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Use of Kitchen Ventilation: Impact on Indoor Air Quality

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Abstract

Indoor air and human health are major housing issues. Biological pollutants, such as molds, are health threats. These pollutants require a moist environment. Regular use of kitchen exhaust ventilation systems can help control excess moisture in the home. As part of a comprehensive study of kitchen design and usage, 78 households in a purposive sample were interviewed about their use of kitchen ventilation systems. Despite the fact that participants regularly and frequently cooked, about one-third rarely ventilated when using the cook top and almost half never ventilated when using the oven. Results of the study suggest that cooks who do use ventilation systems use them to solve cooking problems and not to prevent indoor air quality problems, like those that result from not controlling moisture. Consumers need to better understand the value of kitchen ventilation systems, and how to use them effectively to improve indoor air quality.

Introduction

The quality of indoor air, and its effect on human health, is an issue of major importance in the field of housing. Recently, molds and other biological pollutants in indoor air have received considerable media attention. Litigation and insurance claims have increased as homeowners become concerned about damage from mold, both to the physical structure of the home and to the health of the occupants. The incidence of allergies and asthma has increased, especially among children. Families have learned that biological pollutants, such as molds and dust mites, can exacerbate problems with these illnesses.

Molds, dust mites, and other biological pollutants are naturally occurring in the air, structure, and furnishings of a home. However, to grow to abundance and become a health threat, they require a moist environment. For example, dust mites need a relative humidity of at least 45 percent to

50 percent. Most molds will grow at a relative humidity of over 60 percent. Therefore, adequate control of moisture in the home is necessary to control biological pollutants.

Background: Moisture sources in the home

Moisture in the home is a complex subject. An interaction of many factors -- such as climate, lifestyle of the occupants, construction, mechanical systems, and ventilation -- influences moisture problems. There are many potential sources of excess moisture in a home, including cooking, drying clothes, plants, showering, and bathing. The Canada Mortgage and Housing Corporation (2002a) estimate that the various activities of occupants of a home will generate 2 to 10 gallons of moisture every day. The occupants themselves are a moisture source, with an estimated 3 pounds (pints) of water vapor being produced daily by a typical household of 4 people (USEPA, USPHS, and NEHA 1991).

One area of the home where moisture is generated is the kitchen. Although most experts recommend controlling moisture in the kitchen, it is difficult to find information on just how much moisture is generated in the kitchen and how moisture in the kitchen impacts on moisture problems in the home.

Moisture is generated in a kitchen through cooking. Boiling or simmering of foods on a cook top is particularly a problem (Pickett et al. 1986). In addition, microwave ovens and conventional ovens remove moisture from food and vent it into the kitchen space. The amount of moisture released in cooking will vary, dependent on the type of food, whether or not the food is covered while cooking, and the length and temperature of cooking. Gas cooking appliances will increase the moisture generated as water vapor is a byproduct of gas combustion.

The Cold Climate Housing Information Center at the University of Minnesota estimates that cooking a dinner for a family of four releases 1.22 pints of water into the air (Angell and Olson 1988). This amount more than doubles if a gas range is used (Table 1). The type of cooking appliance -- cook top, range, microwave oven, or oven -- was not identified.

Table 1. Moisture released from cooking sources

Cooking Activity	**Moisture Released: Electric**	**Moisture Released: Gas**
Breakfast for 4 people	0.35 pints	0.93 pints
Lunch for 4 people	0.52 pints	1.23 pints
Dinner for 4 people	1.22 pints	2.80 pints

Simmer, 6-inch pan (10 minutes)	0.1 pints covered 0.13 pints uncovered	
Boil, 6 inch pan (10 minutes)	0.48 pints covered 0.57 pints uncovered	

Source: Angell and Olson 1988

Shuman (1985) also identifies cooking as a major source of household moisture, estimating 0.92 liters (0.44 pints) for electric cooking and 2.15 liters (1.02 pints) for cooking with gas by a typical family of four. Unfortunately, the time period is not identified, although the data is presumed to be per meal. Again, the type of appliance is not identified.

