



Published in final edited form as:

J Safety Res. 2018 December ; 67: 197–201. doi:10.1016/j.jsr.2018.06.001.

Decreasing residential fire death rates and the association with the prevalence of adult cigarette smoking — United States, 1999–2015★,★★

Scott R. Kegler^{a,*}, Ann M. Dellinger^b, Michael F. Ballesteros^a, and James Tsai^c

^aDivision of Analysis, Research, and Practice Integration, National Center for Injury Prevention and Control, CDC, United States of America

^bDivision of Unintentional Injury Prevention, National Center for Injury Prevention and Control, CDC, United States of America

^cOffice on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion, CDC, United States of America

Abstract

Introduction: Each year from 1999 through 2015, residential fires caused between 2,000 and 3,000 deaths in the U.S., totaling approximately 45,000 deaths during this period. A disproportionate number of such deaths are attributable to smoking in the home. This study examines national trends in residential fire death rates, overall and smoking-related, and their relationship to adult cigarette smoking prevalence, over this same period.

Methods: Summary data characterizing annual U.S. residential fire deaths and annual prevalence of adult cigarette smoking for the years 1999–2015, drawn from the National Vital Statistics System, the National Fire Protection Association, and the National Health Interview Survey were used to relate trends in overall and smoking-related rates of residential fire death to changes in adult cigarette smoking prevalence.

★The *Journal of Safety Research* has partnered with the Office of the Associate Director for Science, Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control at the CDC in Atlanta, Georgia, USA, to briefly report on some of the latest findings in the research community. This report is the 52nd in a series of “From the CDC” articles on injury prevention.

★★Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

*Corresponding author at: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Division of Analysis, Research, and Practice Integration, Statistics, Programming, and Economics Branch, 4770 Buford Highway NE, Mailstop F-64, Atlanta, GA 30341, United States of America. skegler@cdc.gov (S.R. Kegler).

Scott R. Kegler, PhD, is a mathematical statistician in the Statistics, Programming, and Economics Branch within the Division of Analysis, Research, and Practice Integration in the Centers for Disease Control and Prevention Injury Center. His work covers a broad range of injury topics.

Ann M. Dellinger, PhD, MPH, serves as Chief of the Home, Recreation, and Transportation Safety Branch in the Centers for Disease Control and Prevention Injury Center. She currently conducts studies in several areas of injury prevention including transportation safety, older adult mobility, older adult falls, and other unintentional injury topics.

Michael F. Ballesteros, PhD, MS, is Chief for the Statistics, Programming, and Economics Branch within the Division of Analysis, Research, and Practice Integration in the Centers for Disease Control and Prevention. His branch provides statistical, economic, IT programming, and informatics expertise to the CDC’s Injury Center. Dr. Ballesteros received his a Masters in Preventive Medicine and doctorate in epidemiology from the University of Maryland at Baltimore. He is a graduate of CDC’s Epidemic Intelligence Service (EIS).

James Tsai, MD, MPH, serves as a senior epidemiologist of the Office on Smoking and Health in the Centers for Disease Control and Prevention Chronic Disease Center. He designs, plans, and conducts epidemiologic studies and secondary data analyses using datasets from nationally representative health surveys focusing on tobacco use and disease prevention.

Results: Statistically significant downward trends were identified for both the rate of residential fire death (an average annual decrease of 2.2% – 2.6%) and the rate of residential fire death attributed to smoking (an average annual decrease of 3.5%). The decreasing rate of residential fire death was strongly correlated with a gradually declining year-to-year prevalence of adult cigarette smoking ($r=0.83$), as was the decreasing rate of residential fire death attributed to smoking ($r=0.80$).

Conclusions and practical applications: Decreasing U.S. residential fire death rates, both overall and smoking-related, coincided with a declining prevalence of adult cigarette smoking during 1999–2015. These findings further support tobacco control efforts and fire prevention strategies that include promotion of smoke-free homes. While the general health benefits of refraining from smoking are widely accepted, injury prevention represents a potential benefit that is less recognized.

