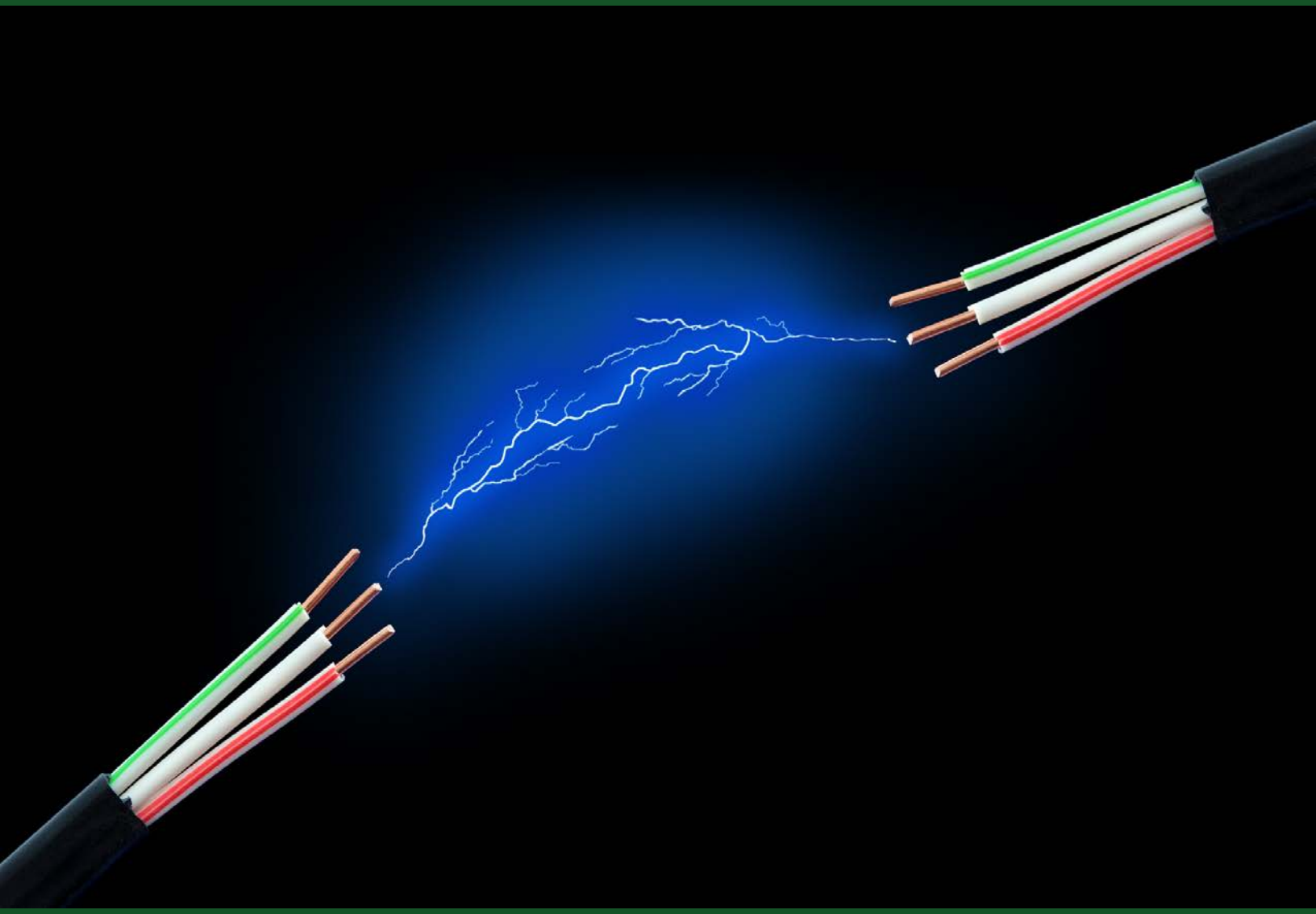
The Influence of Electrical Fires in Residential Homes:

Geospatial Analysis Pointing to Vulnerable Locations and Equipment Failures



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UNIVERSITY OF THE FRASER VALLEY
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BC INJURY research and prevention unit