Using the data from Table 1, cooking can be estimated to put 2 or more pints of water vapor into the air in a typical day. Other moisture sources in a kitchen can include dishwashing (1.05 pints a day) and refrigerator defrosting (1.03 pints per day) (Angell and Olson 1988). To put this amount of moisture into context, consider that it takes only 4 to 6 pints of water vapor to raise the humidity level of a 1000 square foot house by 5 percent (Murphy 1999).

Recommendations to control moisture in the home usually include using exhaust ventilation in the kitchen. For maximum effectiveness, the exhaust ventilation should be near the cooking appliance (Bode 1999; CMHC 2002b; HVI 2001; USEPA 2002; USEPA and USCPSC 1993).

Background: Kitchen ventilation systems

Mechanical ventilation systems in kitchens are often not required by building codes (Kimball 1998; Manclark 1999). For example, a New York study found that only 67 percent of homes surveyed had kitchen exhaust fans (NYSERDA 1998). Although a window may be adequate to meet code requirements, most kitchen designers, as well as indoor air quality experts believe that a mechanical ventilation system is necessary in the kitchen.

In contemporary kitchens, the choices are usually between a fan mounted above the cook top or range, usually with a hood (updraft), or a proximity system, installed in the cook top, or adjacent to the cooking surface (downdraft). Some kitchens may have a ceiling or wall mounted exhaust fan, but that type of system is generally not considered as effective as the updraft or downdraft systems.

Kitchen ventilation systems are usually located over the cook top, considered the primary source of odors, grease, and moisture. An oven in a range typically vents through a burner on the cook top, putting moisture and odors in the vicinity of the ventilation system. A built-in or wall oven typically vents to the front of the appliance, into the room air. A microwave oven, which may vent to the front, side, or back, is usually not placed near the kitchen ventilation system.

Canopy or updraft ventilation systems can be a recirculating system or an exhaust system. Downdraft ventilation systems are all exhaust systems. A recirculating system pulls the air through a filter then returns the air to the room. The filter may be a simple grease filter screen or include a carbon type filter to remove odors. Moisture and heat are not removed. Combustion pollutants from gas cooking, including carbon monoxide and water vapor, may not be removed. Recirculating systems are less expensive and easier to install, but less effective. Exhaust systems, on the other hand, remove air as well as heat, moisture, odors, and grease from the kitchen to the outside.

There are many variables involved in designing an effective exhaust ventilation system for the cooking area in a kitchen. The authors recommend that the following variables be considered:

- Type of cooking
- Type of cooking appliance
- Type of cooking fuel
- Location of the range and/or cook top within the kitchen
- Size and location of the hood, if used
- Size and length of ducts needed to connect from the fan to the exterior vent
- Type and size of fan used in the system
- Make-up or replacement air available to the fan

Ventilation efficiency. Generally, a range hood with an exhaust fan vented to the outside (updraft) is considered the most effective system (Kimball 1998; McDonald, Geragi, and Cheever 1996). The hood helps capture the pollutants, such as moisture and grease, before they disperse in the air in the kitchen. The placement of the fan above the cooking area takes advantage of the natural rise of the heated air. The size of the hood and its distance above the cooking surface are important factors to consider.

A downdraft system can be an effective alternative for grilling, frying, and other cooking from shallow pots and pans. The downdraft system, including those with "pop-up" vents, captures pollutants near their source. A larger fan is required in a downdraft system because there is no hood to help capture the cooking byproducts.

When a cooking appliance is against a wall, ventilation is more effective. Ventilation systems for ranges and cook tops that are in open islands or peninsulas require larger fans.
Effective ventilation is more critical with a gas cooking system. With gas cooking, there are byproducts of combustion, such as carbon monoxide. In addition, gas combustion produces water vapor, so moisture is more of an issue with gas cooking. Commercial style gas ranges, in particular, need larger capacity ventilation systems.

Duct work can alter the efficiency of a ventilation system. The longer the duct run, the more turns or angles, and the smaller the duct, the less efficient the system. A larger fan may be needed to compensate.

