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Household Fire Protection Practices in Relation to Socio-demographic Characteristics: Evidence from a Swedish National Survey

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Abstract. The sociodemographic inequalities in the ownership of residential fire safety equipment, fire prevention practices and fire protection knowledge was studied using an inductive and data-driven approach based on the responses to a national Swedish survey containing individual-level data on several dimensions of home fire safety practices (n = 7507). Cluster analysis was used to summarise home fire safety data and sociodemographic characteristics of the sample were then regressed on the data ordinal regression analysis. The results showed significant correlations between the level of fire protection and a range of factors (sex, age, family composition, income, housing type and country of birth), suggesting a positive effect of socioeconomic success. Further, the results imply that having experienced a residential fire has a positive impact on future fire protection practices, and that higher levels of fire protection interest increases the probability of having a functional smoke detector.

Keywords: Socioeconomic status, Multiple correspondence analysis, Fire safety, Health inequality, Risk factors

1. Introduction

Although large risk reductions in fire-related deaths have been observed in most high-income countries during the last 50–60 years [1], household fires are still a considerable societal problem [2, 3]. Specifically, although fire mortality has decreased from a general perspective, these reductions seem to have been disproportionate in terms of different socio-demographic groups, as well as there being a levelling-off of the decreasing trend. For example, whilst large decreases have been

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seen amongst adults and children, only minor rate reductions have been observed amongst older adults [4]. Also, in regards to older adults, several studies have suggested that the changing demographics, in which the number of older people are increasing substantially [5] will lead to increases in the number of deaths in countries such as Japan [6] and Spain [7].

In terms of general fire mortality and apart from the well-established differences in risk between different age groups [8, 9], a number of socio-demographic risk factors have been identified. These include being male [9, 10], living alone [10–12], belonging to an ethnic minority [13–15], having low educational attainment [13, 16], as well as other deprivation-related factors such as having a low disposable income, receiving social allowance, being unemployed, receiving health-related early retirement pension, etc. [11, 12, 15–20]. Interestingly, many of these socio-demographic differences have been observed since the 1970s [21, 22]. However, these seem to have become even more pronounced [11, 17]. One hypothetical reason for this is the fundamental cause theory, stating that socio-demographic differences increase when preventative measures exist [23].

In terms of prevention, fire-related deaths can be hindered at five points in the fire process; reduce heat; stop ignition of first object; hinder fire growth; initiate evacuation; and complete evacuation [24]. Starting with the first two steps, i.e. the development of an unwanted fire, previous studies have shown that the risk of fire, regardless of result, is higher amongst socio-demographically ''strong'' groups (well educated, high income households) compared to the rest of the population [25, 26]. Therefore, it would seem that it is not that vulnerable socio-demographic groups have a higher risk of fire but rather a reduced ability to hinder fire growth and/or evacuate. Previous studies on child injuries in general have found that sociodemographic differences exist in the possession of safety equipment and the perception of safety. Specifically, they have found that safety equipment is significantly less prevalent in the homes of ethnic minorities [27, 28], single-households [29], low income families [29] and families in rented accommodation [30]. Similar socio-demographic differences have been seen with regards to older people and their fire prevention equipment and evacuation preparedness [31]. If a similar pattern exists regarding the possession and knowledge of fire safety equipment in the general population, this could serve as a potential explanation for the socio-demographic differences in mortality and aid in the identification of prevention measures. It could also help clarify the conflicting results between epidemiological studies of the social determinants of residential fires and studies of fire mortality [32].

2. Method and Materials

For this study, cross-sectional data from a national survey, that was sent to a random sample of the Swedish adult population aged 18–79 years in 2005, was used. The purpose of the survey was to investigate the prevalence of residential fires and to obtain information regarding if the household had various types of fire safety equipment, how the equipment was maintained, and if fire safety education had

Table 1
Description of the Variables Used in the Study

Variable	Type	Categories	Role in cluster analysis	Source	Notes
Smoke detector	Categorical	Household has at least one smoke detector (Yes/No)	Active	Survey	
Functionality testing frequency	Categorical	Once a week; Once every other month; Less often; Other frequency (free text); Does not text; Non-response	Active	Survey	Multiple responses allowed (coded as 7 binary variables)
Testing method	Categorical	Test button; Visual inspection, light; Testing in an external battery tester; By (e.g.) lighting a match; Other method (free text)	Active	Survey	The question reflects the individual or someone else in the household
Fire extinguishing equipment	Categorical	Household has a hand held-fire extinguisher; Household has a fire blanket; Individual has practiced using a hand-held fire extinguisher	Active	Survey	Multiple responses allowed (coded as 3 binary variables)
Education	Categorical	Individual has taken part in fire safety education (at least one course)	Active	Survey	
Information		Individual has obtained fire safety information from: A course; Postal leaflets; Leaflets obtained from elsewhere; Ratio/TV; The internet; An open house at the fire department; Has not obtained any fire safety information	Active	Survey	Multiple responses allowed (coded as 8 binary variables)