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Executive Summary

Secondary suites are becoming more common as a way to relieve the burden of rising housing prices in British Columbia and basements are often converted for this purpose. However, home owners often circumvent the permission and inspection requirements for these conversions in order to save on expensive upgrades for compliance. As a result, there are many *under the radar* secondary suites that go uninspected and often do not meet safety standards. In order to limit the increased risks these secondary suites pose, one plan is to send safety inspectors to visit and inspect homes. The purpose of this study is to aid inspectors by determining whether certain jurisdiction types, living spaces in the home (in particular basements), or equipment in the home carry increased risks for electrical fires and should be inspected with higher priority.

Between 2004 and 2017, there were a total of 28,160 residential fire incidents in British Columbia; of which, 2,635 (9.4%) were electrical fires. These electrical fires resulted in a total of 150 casualties (combined deaths and injuries) and just over $150 million in damages. Of the electrical fires, 1,869 (70.9%) occurred in cities, 426 (16.2%) in municipalities, 315 (12.0%) in regional districts, and 14 (0.4%) in First Nation lands. Fires that originated from the basement accounted for 2,688 (9.6%) of residential fires and 366 (13.9%) of electrical fires.

Prevalence for electrical fires were found to be elevated for fires that originated in basements, common living spaces, bathrooms, laundry rooms, and garages. Fires that originated in kitchens were less likely to be electrical fires. Jurisdiction type did not have an effect on the prevalence of election fires. Burden of electrical fires were mixed with electrical fires having higher material costs but lower human costs. Jurisdiction type, basement, and rooms in the home did not affect the burden of electrical fires in terms of both human and material costs. Taken together, this is strong evidence that risk of electrical fires is mostly due to the effects of attention and neglect, where the risk of electrical fires is lowest in areas most accessed, such as the kitchen, and highest in areas least accessed, such as basements, garages and laundry rooms. The fact that human and material costs of electrical fires was not affected by where the fire originated from suggests that an inspection scheme to reduce the prevalence of electrical fires would be effective in reducing the overall burden of electrical fires in British Columbia.

In terms of areas of the home for electrical safety inspectors, the order of priority is recommended to be: garage, laundry, bathroom, basement, common living space, and then other areas of the home. For garages, permanent wiring, extension cords, and batteries should be the focus. For laundry rooms, clothe dryers and washing machines should be the focus. For bathrooms, electrical components with motors should be the focus. In basements, permanent wiring, switchboards, extension cords, and clothes dryers should be the focus. For common living spaces, permanent wiring, extension cords, outlets, surge protectors, and space heaters should be the focus. Overall, permanent wiring, extension cords, outlets, surge protectors, appliance cords, and electrical equipment with motors were the leading causes of electrical fires.

Introduction

Electrical fires can occur as a function of faulty wiring or as a result of failure or misuse of electrical components, with the most common physical mechanisms being poor connections, arcing across a carbonized path, arcing in air, excessive thermal insulation, and overload (Babrauskas, 2008). To date, there are no studies published based on statistics from Canada, but in the United States, electrical fires represented 13% of total residential structure fires, residential homes and resulted substantial monetary and human losses (Hall, 2013).

The rising housing prices in British Columbia, particularly in the Greater Vancouver Area, have placed considerable strain on the finances of British Columbians. Secondary suites in residential homes are a common means to supplement income and cover mortgage payments. Basements are often converted for this purpose in existing homes originally designed as single family dwellings. Building code regulations in British Columbia require special permissions to be granted in order for basements to be converted into secondary suites. However, home owners often circumvent this requirement in order to save time and money. As a result, these *under the radar secondary suites* go uninspected and often do not meet safety standards. This is particularly true in relation to electrical wiring, resulting in a substantial hazard for electrical fires and other electrical injuries. This is of particular concern, as basement fires, which made up 18% of all house fires (Yung & Lougheed, 2001), increased the odds of injuries (Fabio et al, 2002). In order to limit the increased risks these unreported secondary suites pose, it is proposed to apply a regulatory scheme where homes that contain secondary suites are inspected, paying particular attention to electrical safety.

