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Editor
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This interesting article is a well-done study of the social, economic, and geographic characteristics that define that portion of our society that does not make use of residential smoke detectors. Therefore they are at increased risk of death in house fires. Population-based surveys and studies of this nature need to be expanded to allow planning and implementation of prevention strategies for reduction of risk before the occurrence of a fire or a burn injury. This epidemiologic study will help in the development of strategy for health care providers and health departments to reach those individuals in portions of our society that are at risk and improve their knowledge of burn prevention strategies and increase the use of smoke detectors in residential settings.

Finding Homes Without Smoke Detectors: One Step in Planning Burn Prevention Programs

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Residential fires are the leading cause of burn-related deaths in the United States. Smoke detectors could save many of these lives. A 1993 telephone survey of 661 Kentucky households included questions on residential smoke detectors. Statewide, 16.4% of households did not possess a functioning smoke detector; however, in nonmetropolitan Appalachian counties, 30.5% of households lacked detectors. Characteristics associated with lack of a functioning smoke detector, as determined by multivariate logistic regression, were as follows: living in a nonapartment dwelling (odds ratio [OR] = 4.14, 95% confidence interval [CI] = 1.42 to 12.01); having an annual household income of $20,000 or less (OR = 2.34, CI = 1.49 to 3.68); being unmarried (OR = 1.73, CI = 1.12 to 2.69); living alone (OR = 1.69, CI = 1.02 to 2.80); and living in a nonmetropolitan county (OR = 1.68, CI = 1.05 to 2.69). Knowledge of these population-based characteristics can assist planners of burn prevention programs to target at-risk populations. (J BURN CARE REHABIL 1995;16:548-56)

Efforts to encourage the installation and maintenance of residential smoke detectors are an essential component of any comprehensive burn prevention program. The reason for including smoke detectors in these programs is obvious: Smoke detectors save lives. Occupants of homes without functioning smoke detectors are two to three times more likely to die in house fires as occupants of homes with functioning detectors.[1,2]

Comprehensive burn prevention programs use several strategies to increase the percentage of homes with functioning smoke detectors. Three risk-reducing actions are often advocated: installation of detectors, in an appropriate number and placement within the home; periodic testing of detectors; and maintenance of detectors, including replacement of malfunctioning units or batteries. Strategies to encour-

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age these preventive actions have included local ordinances requiring detectors,[3] smoke detector give-away programs,[4] counseling by physicians and other health professionals,[5] and reminders to test detectors and replace batteries. These strategies reach people through public information and educational campaigns initiated by hospital burn units, health departments, fire departments, and other agencies. These burn prevention programs often link messages about smoke detectors with those for other burn prevention strategies, such as installing antiscald faucets, reducing temperature of water heaters, developing home escape plans, and installing home fire extinguishers.

Despite efforts to promote residential smoke detectors, house fires claim about 4000 lives each year in the United States.[6] Smoke detectors could have saved many of these lives. A North Carolina study reported that 94% of persons killed in house fires lived in dwellings without smoke detectors.[7] In 1990 about one in every five adults in the United States lacked a working residential smoke detector.[8] Greater efforts to place functioning smoke detectors in all homes must be initiated if the United States is to meet its year 2000 goal of no more than 1.2 residential fire deaths per 100,000 population.[9]

Initiating or revising a smoke detector installation and maintenance campaign requires careful planning of messages, content, delivery approach, and target audience.[10] Planners should attempt to identify the locations and characteristics of high-risk dwellings that lack functioning detectors, and to determine the sociodemographic characteristics of the occupants. For example, should the program address nonmetropolitan (i.e., rural) or inner city dwellers; owner-occupied or rental units? Because installation and maintenance by occupants require behavioral actions, knowledge of occupants' ages, levels of education, and family incomes will assist in tailoring the intervention programs to fit particular at-risk populations.