Table 1
continued

Variable	Type	Categories	Role in cluster analysis	Source	Notes
Evacuation plan		Household has considered evacuation routes in case of a fire	Active	Survey	
Implemented measures		Household has implemented fire safety measures as a consequence of a past fire	Active	Survey	
Age	Integer		Not used	Register	Respondent data
Annual income (in thousands SEK)	Continuous		Not used	Register	Respondent data
Sex	Categorical	Male; Female	Supplementary	Register	Respondent data
Age group	Categorical	18–29 years; 30–49 years; 50–64 years; 65–79 years	Supplementary	Register	Derived from Age into groups used by the Swedish Civil Contigencies Agency
Marital status	Categorical	Unmarried; Married; Divorced; Widowed	Supplementary	Register	Respondent data
Income group	Categorical	Lower, middle and upper tertiles	Supplementary	Register	Derived from Annual income
Family type	Categorical	Children < 18 years living at home; Single adult household; Adult household (> 1 adult)	Supplementary	Survey	
Ethnicity	Categorical	Native Swede; Other Nordic countries; Other	Supplementary	Register	Based on country of birth of the respondent
Housing type	Categorical	Single-family home; Multi-family home; Other	Supplementary	Survey	
Fire in the past five years	Categorical	Has your household experienced a residential fire in the past 5 years? (Yes/No)	Not used	Survey	

Table 1
continued

Variable	Type	Categories	Role in cluster analysis	Source	Notes
Smoke detector functionality at survey completion	Categorical	Yes, all are functional; Yes, some are functional; No; Do not know/could not test	Not used	Survey	The respondent, or someone else in the household, was asked to test functionality before answering the question

been completed. The questionnaire also included a variety of sociodemographic questions. The survey was delivered by mail and completed in paper form. The questionnaire was developed by The Swedish Civil Contingencies Agency (MSB), and administered, scanned and entered into a dataset by Statistics Sweden. Each respondent received a letter stating the purpose of the survey and that participation is voluntary, and were asked to consent to the collection of complementary register data. Using the Swedish personal identification number (PIN), a unique identifier that is considered highly reliable as the register covers 99.9% of the Swedish population [33], Statistics Sweden linked administrative register data to each respondent. Data concerning income was obtained from the Income and Taxation register, and country of birth from the Total Population Register, both via Statistics Sweden [34]. Non-respondents received up to three reminders. An anonymized data file was sent to MSB upon completion. The final response rate was 62%, yielding a sample size of 7507 individuals. A complete list of variables included in the analysis are found in Table 1.

2.1. Statistical Analysis

To effectively explore the socio-demographic differences in residential fire protection practices, the different components of the questionnaire relating to these were summarised. Since the variables available were mainly categorical, multiple correspondence analysis with agglomerative hierarchical clustering was used [35], which is a cluster analysis method that allows for the summary of a larger set of categorical (e.g., nominal or ordinal) variables into a smaller number of clusters [36–38]. The FactoMineR package for *R* was used for this part of the analysis.

In the cluster analysis, variables entered to contribute to the clustering procedure are called active variables whilst supplementary variables are used to aid in the interpretation of the clusters, even though they do not actively create the clusters. Table 1 details the role of each variable in the cluster analysis. The available variables that capture safety equipment use, education, information and practices were entered as active variables in order to capture clustering around latent factors related to safety attitudes and behaviours. The goal was to identify a set of clusters that clearly show a variation in the degree to which an individual is interested in, or practice, fire-related safety in their home. Categorical respondent and household characteristics were entered as supplementary variables to analyse how these were distributed between different fire safety clusters (Table 1).

After this, the optimal number of clusters (Q) can be selected in two different ways. The first approach is based on subjective input after a graphical analysis of a hierarchical tree plot (or dendogram) and prior theoretical beliefs regarding the principal components in the data. The second approach is data-driven, and applies an algorithm that automatically selects the optimal Q based on the inertia gain for each additional partitioning [35]. Since there were no prior hypothesis regarding the optimal number of clusters, the latter approach was chosen. The identified clusters were then interpreted using multivariate v-tests to study the statistically significant differences to the sample averages (see [39] for details).

To test other hypotheses (where appropriate), Pearson's χ^2-test (to test bivariate differences between groups), ordinal logistic regression (to estimate the effects of multiple variables on categorical outcome variables), and log-binomial regression models (for binary outcome variables) were used. These analyses were conducted in Stata version 15.1.

3. Results

Six different fire protection clusters were identified in the analysis. Of these, the smallest cluster (n = 82) was mainly clustered around a large number of non-responses regarding safety equipment and other key variables. For this reason, this cluster was omitted from further analysis. Quantitative data from the remaining five clusters can be found in Table 2, where they are compared to the sample average on a range of fire safety behaviours and equipment use.

The results are interpreted in that the clusters represent five distinct levels of safety interest and behaviours related to residential fire safety: (1) *Uninterested in fire safety*, with negative responses to almost all questions regarding safety equipment in the home; (2) *Minimal fire safety*, where individuals belonging to this cluster have smoke detectors, but do not test their functionality; (3) *Reliance on detection*, which is similar to the previous cluster, but with regular testing of the smoke detector's functionality; (4) *Formally educated in fire safety*, which is characterised by individuals who are safety conscious, have extinguishing equipment in their home, and have obtained their knowledge through formal fire safety education, and (5) *Informally educated in fire safety*, which exhibit similar fire safety practices to individuals in the previous cluster, but who have obtained their safety information elsewhere (e.g. through leaflets or newspapers), meaning that compared to cluster 4, knowledge and information has more actively been searched for.