The purpose of this study is to aid inspectors by determining whether certain jurisdiction types, living spaces in the home (in particular basements), or equipment in the home carry elevated risks for electrical fires and should be inspected with higher priority. Specifically, this study has 2 main components. Firstly, to investigate whether prevalence and burden (in terms of human and material costs) of residential electrical fires differ between: i) jurisdiction types, ii) basement and non-basement areas, iii) rooms in the home, and iv) rooms in the basement. Secondly, for rooms with elevated risk for electrical fires, determine whether certain equipment failures or misuses are more likely to result in an electrical fire.

Methodology

DATA OVERVIEW

Fire events in British Columbia from 2004 to 2017 and its associated properties were extracted from data collected by British Columbia Office of the Fire Commissioner (OFC). Fire events were considered to be residential fires if the fires occurred in row, garden, town housing, condominium, apartment, single detached, duplex, 3-plex, and 4-plex residential zones (as classified by the property complex variable). Electrical fires were determined as fires that resulted from electrical short circuit (as classified by the act or omission variable) or from electrical sparks (as classified by the form of heat variable).

Jurisdictions were grouped into: i) cities, ii) municipalities, iii) regional districts, iv) First Nation lands, or v) other/unknown (as classified by the location code variable). The basement variable was grouped into whether: i) the fire originated in the basement, ii) in any other part of the home, or iii) unknown (as classified by the fire origin level variable). The room in the home variable was grouped into: i) common living space, ii) bedroom, iii) bathroom, iv) kitchen, v) laundry, vi) garage, vii) passageway (e.g. hallway, stairs, corridor, elevator, lobby), or viii) other/unknown (as classified by the fire origin area variable). Lastly, equipment of failure or misuse that led to an electrical fire were categorized into: i) cooking equipment, ii) heating equipment, iii) appliances and equipment, iv) electrical distribution equipment, v) other electrical equipment, vi) smoker's material and open flame, vii) exposure, viii) miscellaneous, ix) no igniting object, or x) cannot be determined (as classified by the object of ignition variable).

PREVALENCE AND BURDEN OF ELECTRICAL FIRES

To investigate whether prevalence and burden of electrical differed between the four comparisons, a two-step approach was used. The first step involved conducting a descriptive analysis and a modeling analysis. In the second step, results from the descriptive and modeling analyses were compared and variables that were significant in both analyses were deemed to be significant overall, and thus can be concluded to carry an elevated, or reduced, risk for electrical fires. An alpha level of 0.05 was used to determine significance.

The descriptive analysis involved calculating, with 95% confidence intervals, the proportion of electrical fires to compare prevalence of electrical fires, as well as human casualty rates and dollar cost of material damage to compare burden of electrical fires. Human casualty rates were calculated as the sum of deaths and injuries per 100 fires. Jurisdiction types were compared to a typical fire. Basement fires were compared with non-basement fires. Fires that originated in a specific room were compared to a typical fire. Fires that originated in a specific room in the basement were compared to a typical basement fire. All confidence intervals were Wald intervals and comparisons where the confidence intervals do not overlap were deemed to be significant.

Three types of models were used for the modeling analysis. For the prevalence component, a logistic regression model was used to determine the association between the odds of a fire being an electrical fire with the explanatory variables interest. For the human cost component, a Poisson regression model was used to determine the association between the number of casualties as a result of an electrical fire with the explanatory variables of interest. For the material cost component, a linear regression model was used to determine the association between the dollar loss amount with the explanatory variables of interest. For the Poisson and linear regression models, only electrical fires were included for the analysis. For all three components, two models were conducted: i) a full model where the explanatory variables were jurisdiction type, basement, and room type variables; and ii) a basement-only model where the explanatory variables were jurisdiction type and basement room type variables. Both models were adjusted for the type of residential home. For the basement-only model, only basement fires were included in the analysis. Dummy coding was used for the jurisdiction type and room type variables in order to observe the effects of these types compared to the average electrical fire.