Table 1 lists 10 studies that examined the presence or absence of residential smoke detectors.[1,3,8,11-17] Some studies reported findings based on dwellings surveyed, whereas others reported findings based on number of occupants. The largest of these studies was conducted nationwide as part of the National Health Interview Survey, a household health survey conducted by the US Public Health Service. The study found that the likelihood of having at least one functioning smoke detector in a home varied with household characteristics (e.g., median family income and region of the nation) and occupants' employment status, race, and level of education. Men ages 45 to 64 whose households had annual incomes of less than $10,000 were least likely to live in a home with a working smoke detector. In contrast, men ages 34 to 44 whose households had annual incomes of $55,000 or more were most likely to have a working smoke detector. Overall, people were less likely to have a functioning smoke detector in their homes if they lived in the South, had low income, were nonwhite, or had not completed high school.[8]

Persons designing smoke detector installation and maintenance programs should not rely solely on the findings of previous research to guide them. For several reasons, caution should be exercised in applying such findings to state and local programs. First, state or local epidemiologic data on house fires, burn injuries, and ignition sources should be examined when a program is planned.[10,18] Second, some of the findings are old; the studies were conducted in years when the percentage of homes with smoke detectors was lower than it is today.[19] Third, the extent to which findings from any of these studies reflect conditions in other states, counties, or cities is questionable. Therefore program planners should seek current and accurate data specific to the geographic region targeted by a prevention program. They should look for epidemiologic data on burn injuries and house fires and also for behavioral and environmental factors placing persons at higher risk. Such specific, population-based data have two important advantages. First, they provide a baseline that can be used to monitor the results of any intervention campaign. Second, they may support greater community ownership of and participation in the program.[10]

The issue of local community ownership of prevention programs is particularly important in Kentucky, where from 1979 to 1987 the rate of fire- and burn-related deaths exceeded the national average by about 25%.[20] As a guide to developing future smoke detector installation and maintenance programs for Kentucky, we searched for timely and state-specific data pertinent to program planning: the percentage of households without a functioning smoke detector and the sociodemographic characteristics of those households. Our search failed to locate any statewide data in these two areas.

This article describes a technique for estimating the prevalence of residential smoke detectors via a statewide survey. It also illustrates how the identification of sociodemographic characteristics associated with the absence of a working smoke detector can be beneficial in planning for a smoke detector installation and maintenance program.

Table 1. Population-based studies of residential smoke detectors

Yr published	First author	Referent group	% Without a functioning detector	Method	Location
1994	Mayer	Occupants*	33	Self-report	Nationwide
1993	Piani	Occupants†	21	Self-report	Nationwide
1993	Schwarz	Dwellings	23	Inspection	Philadelphia, Pa.
1993	Johnson	Occupants	37	Self-report	Baltimore, Md.
1992	Hunt	Occupants	32	Self-report	Colorado
1992	Sharp	Dwellings	37	Inspection	Memphis, Tenn.
1991	Santer	Dwellings	25	Self-report	Chicago, Ill.
1986	CDC	Dwellings	23	Self-report	DeKalb Co., Ga.
1986	Hoffman	Dwellings	37	Self-report	Nationwide
1985	McLoughlin	Dwellings	18	Inspection	Montgomery Co, Md.
		Dwellings	30	Inspection	Fairfax Co., Va.

*Ages ≤17 years.
†Ages ≥18 years.

MATERIAL AND METHODS

The most objective method of collecting data on smoke detectors is to inspect homes for placement and functioning of smoke detectors. Because we lacked the financial and personnel resources to coordinate such a survey on a statewide level, we sought a less costly approach in which questions on smoke detectors could be added to an existing statewide survey. Kentucky has two annual statewide health surveys, both conducted by telephone: a division of the state health department polls 2400 households through the Behavioral Risk Factor Surveillance Study,[21] and the University of Kentucky's Survey Research Center administers the Kentucky Health Survey to approximately 650 households.[22] We chose to use the Kentucky Health Survey for three reasons: (1) less time is required for data collection and receipt of results, (2) questions on household characteristics are a standard component of each year's Kentucky Health Survey, and (3) university faculty and staff may add questions to the survey at little or no charge.

Three questions on smoke detectors were added to the survey: (1) "How many smoke detectors do you have in your home?" (2) "To the best of your knowledge, is (are) the detector(s) broken, disconnected, or without batteries?" (3) "To the best of your knowledge, how many of the smoke detectors are broken, disconnected, or without batteries?" The second and third questions were included because previous research has indicated that between 11% and 30% of installed residential detectors are not functional.[1,3,15] The remaining questions in the Kentucky Health Survey addressed household characteristics, family composition, and health issues, including access to health care, health behaviors, health insurance coverage, and chronic disease.