Fan size. Most kitchen design experts recommend a ventilation fan that is sized according to the recommendations of the Home Ventilating Institute (HVI 2001) or the National Kitchen and Bath Association (McDonald, Geragi, and Cheever 1996). The minimum recommendations of the Home Ventilating Institute are comparable to that of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 62 (ANSI/ASHRAE 1999). Although these requirements are determined somewhat differently, the recommendations are similar (Table 2).

oth the Home Ventilating Institute (HVI 2001) and the National Kitchen and Bath Association (McDonald, Geragi, and Cheever 1996) recommend that downdraft systems need larger fans to compensate for the lack of a hood, but do not specify a size. The Home Ventilating Institute recommends following the manufacturer's recommendation (HVI 2001).

Table 2. Recommendations for kitchen ventilation fans

Recommendation			**Fan needed for a typical 30-inch range**
Home Ventilating Institute	**Hood placed along a wall**	**Minimum: 40 CFM per lineal foot**	100 CFM
		Recommended: 100 CFM per lineal foot	250 CFM

	Hood above an island or peninsula (no wall)	**Minimum: 50 CFM per lineal foot**	125 CFM
		Recommended: 150 CFM per lineal foot	375 CFM
National Kitchen and Bath Association	**Hood placed along a wall**	**50 to 70 CFM x the area of the hood in square feet**	250 CFM to 350 CFM
	Hood above an island or peninsula (no wall)	**100 CFM x the area of the hood in square feet**	500 CFM to 700 CFM

Note*:* CFM is cubic feet per minute.

Source: HVI 2000; McDonald, Geragi, and Cheever 1996

Replacement air. A final factor in kitchen ventilation system efficiency is make-up or replacement air, and this is often overlooked. Exhaust ventilation systems remove air from the kitchen, and this air must be replaced. If replacement air is not provided, the fan will not operate effectively. In addition, a negative pressure in the home could be created. If the home has negative pressure, there will be problems with other appliances that need to exhaust to the outside, such as a gas furnace or water heater. This situation is referred to as back drafting. When back drafting occurs, dangerous combustion pollutants as well as excess moisture will be pulled into the home.

In an older home, make-up air usually comes from natural air leakage. In newer, more tightly constructed and energy efficient homes, this replacement air must be provided. A simple solution could be opening a window slightly when operating the kitchen exhaust fan. Other solutions include a mechanical ventilation system that balances air flow in the home.

Noise. Although the noise of a kitchen ventilation system is not a factor in the efficiency of the system, it is a concern of the users. In one survey, noise was the most frequent reason for not using kitchen exhaust fans (NYSERDA 1998). Larger fans and longer or convoluted duct runs can increase noise. Axial or propeller fans are noisier than centrifugal or "squirrel-cage" fans, although the axial fans are cheaper (Kimball 1998). Installing the fan in a remote location, such as the attic, instead of the kitchen, reduces noise.

The Home Ventilating Institute rates the noise of fans in sones. A sone rating of 5.5 or less is considered desirable (Kimball 1998).

In summary, a kitchen ventilation system needs to be carefully designed to provide good control of moisture, heat, grease, odors, and other byproducts of cooking. Many American kitchens are equipped with some sort of mechanical ventilation system. However, ventilation systems are only as effective as their frequency of use.

Kitchen ventilation study

Regular use of kitchen exhaust ventilation systems while cooking is one method to control excess moisture in a home and reduce the potential for problems with mold, dust mites, and other biological pollutants that grow in a moist environment. The purpose of this study, therefore, was to evaluate the use of kitchen ventilation systems and to ascertain the reasons behind consumer behavior with respect to these ventilation systems

Methods. A comprehensive study of kitchen usage was conducted by the Center for Real Life Kitchen Design at Virginia Tech at the request of the National Kitchen and Bath Association. The overall purpose of the study was to determine what kitchens in today's homes are like and what activities are being carried out in them. One phase of the study was an extensive personal interview designed to gather pertinent information about a participant's food shopping and food preparation patterns. As part of a face to face, personal interview of about an hour, participants were asked eleven specific questions about kitchen ventilation.