Keywords

Injury; Fire fatality; Home fires; Smoking

1. Introduction

Each year from 1999 through 2015, residential fires caused between 2,000 and 3,000 deaths in the United States, totaling approximately 45,000 deaths over this 17-year period (Ahrens, 2017; Centers for Disease Control and Prevention, 2016a). Adults 65 years of age and older were consistently at greatest risk (Ahrens, 2017; CDC, 2016a). Smoking is disproportionately related to residential fire deaths, with smoking materials (defined as lighted tobacco products) most recently implicated in 5% of residential fires, but in 22% of residential fire deaths (Ahrens, 2017; Hall, 2013). Other significant causes of residential fire deaths include cooking equipment, heating equipment, electrical/lighting systems, and intentional fires not classified as arson (Ahrens, 2017).

State-specific rates of residential fire death have been shown to be significantly correlated with adult cigarette smoking prevalence in a cross-sectional context (Diekman, Ballesteros, Berger, Caraballo, & Kegler, 2008). The present study examines temporal trends in residential fire death rates (overall and smoking-related) at the national level and their relationship to the prevalence of adult cigarette smoking, over the period 1999–2015.

2. Methods

2.1. Data

Three data time series were central to the analysis: (a) annual numbers (or estimates) of all residential fire deaths; (b) annual estimates of residential fire deaths attributed to smoking; and (c) annual estimates of the prevalence of cigarette smoking among adults. Details concerning these time series are provided below.

National annual numbers of residential fire deaths based on coded death certificate data from the National Vital Statistics System (NVSS) and annual U.S. resident population estimates for the years 1999–2015, for all ages and stratified by age group (<5 years, 5–19 years, 20–

44 years, 45–64 years, 65 years), were obtained using the Web-based Injury Statistics Query and Reporting System (WISQARS) (CDC, 2016a; Kochanek, Murphy, Xu, & Tejada-Vera, 2016). Residential fire deaths were identified by cause of death (*International Classification of Diseases, 10th Revision* [ICD-10] underlying cause codes X00 – X09; excludes arson and secondary fires due to explosions) and place of occurrence (home).

Estimated annual numbers of all residential fire deaths and residential fire deaths attributed specifically to smoking materials for the years 1999–2015 were obtained from the National Fire Protection Association (NFPA) (Ahrens, 2017). The first of these time series is useful for assessing how closely NFPA data (which are estimates) correspond to WISQARS data (which represent a census); the second is key to analyzing the trend in residential fire deaths due to smoking in relation to the trend in adult cigarette smoking prevalence. NFPA estimates are based on data collected through the National Fire Incident Reporting System (NFIRS) and the NFPA Fire Experience Survey (FES) (Ahrens, 2017). The NFIRS data cover approximately 75% of fires occurring each year, drawn from reports provided by approximately 23,000 fire departments representing every state and the District of Columbia (U.S. Fire Administration, 2017). The FES, also completed by fire departments, does not provide the same coverage (or detail) but supports more timely estimates of basic figures such as numbers of fire incidents, civilian deaths and injuries, and property damage costs (Ahrens, 2017; Haynes & Stein, 2017).

Annual estimates of the prevalence (percentage) of U.S. adults (18 years of age) who were current cigarette smokers (reported having smoked 100 cigarettes during lifetime and currently smoked some days/every day) for the years 1999 and 2001–2015 are based on the National Health Interview Survey (NHIS) (CDC, 2016b, 2016c; Jamal et al., 2016). The NHIS is an annual, nationally representative, in-person survey of the noninstitutionalized U.S. civilian population (Jamal et al., 2016).

2.2. Statistical analysis

Annual numbers and rates (per 100,000 persons) of residential fire death were tabulated for the 17-year study period, by final data source (WISQARS or NFPA), cause (all residential fires and residential fires attributed to smoking materials), and age group. Next, national trends in rates of residential fire death during the study period were analyzed using negative binomial rate regression. This approach was conservatively adopted in order to compensate for variability in injury count data that is often in excess of what would be expected (“overdispersion”) assuming a more basic Poisson model (Agresti, 2007), and might also help compensate for any sampling variability in the NFPA estimates. Finally, correlations were explored, both visually and numerically, between residential fire death rates and the prevalence of adult cigarette smoking over time.