While the rank order of the clusters in terms of fire safety interest is clear, the exact distinction between cluster 1 and 2 and between 4 and 5 is less pronounced. For example, the clusters *Uninterested in fire safety* and *Minimal fire safety*, i.e. clusters 1 and 2, mainly differ in whether or not a smoke detector is installed. In Sweden, the owner of a property is responsible for maintaining a reasonable level of fire protection and therefore, if the property is a rental property, the fire protection responsibility is not with the resident, but with the landlord [40], which could serve as an underlying cause for the observed difference in smoke detector use. Unfortunately, this could not be tested using the available data.

Both cluster 4 and 5 exhibit a high level of safety consciousness and therefore rank higher than the other three. As Table 2 suggests, almost all individuals in the formally educated cluster (cluster 4) have obtained formal fire safety training (n = 1875, 98%), while only half of the informally educated cluster (cluster 5) has taken part in such training (n = 500, 48%). To explore this further, the differences in the context in which individuals in the two clusters generally obtained their fire training was studied using Pearson's χ^2-test (Table 3). The results imply that individuals in the formally educated cluster who had received fire training

Table 2
Characteristics of the Clusters Compared to the Sample Average on Observed Fire Safety Practices

Cluster	1	2	3	4	5	Sample average
Variable categories	n = 649 (8.6%)	n = 1371 (18.3%)	n = 2740 (32.9%)	n = 1913 (25.5%)	n = 1022 (13.6%)	n = 7507
Smoke detector						
Has at least one smoke detector	$20.5^{(-)}$	$99.8^{(+)}$	$100.0^{(+)}$	$100.0^{(+)}$	$99.6^{(+)}$	92.5
Functionality testing frequency						
Once a week	$0.2^{(-)}$	$0.7^{(-)}$	$6.1^{(+)}$	$6.7^{(+)}$	5.6	4.7
Once every other month	$0.2^{(-)}$	$0.4^{(-)}$	$14.2^{(+)}$	$15.7^{(+)}$	$14.7^{(+)}$	10.8
Less often	$0.5^{(-)}$	$2.8^{(-)}$	$73.1^{(+)}$	$56.8^{(+)}$	$59.1^{(+)}$	47.5
Other frequency (free text response)	$0.0^{(-)}$	$18.1^{(+)}$	$5.4^{(-)}$	$12.4^{(+)}$	8.4	9.4
Does not test	$0.8^{(-)}$	$77.2^{(+)}$	$0.4^{(-)}$	$6.3^{(-)}$	$9.0^{(-)}$	17.2
Non-response	$98.5^{(+)}$	$0.7^{(-)}$	$0.9^{(-)}$	$2.1^{(-)}$	$3.2^{(-)}$	10.4
Testing method (multiple responses allowed)						
Test button	$0.0^{(-)}$	$6.5^{(-)}$	$77.0^{(+)}$	$78.0^{(+)}$	$68.9^{(+)}$	56.2
Visual inspection, light	$0.9^{(-)}$	$4.2^{(-)}$	$26.9^{(+)}$	$24.1^{(+)}$	$30.7^{(+)}$	20.2
Testing in an external battery tester	$0.2^{(-)}$	$1.4^{(-)}$	$4.9^{(+)}$	4.6	$6.2^{(+)}$	3.9
By (e.g.) lighting a match	$0.0^{(-)}$	$2.6^{(-)}$	$10.5^{(+)}$	$10.7^{(+)}$	$15.0^{(+)}$	8.7
Other method (free text response)	$0.0^{(-)}$	$14.9^{(+)}$	$0.1^{(-)}$	3.5	3.3	4.1
Fire extinguishing equipment						
Has a hand-held fire extinguisher at home	$23.4^{(-)}$	$29.6^{(-)}$	$38.1^{(-)}$	$55.5^{(+)}$	$52.9^{(+)}$	41.5
Has a fire blanket at home	$1.1^{(-)}$	$2.4^{(-)}$	$3.4^{(-)}$	$8.2^{(+)}$	$7.1^{(+)}$	4.7
Has practiced using a hand-held fire extinguisher	$46.4^{(-)}$	$40.6^{(-)}$	$38.0^{(-)}$	$95.9^{(+)}$	58.5	56.4
Education						
Has taken part in fire safety education (at least one course)	$37.1^{(-)}$	$36.4^{(-)}$	$26.3^{(-)}$	$98.0^{(+)}$	48.9	50.5
Information (multiple responses allowed)						
Has obtained fire safety information from…						
A course in fire safety	$13.3^{(-)}$	$5.1^{(-)}$	$0.2^{(-)}$	$63.3^{(+)}$	$25.2^{(+)}$	21.9
Postal leaflets	$10.2^{(-)}$	$6.4^{(-)}$	$8.5^{(-)}$	$21.2^{(-)}$	$52.6^{(+)}$	17.6