After the questionnaire was pilot-tested, households throughout Kentucky were selected by use of a random digit dialing procedure.[23] Trained interviewers telephoned the selected households from July 1 through July 20, 1993. One adult in each household was eligible to complete the questionnaire if he or she spoke English, could hear and speak effectively over the telephone, and was judged by the interviewer to be competent to complete the interview. After obtaining the respondent's consent, the interviewer used a computer-assisted telephone interview technique to read questions and enter answers into a database.[24] Most interviews were conducted after 5:00 PM and lasted an average of 18 minutes.

Data were analyzed with SAS software (SAS Institute Inc., Cary, N.C.) on a mainframe computer.[25] To identify potential risk factors, contingency tables were constructed for the personal and household characteristics of dwellings with or without a functioning smoke detector, and chi-square analysis was used to test for statistical significance. Having identified these risk factors, we then developed a multivariate logistic regression model that calculated adjusted odds ratios for *not* having a working smoke detector for both personal and household risk factors.[26]

RESULTS

To reach the Kentucky Health Survey's annual sample size of about 650 completed interviews, 1462 eligible adults were contacted, and 661 interviews were completed. This response rate (45.2%), somewhat lower than in previous years, raised concerns as to whether the sample was representative of Ken-

Table 2. Sociodemographic characteristics of sample compared with 1990 census of population

Characteristics	Kentucky Health Survey (n = 661)*	US census for Kentucky
Personal		
Female	57.0%	52.0%
High school graduate ≥25 yr old	69.4%	64.6%
Married	60.2%	65.0%
Employed	60.5%	60.5%
Age ≥65	19.0%	19.3%
Household		
Annual income (median)	$22,500	$22,534
Dwelling type		
Apartment	10.5%	10.5%
Single-family home	77.9%	73.9%
Mobile home	8.6%	12.1%
Other	3.0%	3.5%
Number of occupants		
1 Person	20.4%	23.3%
2 Persons	34.1%	31.9%
Mean	2.6	2.6
County		
Metropolitan	40.9%	46.5%
Nonmetropolitan	59.1%	53.5%

*Includes 11 respondents who did not answer all three smoke detector questions.

tucky households. Table 2 provides a comparison between the Kentucky Health Survey and the 1990 census for Kentucky for selected sociodemographic characteristics.[27] The figures for the survey sample are similar to those of the census, although the sample contained a slightly greater proportion of single-family homes and homes in nonmetropolitan counties.

Four household categories were defined, based on answers to the questions about presence and functioning of smoke detectors: (1) no smoke detector installed, (2) smoke detector(s) installed, none functional, (3) smoke detector(s) installed, some functional, and (4) smoke detector(s) installed, all functional. Table 3 shows the percentage of households in each category.

Households Without a Functioning Smoke Detector. About one in six households ($n = 106$, 16.4%) lacked a functioning smoke detector, according to occupants' reports. These households included two subgroups: households in which no smoke detector was installed ($n = 80$, 75.5%) and households in which all smoke detectors were nonfunctional. Most (58.4%) of the households with no

Table 3. Smoke detector status in Kentucky households ($n = 650$)

Status	n	% of total
No functioning detector	106	16.3
None installed	80	
Installed, none functional	26	
One or more functioning detectors	544	83.7
Installed, <100% functional	19	
Installed, 100% functional	525	

installed smoke detector were located in nonmetropolitan (i.e., rural) counties. A comparison of characteristics in these two subgroups of households revealed few differences. Both subgroups tended to be composed of single-family, nonfarm households located in nonmetropolitan counties, with an annual household income of less than $20,000. Among households in which all installed detectors were reported nonfunctional, three out of four were homes where only one detector had been installed.