The interview took place in the Center for Real Life Kitchen Design, before respondents participated in a cooking activity that was part of the comprehensive study. The unit of analysis for the study was a household, with the interview being conducted with the primary cook or cooks in the household.

Description of sample. There were 78 households represented in the sample for the interview. Participants were selected through advertisements and "word of mouth." A screening interview was used to achieve distribution of household size, types, and ages. Although the interview was a purposive sample, the demographic characteristics were similar to a random national telephone survey of 630 people that was also conducted as part of the comprehensive study.

Household size ranged from one to five people, with a mean of 2.5. There were 39 percent family, 36 percent couple, and 21 percent single households. Most participants (77 percent) were homeowners, and lived in single family houses (80 percent). About 90 percent of the sample lived in homes larger than 1000 square feet, with 52 percent living in homes larger than 2000 square feet. The age of the homes of participants was well distributed, with 42 percent living in homes less than 10 years old and 33 percent living in homes that were more than 30 years old.

The age of participants responding to the interview ranged from 19 to 87, with a mean of 46.6 years. Over half (51 percent) of the participants indicated that they had respiratory problems, including allergies, asthma, or chronic lung disease.

The participants in the interview cooked on a regular and frequent basis: 68 percent cooked complete meals five or more times per week and 97 percent prepared dinner on a regular basis. Common cooking activities that were done on a regular basis included: baking (83 percent), stir frying (56 percent), quantity freezing (36 percent), preparing gourmet foods (32 percent), and canning (32 percent).

The majority of participants (84 percent) had electric ranges. Most of the participants (92 percent) owned a microwave oven. An interesting finding is that 32 percent used the microwave oven about the same as their range top, and 31 percent used the microwave oven more than the range top.

Results. Most of the participants (92 percent) reported having mechanical kitchen ventilation systems. The most common type of kitchen ventilation system was an updraft system -- hood attached to a cabinet over the cook top or range (Table 3). The most common features in the ventilation systems were a light (91 percent) and a multi-speed fan (84 percent). The majority of the ventilation systems (55 percent) were ducted to the outside. However, 17 percent of the participants did not know if their ventilation systems exhausted to the outside.

Table 3. Types of kitchen ventilation systems

Type of Ventilation System	Frequency (percent)	Frequency (n)
Hood attached to a cabinet	64	46
Vent fan in over-the-range microwave oven	15	11
Down-draft unit in a range top grill	10	7
Hood over an island range top	6	4
Hood over a range top (no cabinet)	3	2
Vent fan in the wall	3	2

Note: Percentages do not equal 100 due to rounding

Only 8 percent of the participants used their ventilation system whenever they cooked, while 8 percent used ventilation "almost never," and 15 percent used ventilation only "once in a while." Controlling odors and smoke were the most common reasons for using a kitchen ventilation system. Noise was the most common reason for avoiding the kitchen ventilation system. Table 4 describes the most frequent reasons that people cited for using or not using their kitchen ventilation systems.

Table 4. Use of kitchen ventilation systems

Reasons		**Percent (n)**
Reasons for Using Ventilation	**Get odors out**	47 (33)
	Get smoke out	45 (32)
	Get steam out	23 (16)
	Remove heat	20 (14)
	Control grease	14 (10)
	Clean the air	11 (8)
Reasons for Not Using Ventilation	**Too noisy**	48 (22)
	Not necessary	48 (22)
	Don't think about it	20 (9)

Note: Participants could give more than one response, so percentages do not equal 100. Participants gave various reasons for using their kitchen ventilation systems specifically with cook top cooking, typically to solve problems with odor, smoke, and steam (Table 5). Kitchen ventilation was less common when only the oven was being used. When using the oven, 46 percent never used ventilation, while 28 percent only used ventilation for oily/greasy foods and 17 percent for smelly foods.