Table 2
continued

Cluster Variable categories	1 n = 649 (8.6%)	2 n = 1371 (18.3%)	3 n = 2740 (32.9%)	4 n = 1913 (25.5%)	5 n = 1022 (13.6%)	Sample average n = 7507
Leaflets obtained elsewhere	5.9(−)	3.7(−)	4.1(−)	10.3	31.7(+)	9.5
Newspapers	10.6(−)	3.1(−)	2.0(−)	3.7(−)	79.7(+)	14.1
Radio/TV	13.7(−)	5.0(−)	3.8(−)	8.3(−)	79.8(+)	16.5
The internet	0.9	0.8(−)	0.0(−)	0.9(−)	8.3(+)	1.6
An open house at the fire department	2.8	1.8(−)	0.9(−)	5.8(+)	8.5(+)	3.5
Has not obtained any fire safety information	49.9(+)	51.8(+)	60.6(+)	3.9(−)	0.0(−)	35.1
Other						
Has considered evacuation routes in case of a fire	62.3(−)	55.4(−)	72.2(−)	90.6(+)	86.4(+)	74.7
Has implemented fire safety measures as a consequence of a past fire	0.8(−)	1.1	0.7(−)	2.0(+)	2.2(+)	1.3

Notes (+) = significantly greater than the sample average (at the 0.05-level) according to a multivariate v-test, (−) = significantly lower than the sample average. The values in each cell represent the percentage of individuals in the cluster belonging to each variable category unless otherwise stated. The sum of observations from all clusters does not correspond to the sample total due to omission of 82 individuals who formed an uninterpretable, "unknowns" cluster

Table 3
Comparison Between the Informally and Formally Educated Clusters in Answers to the Follow-up Question: ''In What Context Did You Receive Your Fire Safety Training?'' for Individuals Who Reported Having Obtained Formal Fire Safety Training

Answer	Cluster 5 n = 1875	Cluster 6 n = 500	Percentage point difference	Relative change (%)	$\chi^2(1)$	*p* value
School	13.39	22.8	− 9.4	− 41.3	26.9	0.00
Work	77.71	70.2	7.5	10.7	12.2	0.00
Military training	20.37	31	− 10.6	− 34.3	25.5	0.00
Civil defense training	7.95	7.6	0.4	4.6	0.1	0.80
Fire brigade	20.53	22.8	− 2.3	− 10.0	1.2	0.27
Other	6.61	7	− 0.4	− 5.6	0.9	0.76
Cannot remember	0.11	0.4	− 0.3	− 72.5	2.0	0.16

Notes The data presented above is a subset of the sample that answered yes to having received formal fire safety education. Hence, the cluster sizes (n) do not correspond to the actual cluster size reported in the main tables

were more likely to have received work-based education compared to the informally educated cluster. Still, having received fire training at work was the most common answer in both groups (77.7 vs. 70.2%, $p < 0.001$). Individuals in the informally educated cluster were instead more likely than those in the formally educated cluster to have received school-based (13.4 vs. 22.8%, $p < 0.001$) or military-based education (20.4 vs. 31.0%, $p < 0.001$). In essence, the formally educated cluster appears more likely to have held jobs where fire training is provided, while individuals in the informally educated cluster are more likely to have actively sought out information on their own (even after obtaining formal fire safety training).

3.1. Socio-demographic Differences Between the Clusters

Several statistically significant differences emerged when supplementary, socio-demographic variables were used to characterise the clusters. The quantitative results are presented in Table 4, and an interpretation of the cluster analysis, from a socio-demographic perspective, is presented in Table 5. The socio-demographic variables that are highlighted are those that are over-represented in the clusters compared to the sample average (according to the multivariate v-tests seen in Table 4), and thus represent how the clusters distinguishes themselves from the sample norm.

As can be seen in Tables 4 and 5, considerable socio-demographic differences exist between the five clusters. As mentioned previously, *Uninterested in fire safety* and *Minimal fire safety* merely differed in whether a smoke detector was installed. However, with the addition of supplementary variables, socio-demographic differences appeared between these clusters that could explain the differences in protec-