Households With a Functioning Smoke Detector. Five out of six households (83.6%) reported having at least one functioning smoke detector. These households also included two subgroups: those in which all installed smoke detectors were reported to be operational and those reporting at least one nonfunctioning detector in addition to a working detector. Among households reporting that all detectors worked, two thirds reported having two or more detectors installed. Households in metropolitan counties reported having two or more installed detectors significantly more often than households in nonmetropolitan counties ($\chi^2 = 13.1$, $df = 1$; $p < 0.01$). Nineteen persons reported that their homes contained both functional and nonfunctional smoke detectors. These households had an average of 2.8 detectors installed, though an average of only 1.6 detectors were reported to be operational.

Comparison of Households With and Without Functioning Detectors. Characteristics associated with the lack of a functioning smoke detector in a household were analyzed by use of logistic regression. Table 4 compares households with and without functional detectors on a number of personal and household characteristics (independent variables). For each characteristic the table shows the number of respondents who reported having at least one functioning smoke detector, and the number and percentage who reported having no working smoke detector. The adjusted odds of *not* having a working smoke detector, with 95% confidence intervals, are shown in the last two columns.

Table 4. Characteristics of households with and without functioning smoke detectors and adjusted odds ratios of not having a functioning detector

Characteristics	Functioning detector in home				
	Yes (n = 544)*	No (n = 106)*	% No (16.3%)	Adjusted odds ratio	95% CI
Household characteristics					
Dwelling type					
Apartment†	64	4	5.9		
All others	480	102	17.5	4.14‡	1.42-12.01
Annual income					
>$20,000†	312	38	10.9		
≤$20,000	232	68	22.7	2.34‡	1.49-3.68
Household size					
≥2 Persons†	441	75	14.5		
1 Person	101	31	23.5	1.69§	1.02-2.80
County location					
Metropolitan†	237	30	11.2		
Nonmetropolitan	306	76	19.9	1.68§	1.05-2.69
Personal characteristics					
Marital status					
Married†	340	50	12.8		
All others	200	56	21.9	1.73§	1.12-2.69
Has personal physician					
Yes†	468	86	15.5		
No	76	20	20.8	1.60	0.91-2.82
Education (yr)					
≥12†	431	71	14.1		
<12	111	34	23.5	1.48	0.90-2.43
Employed					
Yes†	337	52	13.4		
No	203	53	20.7	1.42	0.84-2.40
Age (yr)					
<65†	451	77	14.6		
≥65	93	29	23.8	1.29	0.72-2.33
Current smoker					
No†	403	80	16.6		
Yes	141	26	15.6	1.22	0.72-2.05
Sex					
Male†	234	42	15.2		
Female	310	64	17.1	1.10	0.68-1.75

CI, Confidence interval.
*Some people did not answer every question on personal and household characteristics.
†Referent group.
‡$p < 0.01$.
§$p < 0.05$.

Household Characteristics. Four household characteristics were strongly associated with absence of a working smoke detector. In general a home was less likely to have a working smoke detector if it was located in a nonmetropolitan county, it was not an apartment, it was occupied by only one person, or the annual household income was less than $20,000. There were no statistically significant differences among various types of nonapartment dwellings—such as single-family homes, duplexes, condominiums, townhouses, and mobile homes—in the likelihood of not having a functioning smoke detector in the home.

The finding that households in nonmetropolitan counties were less likely to have a functioning smoke detector was explored further by contrasting counties in the Appalachian and non-Appalachian portions of the state. The Appalachian region is the

mountainous portion of eastern and central Kentucky; this region typically has a lower per capita income and higher unemployment rate than the rest of the state. Households in the state's 45 nonmetropolitan Appalachian counties were almost three times as likely not to have a functioning smoke detector as those in nonmetropolitan counties located outside Appalachia (Table 5).

Personal Characteristics. Marital status was the only personal characteristic significantly associated with the absence of a functioning smoke detector. As a group, persons who were single, widowed, divorced, or separated were almost twice as likely as married persons to lack a working smoke detector. The association between not having a functional smoke detector and not having a regular, personal physician, though suggestive, was not statistically significant (Table 4). Other personal characteristics such as sex, years of schooling, employment status, age, and smoking status did not show a significant association with the absence of a working smoke detector. Race, although found to be a significant factor in another study,[13] was excluded as a classification variable in this study, because nonwhite respondents comprised only 6% of the sample.