3. Results

3.1. Numbers and rates of residential fire death

Annual NFPA estimates of residential fire deaths tended to be somewhat greater than annual numbers obtained using WISQARS (Table 1). Excluding the year 1999, for which the NFPA

and WISQARS numbers coincide, the NFPA estimates were on average 9.2% higher than the WISQARS numbers, with annual differences varying between -4.6% and +17.0%.

The annual rate of residential fire death decreased from 1.04 per 100,000 persons in 1999 to 0.71–0.80 per 100,000 in 2015, depending on the data source (Table 1). The annual rate of residential fire death attributed to smoking materials decreased from 0.30 per 100,000 persons in 1999 to 0.17 per 100,000 in 2015, corresponding to roughly half of the observed decrease in the overall residential fire death rate.

The decrease in the overall rate of residential fire death reflects steady decreases that occurred in four of the five age groups considered; only the age group representing persons 45–64 years old showed no long-term decrease (Table 2). Despite decreasing rates, older adults (> 65 years old) remained at substantially greater risk than any other age group throughout the study period. Young children (<5 years old) represented the group exhibiting the second greatest risk at the outset of the study period. This age group showed the greatest reduction in risk, with the annual rate decreasing nearly three-fold, and dropping from second-most at risk to third-most at risk by the end of the study period.

3.2. Rate trend modeling

Statistical diagnostics indicated that the negative binomial rate regression approach was appropriate for application to the study data. This approach showed a statistically significant decrease in the overall rate of residential fire death of 2.6% per year on average using the WISQARS data ($p < 0.01$) and a comparable decrease in the overall rate of 2.2% per year on average using the NFPA data ($p < 0.01$). The rate regression analysis further showed a decrease in the rate of residential fire death attributed to smoking materials of 3.5% per year on average ($p < 0.01$).

3.3. Empirical correlations over time

The decrease in the overall rate of residential fire death (WISQARS) coincided closely with the decrease in the prevalence of adults who were current cigarette smokers (Fig. 1; cubic spline interpolation). The Pearson correlation between these two measures (excluding one incomplete data point [year 2000]) was +0.83. Although the rate of residential fire death attributed to smoking materials (NFPA) exhibited somewhat greater year-to-year variability than the overall rate, the decrease in this rate similarly coincided with the decrease in the prevalence of adult cigarette smoking (Fig. 2; cubic spline interpolation), with a Pearson correlation (excluding one incomplete data point [year 2000]) of +0.80.

4. Discussion

The reported findings indicate a statistically significant decrease in both the overall residential fire death rate and the rate of residential fire death attributed to smoking materials over the 17-year study period, and illustrate a clear correspondence between these decreases and the decreased prevalence of adult cigarette smoking.

The U.S. Surgeon General has concluded that cigarette smoking is the leading preventable cause of mortality in the United States and causes a high morbidity burden (U.S. Department

of Health and Human Services, 2014). Regarding the specific risk of fire death, the findings of the current study are consistent with previous research showing a steadily declining trend in home fire fatalities attributed to smoking materials (Hall, 2013). Factors other than smoking prevalence might have contributed to the observed decreases in residential fire deaths. Household smoke alarms represent one potential factor, and community-based fire safety programs that include home smoke alarm installation have been shown to be effective in terms of both dissemination and reductions in injury and death (Istre et al., 2014; Ta, Frattaroli, Bergen, & Gielen, 2006). It should be noted in the present context, however, that a large national survey indicated that 95% of households already had smoke alarms in place (with 86% reporting testing at least once a year) during the early part of the period covered by this study (Ballesteros & Kresnow, 2007), suggesting that this percentage could not have increased meaningfully over the study period. Other advances in fire prevention and safety might also have contributed to decreases in residential fire deaths. Residential sprinkler technology is being increasingly adopted in one- and two-family homes. While still not as common as smoke alarms, there is evidence that residential sprinklers can reduce occupant injuries and deaths, reduce property losses, and improve firefighter safety (Pollack, Frattaroli, & Somers, 2015). The sale and use of reduced ignition propensity (RIP) cigarettes (Alpert, O'Connor, Spalletta, & Connolly, 2010), which are designed to self-extinguish when not being continually smoked, might also contribute to reducing fire risk. Two studies concluded that RIP legislation, adopted by all states over the period 2004–2011, was associated with reduced likelihood of residential fires caused by cigarettes and reduced rates of residential fire death (Alpert, Christiani, Orav, Dockery, & Connolly, 2014; Yau & Marshall, 2014). Notable increases in the prevalence of homes (both with and without current smokers) with smoke-free rules have also been documented over a period significantly overlapping with the current study period (King, Patel, Babb, Hartman, & Freeman, 2016).