Table 4
Sociodemographic Characteristics of the Five Clusters

Cluster Variable	1 n = 649 (8.6%)	2 n = 1371 (18.3%)	3 n = 2740 (32.9%)	4 n = 1913 (25.5%)	5 n = 1022 (13.6%)	Sample average n = 7507
Continuous						
Age (mean, SD)	47.9 (18.2)	45.9 (17.2)	52.0 (16.9)	49.8 (14.5)	52.1 (15.4)	50.1 (16.5)
Annual income, in thousands SEK (mean, SD)	187.1 (175.5)	215.5 (179.6)	212.8 (159.2)	248.3 (152.2)	238.1 (174.0)	223.5 (165.7)
Categorical (percentage of cluster)						
Male sex	40.7	36.2$^{(-)}$	42.6	52.0$^{(+)}$	46.5	44.2
Age group						
18–29 years	21.1$^{(+)}$	20.1$^{(+)}$	11.0$^{(-)}$	9.1$^{(-)}$	8.2$^{(-)}$	12.6
30–49 years	32.2	38.7$^{(+)}$	33.3$^{(-)}$	38.8$^{(+)}$	34.0	35.6
50–64 years	22.5$^{(-)}$	22.6$^{(-)}$	26.0$^{(-)}$	33.6$^{(+)}$	32.0$^{(+)}$	27.8
65–79 years	24.2	18.7$^{(-)}$	29.7$^{(+)}$	18.5$^{(-)}$	25.8	24.0
Marital status						
Unmarried	37.9$^{(+)}$	38.0$^{(+)}$	27.3$^{(-)}$	30.6	26.4$^{(-)}$	30.8
Married	38.2$^{(-)}$	40.7$^{(-)}$	51.7$^{(+)}$	50.4$^{(+)}$	53.7$^{(+)}$	48.4
Divorced	18.3	17.1	15.3	15.5	14.0	15.8
Widowed	5.5	4.2	5.7$^{(+)}$	3.5$^{(-)}$	5.9	5.0
Income group						
Lower tertile	47.3$^{(+)}$	38.4$^{(+)}$	37.4$^{(+)}$	21.8$^{(-)}$	30.1$^{(-)}$	33.6
Middle tertile	29.0$^{(-)}$	30.5$^{(-)}$	33.0	37.0$^{(+)}$	34.3	33.3
Upper tertile	23.7$^{(-)}$	31.1	29.6$^{(-)}$	41.2$^{(+)}$	35.6	33.1
Family type						
Children < 18 years living at home	25.7$^{(-)}$	32.8$^{(+)}$	27.9$^{(-)}$	33.4$^{(+)}$	30.6	30.3
Single adult household	23.9$^{(+)}$	16.5	14.8	12.1$^{(-)}$	12.3$^{(-)}$	14.9
Adult household (> 1 adult)	46.1$^{(-)}$	47.7$^{(-)}$	54.4$^{(+)}$	52.9	54.5	52.0
Ethnicity						
Native Swede	80.7$^{(-)}$	85.1$^{(-)}$	85.9$^{(-)}$	91.2$^{(+)}$	90.3$^{(+)}$	87.2
Other Nordic countries	3.5	2.8$^{(-)}$	4.6	3.6	4.9	8.8
Other	15.7$^{(+)}$	12.0$^{(+)}$	9.5	5.3$^{(-)}$	4.8$^{(-)}$	8.8
Housing type						
Single-family home	39.6$^{(-)}$	46.7$^{(-)}$	57.6	70.5$^{(+)}$	71.3$^{(+)}$	59.1
Multi-family home	55.2$^{(+)}$	50.0$^{(+)}$	39.3	27.0$^{(-)}$	26.1$^{(-)}$	37.8
Other	4.3$^{(+)}$	2.8	2.3	2.0	2.0	2.4

Notes (+) = significantly greater than the sample average (at the 0.05-level) according to a multivariate v-test, (–) = significantly lower than the sample average (tests were not performed for continuous variables). The values in each cell represent the percentage of individuals in the cluster belonging to each variable category unless otherwise stated. The sum of observations from all clusters does not correspond to the sample total due to omission of 82 individuals who formed an uninterpretable, ''unknowns'' cluster

tion. Specifically, although being unmarried was more common in both clusters, in the *Minimal fire safety* cluster, female respondents were more prevalent compared to the *Uninterested in fire safety* cluster where men were more common. Gender differences in fire protection has previously been well established [41] and could

Table 5
Qualitative Interpretation and Description of Each Cluster in Terms of Sociodemographic Characteristics

Cluster	Qualitative description
Cluster 1—Uninterested in fire safety	The individuals in this cluster are often young (18–29 years), have a low level of income and are more often born outside of Sweden. They often live in a single household in a multi-family house
Cluster 2—Minimal fire safety	The individuals in this cluster are more often young (18–29 years), unmarried and have a low level of income. Women are more prevalent in this cluster. Individuals in this cluster more often live in multi-family houses, are born outside of Sweden and have children
Cluster 3—Reliance on fire detection	The individuals in this cluster are more often older (65 years or above), married or widowed and have a low level of income. They are slightly more often female and born in Scandinavia or Europe
Cluster 4—Formally educated in fire safety	The individuals in this cluster more often live in a single-family home, are more often men, middle-aged (50–64 years) or 30–49 years, born in Sweden, married, have children and have a high or medium level of income
Cluster 5—Informally educated in fire safety	The individuals in this cluster more often live in a single-family home, are more often middle-aged (50–64 years), born in Sweden and are married

therefore serve as a partial explanation for the difference. Likewise, in the *Minimal fire safety* cluster, having children was more common, a factor that has previously been shown to increase worry and risk perception [42], and therefore likely to increase the motivation to protect.

Socio-demographic differences were also observed between the two other similar clusters; *Formally educated in fire safety* and *Informally educated in fire safety*. It would seem that differences exist regarding income, age and whether children live at home (*Informally educated in fire safety* earn more, are older and are less likely to have children living at home). Therefore, although job type is not available in the dataset, given the sociodemographic differences, it may be that the individuals in the informal education group more often have jobs where formal fire training is less likely to be required.