DISCUSSION

This cross-sectional study sought to identify characteristics of households without a functioning smoke detector. Knowledge of these personal and household characteristics would aid in the development of burn prevention programs in Kentucky that encourage installation and maintenance of residential smoke detectors. Though other studies of smoke detector prevalence have used multivariate analysis, we believe this is the first study to employ the technique of logistic regression with use of a statewide sample.

This study reports a lower percentage of households (16.4%) without a functional smoke detector than any study published to date. Several factors may be responsible for this finding. One possible reason may be the systematic bias of telephone surveys, which exclude residences without telephones. Although about 90% of households in Kentucky have telephones, this percentage varies by county from 70.7% to 98.3% (personal communication, Teri Wood, PhD, Director, University of Kentucky Survey Research Center, 1994). A national study reported that dwellings without telephones are more likely to be in rural areas and to be occupied by persons below the poverty level than dwellings with telephones. Dwellings without telephones also are more likely to lack functional smoke detectors.[28] Thus the percent of homes in Kentucky without functional smoke detectors is probably higher than that found by telephone survey methods, but the extent of error cannot be estimated until observational studies are conducted in homes without telephones.

Table 5. Prevalence of smoke detectors in Kentucky's 99 nonmetropolitan counties, by regional designation

	Functioning smoke detector		
County designation	Yes	No	% No
Appalachian	121	53	30.5
Non-Appalachian	185	23	11.4

$\chi^2 = 22.38$ ($df = 1$); $p < 0.001$.

Use of self-report, rather than direct observation, also may explain why the study found so few homes without a functional smoke detector. Respondents may assume that their smoke detectors work when in fact they do not. Another possible explanation is that some people are misinformed about the number of detectors present in the household. Perhaps some respondents thought it was socially desirable to claim that they had a smoke detector, even if they had none. Although this study is unable to measure the extent of discrepancy due to self-report, findings from one study that used both self-report and inspection concluded that occupants overestimate the presence of detectors.[1] If such overestimation did occur, it is not altogether unexpected; people also overestimate their use of other injury protection devices, such as automotive seat belts.[29]

Although this study found a lower percentage of homes without a working smoke detector than was found in other studies, some household and personal characteristics associated with absence of a working smoke detector were similar to those reported in other studies. Our finding of a strong association between low household income and absence of a working smoke detector was consistent with results reported in two other studies that used multivariate techniques.[3,14]

Among the household characteristics in Table 4, the variable showing the strongest association with absence of smoke detectors was the type of dwelling. Residents of apartments were much more likely to claim a working smoke detector than occupants of other dwellings, including single-family homes, mobile homes, and duplexes. Apartments may be more likely than other types of dwellings to contain detec-

tors required by local ordinance or insurance carriers. For 1992, apartment fires accounted for only 7% of residential fire deaths in Kentucky; yet 10.5% of the state's population reside in apartments.[30]

This study found that mobile homes were about as likely to have a working smoke detector as other types of nonapartment dwellings. This finding is consistent with findings from an analysis of children ages 0 to 17 years in the 1990 National Health Interview Survey. That survey, which used number of children rather than number of dwelling units as the basis for reporting prevalence, found that two thirds (66.3%) of children under age 18 living in mobile homes had functional smoke detectors in their homes, about the same proportion as those children living in houses, apartments, and flats (66.7%).[11] In our study, however, we were able to reach only mobile homes with telephones, which may account for the smaller percentage of mobile homes in the sample than is indicated by the census. Because homes without telephones are more likely not to have a smoke detector, the actual percentage of mobile homes with functioning smoke detectors is probably below the 82.1% found in our study.

Another finding of this study is that households occupied by only one person were less likely to have a working smoke detector than homes with two or more persons. Persons living alone in our survey were also more likely to have low income, be over 65 years old, and be unmarried—all factors strongly associated with absence of a functioning smoke detector.