4.1. Limitations

There were several study limitations. First, the NFPA data represent estimates as opposed to census numbers. NFPA estimates of all residential fire deaths tended to be somewhat higher than corresponding WISQARS numbers (9.2% higher on average). Although it is not possible to determine from the study data, a comparable level of overestimation in NFPA estimates of residential fire deaths attributed to smoking materials would presumably not account for the observed association between the annual rate of such deaths and the annual prevalence of adult cigarette smoking, given the strength of the association. Second, correlations between rates of residential fire death (overall and smoking-related) and the prevalence of adult cigarette smoking are based on national-level data aggregates and are thus ecological, potentially suggesting stronger associations than might be observed at the household or individual levels. Further, such associations do not necessarily indicate a cause-and-effect relationship. In this regard, it is noted that large-scale (state-level) data aggregates have been previously employed to characterize the cross-sectional association between rates of residential fire death and smoking prevalence (Diekman et al., 2008), and that the role of smoking as cause of residential fires is well understood. Third, regional and/or state-level analyses were not attempted because several of the data time series were available only at the national level.

4.2. Conclusions

Decreasing U.S. residential fire death rates, both overall and smoking-related, coincided with a declining prevalence of adult cigarette smoking during 1999–2015. Although residential fire deaths are often attributed to causes other than smoking, these findings nonetheless provide support for implementing proven comprehensive tobacco control programs and fire prevention strategies that include promotion of smoke-free homes and installation and proper maintenance of fire safety equipment. While the general health benefits of refraining from smoking are widely accepted, injury prevention represents a potential benefit that is less recognized.

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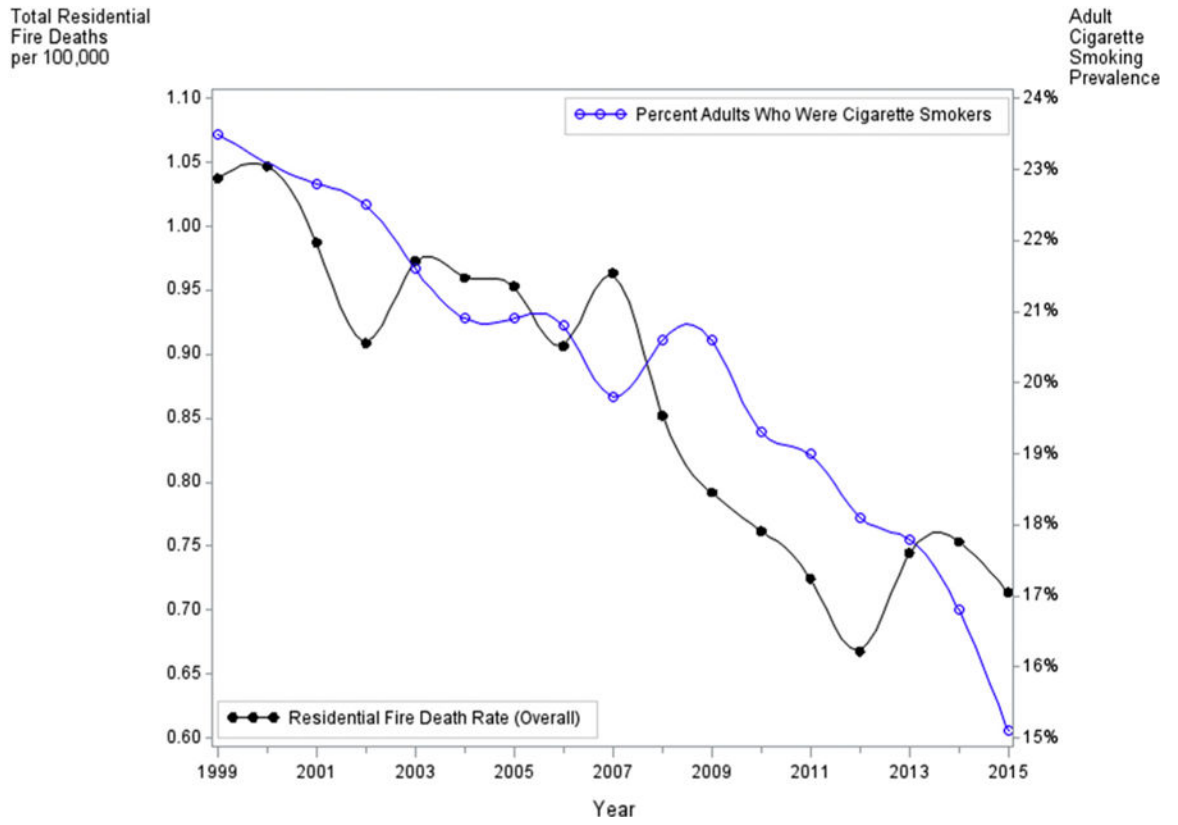