EQUIPMENT OF ELEVATED RISK

In rooms with elevated risk for electrical fires, proportions of electrical fires that originated from that room due to equipment failure were calculated, with 95% confidence intervals, for the leading equipment failures and equipment categories. Due to the combination of a large number of equipment variables and low counts for some equipment and categories, only those which resulted in at least 14 electrical fire events (at least 1 electrical fire per year, on average) for both individual equipment as well as equipment categories were included in the analysis.

Results

PREVALENCE OF ELECTRICAL FIRES

Descriptive Analysis

Between 2004 and 2017, there were a total of 28,164 residential fire incidents in British Columbia; of which, 2,635 (9.4%) were electrical fires. Of the electrical fires, 1,869 (70.9%) occurred in cities, 426 (16.2%) in municipalities, 315 (12.0%) in regional districts, and 14 (0.4%) in First Nation lands. The proportion of electrical fires was higher in municipalities (11.1%), lower in First Nation lands (5.9%), and no significant differences for cities and regional districts when compared with the overall proportion (Table 1)

TABLE 1: PROPORTION OF ELECTRICAL FIRES IN DIFFERENT JURISDICTION TYPES (SIGNIFICANT EFFECTS IN BOLD).

Location Type	All Fires [%] (95% CI)	Electrical Fires [%] (95% CI)	Proportion of Electrical Fires (95% CI)
City	20,844 [74.0%] (73.5, 74.5)	1,869 [70.9%] (69.2, 72.7)	9.0% (8.6, 9.4)
Municipality	3,842 [13.6%] (13.2, 14.0)	426 [16.2%] (14.8, 17.6)	**11.1% (10.1, 12.1)**
Regional District	3,059 [10.9%] (10.5, 11.2)	315 [12.0%] (10.7, 13.2)	10.3% (9.2, 11.4)
First Nations	238 [0.8%] (0.7, 1.0)	14 [0.5%] (0.3, 0.8)	**5.9% (2.9, 8.9)**
Others/Unknown	177 [0.6%] (0.5, 0.7)	11 [0.4%] (0.2, 0.7)	6.2% (2.7, 9.8)
Overall	28,164 [100%]	2,635 [100%]	9.4% (9.0, 9.7)

Fires that originated from the basement accounted for 2,688 (9.6%) of residential fires and 366 (13.9%) of electrical fires. The proportion of basement fires being electrical fires (13.6%) was significantly higher than the proportion of non-basement fires (9.2%) as well as the overall proportion of 9.4% (Table 2).

TABLE 2: PROPORTION OF ELECTRICAL FIRES THAT ORIGINATED FROM THE BASEMENT (SIGNIFICANT EFFECTS IN BOLD).

Basement	All Fires [%] (95% CI)	Electrical Fires [%] (95% CI)	Proportion of Electrical Fires (95% CI)
No	24,001 [85.2%] (84.8, 85.6)	2,206 [83.7%] (82.3, 85.1)	**9.2% (8.8, 9.6)**
Yes	2,688 [9.6%] (9.2, 9.9)	366 [13.9%] (12.6, 15.2)	**13.6% (12.3, 14.9)**
Unknown	1,471 [5.2%] (5.0, 5.5)	63 [2.4%] (1.8, 3.0)	4.3% (3.2, 5.3)
Overall	28,164 [100%]	2,635 [100%]	9.4% (9.0, 9.7)

TABLE 3: PROPORTION OF ELECTRICAL FIRES THAT ORIGINATED FROM DIFFERENT ROOMS OF THE HOME (SIGNIFICANT EFFECTS IN BOLD).