The tendency for homes in nonmetropolitan counties of Kentucky to not have a working smoke detector is also consistent with nationwide findings of the 1990 National Health Interview Survey.[8] Smoke detector ordinances are less common in Kentucky's 99 nonmetropolitan counties than in the 21 metropolitan counties, which may explain this finding. Dwellings in jurisdictions that require smoke detectors by ordinance are more likely to have detectors than dwellings in jurisdictions without such ordinances.[3] However, we were unable to determine whether this holds true in Kentucky, because there is no listing of such laws available in the state.

The finding that nonmetropolitan counties in Appalachia were three times as likely to not have a functioning smoke detector as other nonmetropolitan counties underscores the value of conducting a statewide survey. In 1992, 68% of the deaths from house fires in Kentucky occurred in nonmetropolitan counties, although only 53.5% of state residents live in those counties.[27,30] In about one third ($n = 42$, 35%) of Kentucky's 120 counties, the fire- and burn-related death rate is at or above the 75th percentile of national fire- and burn-related death rates.[20] Of these 42 counties, 98% are nonmetropolitan, and nearly half are in Appalachia.

In addition to household characteristics, several of the respondents' personal characteristics were associated with lack of a working smoke detector. However, caution should be used in interpretation of findings based solely on personal characteristics, because the sampling plan for the study allowed *any* one adult per household to complete the survey. The finding that, as a group, widowed, divorced, separated, or single persons were less likely to have a functioning smoke detector has been reported elsewhere, though only for men.[14]

The association between not having a smoke detector and not having a personal physician, though not statistically significant, has immediate implications for primary prevention. Physicians have a significant role in inquiring about smoke detectors and recommending them to their patients.[13] Because patients without personal physicians may be more likely to seek clinic or emergency department care, staffs of those facilities should be alerted to opportunities to encourage the use of smoke detectors.

Though our results contained both similarities and differences when compared with other studies, this study yielded valuable findings that could be useful in Kentucky. These results, when placed in a conceptual framework of health education planning, can be especially valuable when smoke detector installation and maintenance campaigns are designed. One such conceptual model is the PRECEDE approach to health promotion planning,[18] which guides planners in assessing social, epidemiologic, behavioral, and contextual factors to establish programs' objectives, priority areas, and intervention steps. Findings from our survey clearly indicate that more rigorous efforts must be made to reach households in nonmetropolitan counties, particularly in Appalachia, with appropriate intervention strategies that will result in increased installation and maintenance of smoke detectors. Likewise, for the state at large, low-income persons living alone in nonmetropolitan counties should be the focus of more intense intervention programs. One strategy for health providers, hospital personnel, and health departments to use in reaching individuals in these nonmetropolitan counties could be to work in conjunction with the Cooperative Extension Service, a service component of state university agricultural programs.[31] At the county or state level, individual county extension agents and exten-

sion specialists in health and safety can provide resources and expertise to help reach the rural populations.

Several opportunities for further research on smoke detectors and other burn prevention topics unfold from this study. Although we were limited to three questions in the survey, answers to additional questions would be helpful. These questions could include age of dwelling, placement of each smoke detector, and how the respondent knows whether or not the detector works. Occupants should also be asked their reasons for not installing smoke detectors or for not maintaining them in working order. Telephone survey results also could be used to assess other household factors associated with burn injuries, such as hot water temperature, planned escape routes, home fire extinguishers, and scald-guard faucets.

This study's use of an existing statewide poll to collect data on burn prevention issues can be replicated in many states. Burn prevention specialists and others should contact university-based polling organizations and other nonprofit polling groups and ask them to include questions related to burn prevention in routine random surveys. The membership of the National Network of State Polls[32] includes 50 polling organizations in 40 states, many based at state-supported universities. Use of these polling organizations can offer burn prevention specialists a relatively low-cost approach to assessing risk factors for house fires and burns and to determining occupants' knowledge of prevention strategies. Because many surveys routinely include questions on respondents' demographic characteristics and residence location, data obtained from surveys can help pinpoint individuals and locations at high risk.

Though data obtained from such surveys may be beneficial, they should not be the only component used to plan a comprehensive burn prevention program. Clearly, epidemiologic data on house fires, burn injuries, and house fire deaths also must be a component of the planning process. However, such data are collected only after property is damaged or individuals are injured or killed. Population-based surveys can provide complementary data that may be useful in reducing risk before a fire or burn injury occurs.

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