The *Reliance on detection* cluster differs considerably from other clusters, in that older adults and women are more prevalent in this group. Given the prevalence of testing smoke detectors in various ways, this group seems to be fire safety conscious, while heavily reliant on detection rather than extinguishing or escaping the fire. This could potentially be an artefact of a perceived (or actual) ability to cope with a fire by other means than escape or by the help of the rescue services. Specifically, old age has considerable effects on the physical and cognitive abilities of an individual [43] meaning that evacuation or more complex fire extinguishing can be difficult or impossible. Therefore, an early detection becomes the only reasonable preventative measure for older adults with reduced capabilities.

Table 6
Ordinal Logistic Regression Results for Correlations Between Sociodemographic Characteristics and Different Degrees of Fire Safety Behaviour (from Low to High)

	Outcome	
Variable category	Four level fire protection scale (Odds ratio, 95% CI)	Three level fire protection scale (Odds ratio, 95% CI)
Male sex	1.34 (1.21, 1.47)	1.36 (1.24, 1.50)
Age group		
18–29 years	1 (reference)	1 (reference)
30–49 years	1.52 (1.30, 1.78)	1.55 (1.3, 1.85)
50–64 years	1.97 (1.65, 2.35)	2.03 (1.71, 2.43)
65–79 years	1.58 (1.33, 1.89)	1.63 (1.37, 1.95)
Marital status		
Unmarried	1 (reference)	1 (reference)
Married	0.98 (0.87, 1.1)	0.99 (0.86, 1.14)
Divorced	0.86 (0.75, 0.99)	0.87 (0.74, 1.02)
Widowed	1.13 (0.89, 1.43)	1.14 (0.9, 1.44)
Income group		
Lower tertile	1 (reference)	1 (reference)
Middle tertile	1.35 (1.2, 1.52)	1.32 (1.18, 1.49)
Upper tertile	1.3 (1.15, 1.46)	1.26 (1.12, 1.42)
Family type		
Children under 18 living at home	1 (reference)	1 (reference)
Single person household (one adult)	0.7 (0.58, 0.83)	0.71 (0.6, 0.85)
Adult only household (more than one adult)	0.9 (0.80, 1.02)	0.9 (0.8, 1.01)
Ethnicity		
Native Swede	1 (reference)	1 (reference)
Other Nordic countries	1.12 (0.9, 1.38)	1.13 (0.91, 1.4)
Other	0.61 (0.52, 0.71)	0.61 (0.52, 0.71)
Housing type		
Single-family home	1 (reference)	1 (reference)
Multi-family home	0.52 (0.47, 0.57)	0.51 (0.46, 0.56)
Other	0.55 (0.42, 0.73)	0.57 (0.43, 0.74)
Diagnostics		
Log-likelihood	− 9013.5	− 7751.6
Likelihood ratio test, $\chi^2(17)$	654.0***	641.2***
n	7425	7425

Notes The four level scale is coded as follows: (1) Uninterested in fire safety, (2) Minimal fire safety, (3) Reliance on detection, and (4) Formally educated in fire safety + Informally educated in fire safety. The three level scale merges (1) and (2) into one category. The odds ratios (OR) can be interpreted as the change in odds for a belonging to a higher level on the fire protection scale associated with a change in predictor category compared to its reference value (indicated by "reference" in the table), keeping all other variables in the model constant

***$p < 0.001$

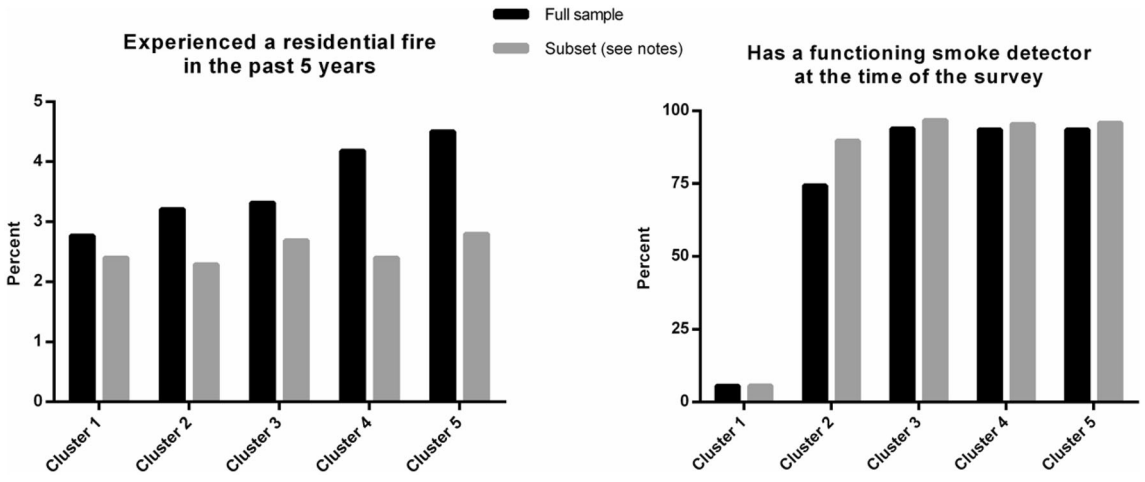

Figure 1. Prevalence of fires in the past 5 years (left panel) and prevalence of functioning smoke detectors at the time of the survey (right panel). The subsets are coded as follows: (1) left panel: individuals who reported having changed their practices as a consequence of a previous fire were removed (2) right panel: individuals who reported not being able to test their smoke detector functionality at the time of the survey were removed.