Table 5. Reasons for using kitchen ventilation with a cook top

Reason	**Frequency (percent)**	**Frequency (n)**
When lots of steam forms	40	29
When I burn something	26	19
When I cook certain foods	26	19

Note: Percentages do not equal 100 because only the most frequent results are reported.
A few participants used their kitchen ventilation system for purposes other than cooking. These purposes included operating the fan when using strong cleaners (6 percent) and cleaning the oven (3 percent).

The data were analyzed using cross-tabulation and chi-square to determine if there were unique patterns of ventilation system usage. However, there were no differences between electric or gas ranges, different types of ventilation systems, reasons for using ventilation, or age of participants.

Discussion. The authors of this paper took advantage of a comprehensive research project on kitchen design and usage to explore the issue of kitchen ventilation systems as an indoor air quality issue. A limited number of questions were asked of a relatively small, purposive sample. However, the sample had a reasonable demographic distribution. In addition, most participants cooked frequently in kitchens with ventilation systems, which made them an important group to study in this context.

The results of this study suggest that cooks are using kitchen ventilation systems to solve problems related to cooking, such as to remove odors, smoke, and grease, and less often to prevent air quality problems. Moisture control and prevention of mold or other biological pollutants resulting from excess moisture was not an expressed concern. The impact of kitchen ventilation systems on the air in the whole house was not an issue.

A sizable minority of the sample did not use their ventilation systems with any regular frequency, especially when using the oven. Noise, as the reason to avoid using the ventilation system, is not a surprising finding. Noise might explain a reluctance to use a ventilation system, especially in a busy family kitchen. However, half the sample did not even think ventilation was needed.

The participants in this study were frequent microwave oven users. In fact, the dominance of the microwave oven as a primary cooking appliance was one of the major findings of the comprehensive study. None of the participants identified specifically using a ventilation system when cooking in the microwave oven. The need for a ventilation system when microwave cooking may be perceived as similar to that of the regular oven, and not a cook top. Ventilation during oven cooking was less common. Therefore, the frequency of microwave cooking may help to explain less frequent use of kitchen ventilation systems. However, both a microwave oven and a regular oven do typically vent into the kitchen and thus introduce moisture and odors into the living space.

Implications. In today's more tightly constructed and energy efficient homes, indoor air quality is a concern. Excess moisture is an issue in the increase of biological pollutants such as mold and dust mites, as well as in the potential for structural damage. A tightly constructed home has few "natural" leaks. Moisture and other pollutants will build up inside the home unless there is adequate exhaust ventilation with make-up or replacement air.

The kitchen is clearly a source for moisture and air pollutants. Kitchen ventilation systems are available in most homes and can be used to help control moisture and air quality throughout the home. However, the participants in this study only used them for limited purposes and mostly associated their use with cooking byproducts. In addition, ventilation was described as more an issue for range top cooking as opposed to the oven or microwave oven.

Educational opportunities. The findings of this study clearly present educational opportunities for family and consumer scientists. Mechanical kitchen ventilation systems need to be seen as a way to help control excess moisture in the home and minimize the potential for mold problems. This is not only an indoor air quality issue but a health issue. Educational programs on moisture control in the home, mold, home heating and cooling, asthma, indoor air quality, and healthy homes are examples of opportunities to specifically discuss kitchen ventilation systems. Kitchen design and appliance selection programs should put greater emphasis on selection of ventilation systems. Further, the topic of kitchen ventilation systems should be integrated into foods classes. Using ventilation is a necessary adjunct to cooking.

In the preparation of this paper, a number of books on kitchen design were reviewed. Most of the authors discussed kitchen ventilation, but only briefly and with limited technical information. The emphasis was often on the choice between updraft and downdraft, the size of the fan, and the aesthetics of the hood. Viewing ventilation as a system, and including issues of pollutants removed, installation, duct work, and replacement air, was often omitted, especially in consumer oriented books. These topics are important and need to be included in discussions of kitchen ventilation. This is particularly important as the design of the total system can make a difference in the noise of the ventilation system, and noise was a barrier to use for many participants in this study. Clearly, complete information on kitchen ventilation systems and their use is needed in forms accessible to consumers.