Fig. 1. Annual rates of residential fire death ¹(WISQARS) and adult cigarette smoking prevalence ²(NHIS), U.S., 1999–2015. ¹ICD-10 underlying cause codes X00–X09; occurrence at home. ²Annual estimates of the prevalence (percentage) of U.S. adults (≥ 18 years of age) who were current cigarette smokers.

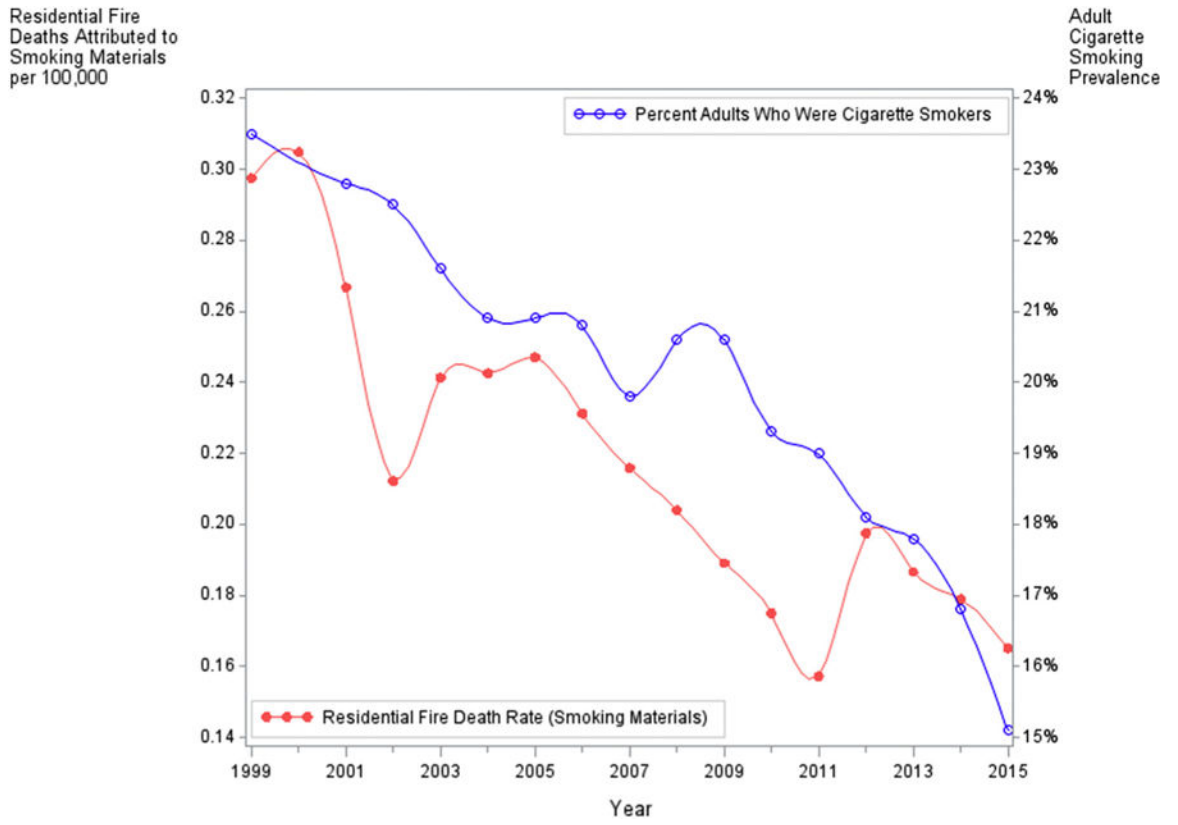


Fig. 2. Annual rates of residential fire death attributed to smoking materials (NFPA) and Adult cigarette smoking prevalence ¹(NHIS), U.S., 1999–2015. ¹Annual estimates of the prevalence (percentage) of U.S. adults (18 years of age) who were current cigarette smokers.

Table 1

Numbers and crude rates (per 100,000) of residential fire death, by data source, U.S., 1999–2015.

Year	WISQARS^a		NFPA^b			
	All residential fire deaths		All residential fire deaths		Attributed to smoking materials	
	Number	Rate	Number	Rate	Number	Rate
1999	2895	1.04	2895	1.04	830	0.30
2000	2955	1.05	3420	1.21	860	0.30
2001	2813	0.99	3110	1.09	760	0.27
2002	2614	0.91	2670	0.93	610	0.21
2003	2823	0.97	3145	1.08	700	0.24
2004	2810	0.96	3190	1.09	710	0.24
2005	2816	0.95	3030	1.03	730	0.25
2006	2704	0.91	2580	0.86	690	0.23
2007	2902	0.96	2865	0.95	650	0.22
2008	2592	0.85	2755	0.91	620	0.20
2009	2430	0.79	2565	0.84	580	0.19
2010	2352	0.76	2640	0.86	540	0.17