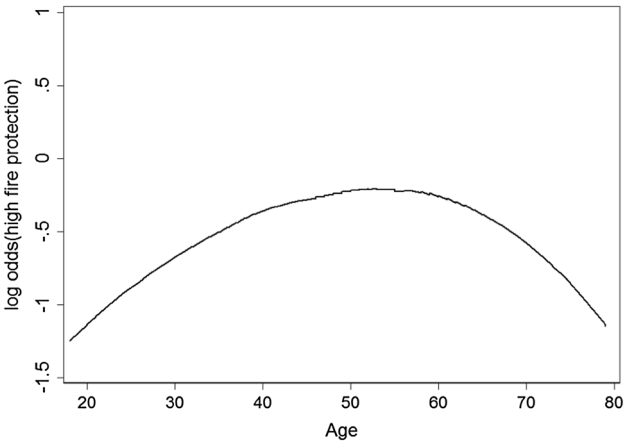

Figure 2. The log-odds of having a high level of fire protection (clusters 4 and 5) by age. The curve was produced non-parametrically using a lowess smoother.

3.2. Regression Results

Many of the socio-demographic variables presented in Table 4 co-vary (e.g. age and income), and it is therefore also important to consider how each variable independently affects fire safety behaviour. To identify which variables still appeared to modify safety practices, while keeping the others constant, a four-level fire protection scale (from 1 to 4, where 1 low and 4 is high) was coded using the obtained clusters, merging the formally and informally educated clusters into one due to their similarities in exhibited fire safety behaviour. The results from this can be found in Table 6. The robustness of the results was also tested to a three-level version of the scale, merging the *Uninterested in fire safety* and *Minimal fire safety* clusters as well. As can be seen, the inferences and effect sizes are largely invariant to coding scheme. They were also robust to using the full range of the clusters in a five-level scale, where switching the rank order of the two educated clusters does not affect the results (available from the authors upon request).

Running ordinal logistic regression models on these scales shows that men score higher on the fire safety scale than women, and that young respondents score significantly lower than older respondents. Marital status does not appear to affect these behaviours when adjusted for the other covariates. Rather, it appears that family type is the dominant variable, where single adult households score much lower than households with children or adult-only households with more than one adult. Individuals with lower income are on average less likely to exhibit fire safety behaviours than respondents in the middle- or high-income groups, and immigrants from non-Scandinavian countries also score significantly lower than native Swedes or immigrants from other Scandinavian countries. Finally, respon-

dents living in single family homes tend to score higher than those living in multi-family homes (Table 6).

3.3. Correlation with Fires in the Past 5 Years

While the survey was not designed to test the causal effects of different safety behaviours (which would require an experimental or quasi-experimental setting), correlations were tested with self-reported residential fires in the past five years using a log-binomial regression model (residential fires reported in the sample = 273). For this, the four-level fire safety scale derived above was used (the inferences were invariant to using the alternative scales). The results produced a positive coefficient, which if taken at face value would suggest that higher fire safety scores are associated with a higher risk of fires (Risk Ratio [RR] 1.17, 95% confidence interval [CI]: 1.02–1.32). However, since the questions regarding safety practices refer to the individual's current state, while the residential fire question encompasses a five-year span, this could be an artefact of reverse causality. This notion is supported by the fact that omitting individuals who reported having changed their fire safety practices due to a past fire (n = 100) from the model yields a non-significant coefficient (RR 1.02, 95% CI: 0.88–1.19). The differences in past fire prevalence by cluster, and the effect of removing the individuals who have changed their safety practices since, are shown in the left panel of Fig. 1. This result is consistent with previous research on individual disaster preparedness and fires [44], but cannot explain a large part of the variation in fire safety behaviours due to the low prevalence of residential fires in the sample (2 percent).

3.4. Correlation with Smoke Detector Functionality

During the survey, respondents were also asked to check the functionality of their smoke detector and report the results. In total, 82.1 percent of the sample reported having at least one functional smoke detector in their home. Testing the correlation between the four-level fire safety scale and functionality in the same manner as above, the probability of having a functional smoke detector increases, on average, by 19 percent for each step in the scale (RR 1.19, 95% CI: 1.18–1.20). As can be seen in Fig. 1, the cluster that does not frequently test the functionality (*Minimal fire safety*) clearly has a lower probability of having a functional smoke detector as compared to those that do, despite the fact that they are just as likely to have a smoke detector in their home (Table 2). Removing the individuals who reported not being able to test their alarms functionality at the time of the survey, these differences were smaller, but still remained statistically significant (RR 1.14, 95% CI: 1.13–1.16). In fact, even when ignoring the *Uninterested in fire safety* cluster while accounting for ability to test, the prevalence of functional smoke detectors is still significantly greater in the three clusters that regularly perform functionality tests compared to the *Minimal fire safety* cluster (89.7 vs. 96.1%, $\chi^2(1) = 81.6$, $p < .001$).

