between manufacturers in sensitivity to cooking particles when installed within 10 ft. to 15 ft. of a cooking appliance.

Additional research on a larger sample size may be necessary to achieve a more accurate representation of the general population. Factors in an expanded research effort could include additional cooking behaviors, various kitchen configurations (e.g., different ceiling heights), exhaust fan usage, and additional smoke alarm locations. An evaluation of the effects of exhaust fan usage should include an investigation of whether the exhaust fan affects nuisance alarms and detection of cooking fires at various distances from the cooking appliance. The CPSC staff study did not evaluate the effectiveness of smoke alarms from cooking fires. It is important to examine the effects of smoke alarm location on detecting a cooking fire to balance nuisance alarms and life safety in the event of a cooking fire.

CPSC staff acknowledges the contributions by the participants that opened their homes for this study.

## References

- [1]Chowdhury, R. et al. August 2008. *2003-2005 Residential Fire Loss Estimates*. U.S. National Estimates of Fires, Deaths, Injuries, and Property Losses from Unintentional Fires. Washington DC: U.S. Consumer Product Safety Commission.
- [2]Ahrens, M. April 2007. *US Experience with Smoke Alarms* Other Fire Detection/Alarm Equipment. Quincy, MA: National Fire Protection Association.
- [3]Ahrens, M. (2004). "False Alarms and Unwanted Activations" from U.S. Experience with Smoke Alarms and Other Fire Detection/Alarm Equipment. *National Fire Protection Association*. Quincy, MA.
- [4]DiGiuseppi C., et al. (2002). Incidence of fires and related injuries after giving out free smoke alarms: cluster randomized controlled trial. *BMJ*, 325, 995-999.
- [5]DiGiuseppi, C., Roberts I., & Speirs N. (1999) Smoke alarm installation and function in inner London council housing. *Arch Dis Child*, 81, 400-403.
- [6]Fazzini, T., Perkins, R. & Grossman D. (2000). Ionization and photoelectric smoke alarms in rural Alaskan homes. *West J. Med*, 173, 89-92.
- [7]Istre G. & Mallonee S. (2000) Commentary, Smoke alarms and prevention of house-fire-related deaths and injuries. *West J Med*, 173, 92-93.
- [8]Kuklinski D., Berger L., & Weaver J. (1996). Smoke Detector Nuisance Alarms: A Field Study in a Native American Community. *NFPA Journal*, 90(5), 65-72
- [9]Ludington J. & Newsad R. (2000). Home Safety Assessment/Intervention in American Indian Homes in California: A role for IHS engineering staff. *Journal of Environmental Health*, 13-18.
- [10]Roberts H., et al. (2004). Putting public health evidence into practice: increasing the prevalence of working smoke alarms in disadvantaged inner city housing. *J Epidemiol Community Health*, 58, 280-285.
- [11]Rowland D., et al. (2002) Prevalence of working smoke alarms in local authority inner city housing: randomized controlled trial. *BMJ*, 325, 998-1001.
- [12]CBS News, [www.cbsnews.com](http://www.cbsnews.com). How and Where Americans Eat, New York, November 20, 2005. Downloaded on February 27, 2008.
- [13]Energy Information Administration, Department of Energy, 2001 Cooking Trends in the United States: Are We Really Becoming a Fast Food Country? <http://www.eia.doe.gov>. Downloaded on February 27, 2008.