2011	2259	0.72	2520	0.81	490	0.16
2012	2097	0.67	2380	0.76	620	0.20
2013	2354	0.74	2755	0.87	590	0.19
2014	2400	0.75	2745	0.86	570	0.18
2015	2290	0.71	2560	0.80	530	0.17

^aWeb-Based Injury Statistics Query and Reporting System (ICD-10 underlying cause codes X00 – X09; occurrence at home).

^bNational Fire Protection Association.

Table 2Crude rates (per 100,000) of residential fire death, by age group, U.S., 1999–2015.^a

Year	Age group					
	<5 years	5–19 years	20–44 years	45–64 years	65 years	All ages
1999	1.68	0.54	0.65	0.96	2.84	1.04
2000	1.63	0.52	0.62	1.08	2.87	1.05
2001	1.37	0.47	0.65	1.03	2.59	0.99
2002	1.23	0.50	0.56	0.94	2.40	0.91
2003	1.21	0.43	0.55	1.11	2.75	0.97
2004	1.18	0.48	0.55	1.09	2.58	0.96
2005	1.15	0.43	0.54	1.05	2.69	0.95
2006	1.09	0.40	0.50	1.04	2.52	0.91
2007	1.15	0.44	0.52	1.11	2.63	0.96
2008	0.87	0.35	0.41	1.03	2.50	0.85
2009	0.91	0.29	0.42	0.94	2.21	0.79
2010	0.74	0.27	0.35	0.95	2.23	0.76
2011	0.63	0.24	0.34	0.91	2.10	0.72
2012	0.52	0.19	0.29	0.86	1.98	0.67
2013	0.66	0.25	0.33	0.93	2.09	0.74
2014	0.62	0.24	0.36	0.89	2.17	0.75
2015	0.57	0.19	0.27	0.95	2.04	0.71

^aWeb-based Injury Statistics Query and Reporting System (ICD-10 underlying cause codes X00 – X09; occurrence at home).

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