4. Discussion

The aim of this study was to investigate socio-demographic differences in the ownership of residential fire safety equipment, fire prevention practices and knowledge of fire prevention. The results show clearly that, in Sweden, considerable differences exist in household fire protection practices between different socio-demographic groups. These results are consistent with previous studies that have found a significantly lower use of preventative measures or practices amongst ethnic minority families [27, 28, 45, 46], single-households and low income families [29], individuals with a lower educational level [47, 48] as well as those living in socially deprived areas [49, 50], thereby indicating that the level of protection is a highly plausible cause of the socio-demographic differentiation in fire-related mortality.

The results in this study also show that there seems to be a certain "socio-demographic maturity" in the probability of belonging to a high fire protection cluster that takes the form of an inverted u-curve across the lifespan, as shown in Fig. 2. Specifically, younger individuals living in single households with low income tend to exhibit low levels of fire protection. The level of protection then increases with sociodemographic development, to peak during middle-age when individuals have higher income and live in single-family homes with children and to then decrease again with old age, a pattern also seen in a UK government study [51]. Whether this is true from an individual perspective, i.e. that the level of protection varies throughout an individual's life, cannot be tested without access to longitudinal data, although previous studies have shown that adding a child to a household greatly increases the probability of the household having an existing fire escape plan and the probability decreases with old age [52, 53]. This is particularly interesting given the fact that the curve in Fig. 2 does not mimic cross-sectional evidence of changes in positive attitudes towards risk-taking across the life span, which are consistently negative in most risk-taking domains [54]. Likewise, given that experiences of fires or similar emergency situations have been shown to increase precautionary behaviour [44] and that logically more older people would have experienced emergencies, it could be expected that a linear, increasing, fire protection curve could be seen.

Hypothetically, the regression in protective behaviours in old age compared to middle-age may be indicative of a change in the ability to perform active protective behaviours rather than an effect of changes in attitudes and perceptions of fire risks. If this is the case, i.e. that the reduced protection amongst older adults is the result of physical and mental aspects rather than attitude or risk perception, the interventions required to increase the resilience towards residential fires will likely differ between younger and older age groups as well as requiring more innovative solutions for older adults [55].

With regards to the groups with low levels of protection, a number of studies have shown effective interventions such as smoke alarm installations, education or multi-facetted programs [10, 56–58]. Also, a recent Cochrane review found little evidence that effective interventions to promote home fire safety practices differed in effectiveness by social group [57] meaning that it would seem that the socio-demographic differences in fire protection are not carved in stone. For the oldest age

groups, given that it would seem as traditional preventative efforts are somewhat abandoned with increased age as a result of decreased physical and mental capabilities, other prevention efforts with different approaches need to be developed. As highlighted by both Jennings [59] and Corcoran et al. [60] in their respective theoretical models, differences in fire risk and fire protection are most likely the results of complex interactions of individual, societal and structural factors. For older adults this may be particularly important, especially in regards to societal factors such as loneliness, social exclusion and financial difficulties. Such aspects have been highlighted as important to include in prevention programmes [55] given that they have also been shown to increase risk behaviour [61, 62]. Therefore, whilst holistic, multi-facetted programs are required for all groups with low levels of prevention, it would seem unreasonable to suggest that the same interventions are suitable for all groups.

4.1. Limitations

Firstly, data was used from a previously conducted survey and therefore no influence was had on the definition and scope of the variables collected. However, the survey captured many important aspects of residential fire safety behaviours and thus sufficiently served the purposes of this study. Still, since the procedure surrounding the creation and interpretation of the clusters, and the subsequent fire safety scales, is inductive and data-driven, it should be noted that the results could be affected by the addition of more variables relating to fire safety (e.g. explicit questions regarding safety attitudes, knowledge tests, and the presence of passive interventions such as sprinkler systems). Another issue with the data is that some of the safety questions were answered on the behalf of the household, whilst the register data was linked to the respondent, which may introduce some bias into the observed correlations between the affected variables (e.g., age and smoke detector functionality testing). Secondly, the survey response rates might be non-randomly conditional on sociodemographic factors in a manner that is correlated with fire safety practices. If true, this could affect the external validity of the study in the sense that, for instance, respondents with low socioeconomic status are not necessarily representative of non-respondents from the same strata. Thirdly, while we hope that the results are generalisable to other contexts, they may not be comparable to countries in which cultures, fire protection laws and socioeconomic conditions differ greatly from that of Sweden.

5. Conclusion

Considerable socio-demographic differences exist in the level of residential fire protection. This study suggests that socio-demographic factors associated with fire protection are similar to those associated with fire mortality but not with the risk of fire regardless of outcome. Therefore, from a preventative perspective, it would seem important to focus on increasing the fire protection capabilities amongst individuals with lower socio-demographic levels. In particular, in terms of access to information, training and extinguishing equipment.

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