Manufacturers of kitchen ventilation systems should take note of the opportunities suggested by this study. Healthy indoor air and control of mold problems are topics of public interest today. Design of quieter products would be advantageous. More consumer education on the installation of kitchen ventilation as a system to increase both its use and effectiveness would be beneficial. Continued development of flexible control systems, including automatic controls, is desirable.

Conclusion

Kitchen ventilation systems, while being used by some cooks to "clear up" cooking problems, are not being selected and used to their full potential to help prevent indoor air quality problems in the home. Despite the common recommendation by indoor air quality experts to use kitchen exhaust systems (vented to the outside) to help control moisture, equipment is not being fully utilized. There is a message to manufacturers to continue to find ways to make exhaust ventilation systems easier and quieter to use. There is a message to family and consumer sciences professionals and educators to help consumers better understand the effective use of kitchen ventilation systems.

References

American National Standard Institute and American Society of Heating, Refrigeration and Air-conditioning Engineers (ANSI/ASHRAE). 1999. *Standard 62: Ventilation for acceptable indoor air quality*. Atlanta, GA.

Angell, W. J., and W. W. Olson. 1988. Moisture sources associated with potential damage to cold climate housing. *Condensation and related moisture problems in the home*, edited by John Merrill & Kathleen Parrott, 13-19. Urbana-Champaign, IL: American Association of Housing Educators and Small Homes Council-Building Research Council.

Bode, M. 1999. Bugs, mold and rot. *Healthy indoor air for America's homes*, 3rd ed., edited by M. Vogel and K. McMindes. Bozeman, MT: MSU Extension Service.
Canada Mortgage and Housing Corporation (CMHC). 2000a. *Finding the moisture level in your house.* On-line: http://www.cmhc-schl.gc.ca/en/burema/gesein/Momo/moaipr/moaipr_006.cfm.

Canada Mortgage and Housing Corporation (CMHC). 2000b. *Problems in your kitchen?* On-line: http://www.cmhc-schl.gc.ca/en/burema/gesein/Momo/moaipr/moaipr_005.cfm.

Home Ventilating Institute (HVI). 2001. *Home ventilation & indoor air quality.* Cleveland, OH: Contracting Business Magazine. On-line: http://www.hvi.org.

Kimball, H. 1998. *The kitchen consultant.* Newtown, CT: The Taunton Press.

Manclark, B. 1999. Oversized kitchen fans-an exhausting problem. *Home Energy Magazine*Online: http://hem.dis.anl.gov/eehem/99/990113.html.

McDonald, M., N. Geragi, and E. Cheever. 1996. *Kitchen industry technical manuals: Kitchen mechanical systems* (volume 2), 3rd ed. Hackettstown, NJ: National Kitchen and Bath Association and University of Illinois Small Homes Council.

Murphy, W. 1999. IAQ building science instructional module. *In Healthy indoor air for America's homes*, 3rd ed., edited by M. Vogel and K. McMindes. Bozeman, MT: MSU Extension Service.

New York State Energy Research and Development Authority (NYSERDA). 1998. *Residential ventilation systems*. Report 98-7. Albany, NY:

Pickett, M. S., M. Arnold, L. Ketterer, and Peet, L. J. 1986. *Household equipment in residential design*. 9th ed. New York, NY: John Wiley & Sons.

Shuman, E. C. 1985 Sources of moisture that affect construction performance. *Moisture control in buildings*, edited by E. Bales, 13-20. Washington, DC: Building Thermal Envelope Coordinating Council.

United States Environmental Protection Agency (USEPA). 2002. *A brief guide on mold moisture, and your home.* On:line: http://www.epa.gov/iaq/molds/moldguide.

United States Environmental Protection Agency (USEPA) and United States Consumer Product Safety Commission (USCPSC). 1993. *The inside story: A guide to indoor air quality*. EPA 402-K-93-007. Washington, DC.

United States Environmental Protection Agency (USEPA), United States Public Health Service (USPHS), and National Environmental Health Association (NEHA). 1991. *Introduction to indoor air quality: A reference manual.* EPA/400/3-91/003. Washington, DC.

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