Room Type	All Fires [%] (95% CI)	Electrical Fires [%] (95% CI)	Proportion of Electrical Fires (95% CI)
Common Living	2,380 [8.5%] (8.1, 8.8)	299 [11.3%] (10.1, 12.6)	**12.6% (11.2, 13.9)**
Bedroom	2,093 [7.4%] (7.1, 7.7)	218 [8.3%] (7.2, 9.3)	10.4% (9.1, 11.7)
Bathroom	572 [2.0%] (1.9, 2.2)	90 [3.4%] (2.7, 4.1)	**15.7% (12.8, 18.7)**
Kitchen	8,560 [30.4%] (29.9, 30.9)	389 [14.8%] (13.4, 16.1)	**4.5% (4.1, 5.0)**
Laundry	844 [3.0%] (2.8, 3.2)	128 [4.9%] (4.0, 5.7)	**15.2% (12.7, 17.6)**
Garage	903 [3.2%] (3.0, 3.4)	150 [5.7%] (4.8, 6.6)	**16.6% (14.2, 19.1)**
Passageway	863 [3.1%] (2.9, 3.3)	94 [3.6%] (2.9, 4.3)	10.9% (8.8, 13.0)
Others/Unknown	11,945 [42.4%] (41.8, 43.0)	1,267 [48.1%] (46.2, 50.0)	**10.6% (10.0, 11.1)**
Overall	28,164 [100%]	2,635 [100%]	9.4% (9.0, 9.7)

Compared to the overall proportion of all fires being electrical fires (9.4%), five rooms demonstrated significantly elevated proportions of fire events being electrical fires – common living space (12.6%), bathroom (15.7%), laundry (15.2%), and garage (16.6%). Even though kitchen fires made up the largest proportion of both electrical fires (14.8%) and overall fires (30.4%), the proportion of kitchen fires that were electrical fires was less than half of the overall proportion at 4.5%. 48% of electrical fires had no identified room as the originating area (Table 3).

When looking at just basement fires, compared to the overall proportion of basement fires being electrical fires (13.6%), two rooms had significantly lower proportions of fire events being electrical fires – bathroom (4.3%) and kitchen (3.4%). No rooms had higher proportions of fire events being electrical fires. 60% of electrical fires in the basement had no identified living space as the originating area (Table 4).

TABLE 4: PROPORTION OF ELECTRICAL FIRES THAT ORIGINATED FROM DIFFERENT ROOMS IN THE BASEMENT OF THE HOME (SIGNIFICANT RESULTS IN BOLD).

Room Type (Basement)	All Fires [%] (95% CI)	Electrical Fires [%] (95% CI)	Proportion of Electrical Fires (95% CI)
Common Living	297 [11.0%] (9.9, 12.2)	44 [12.0%] (8.7, 15.4)	14.8% (10.8, 18.9)
Bedroom	243 [9.0%] (8.0, 10.1)	30 [8.2%] (5.4, 11.0)	12.3% (8.2, 16.5)
Bathroom	46 [1.7%] (1.2, 2.2)	2 [0.5%] (0.0, 1.3)	**4.3% (0.0, 10.2)**
Kitchen	470 [17.5%] (16.0, 18.9)	16 [4.4%] (2.3, 6.5)	**3.4% (1.8, 5.0)**
Laundry	249 [9.3%] (8.2, 10.4)	41 [11.2%] (8.0, 14.4)	16.5% (11.9, 21.1)
Garage	56 [2.1%] (1.5, 2.6)	5 [1.4%] (0.2, 2.6)	8.9% (1.5, 16.4)
Passageway	81 [3.0%] (2.4, 3.7)	10 [2.7%] (1.1, 4.4)	12.3% (5.2, 19.5)
Others/Unknown	1,246 [46.4%] (44.5, 48.2)	218 [59.6%] (54.5, 64.6)	17.5% (15.4, 19.6)
Overall	2,688 [100%]	366 [100%]	13.6% (12.3, 14.9)

Modeling Analysis

From the full model, it was found that jurisdiction type had no significant association with the odds of an electrical fire. Basement fires demonstrated 39% higher odds of being an electrical fire when compared to non-basement fires. Compared to all fires, four rooms had elevated odds ratios for being an electrical fire: common living space (17%), bathroom (53%), laundry (43%), and garage (86%). Kitchen fires had 64% reduced odds of being an electrical fire. The other rooms had no significant associations with the odds of an electrical fire. For the basement only model, jurisdiction type had no significant association with the odds of a basement electrical fire. No basement rooms had elevated odds for an electrical fire, while bathrooms and kitchen had reduced odds of an electrical fire of 83% and 87%, respectively (Table 5).

TABLE 5: LOGISTIC REGRESSION RESULTS LOOKING AT THE ASSOCIATION BETWEEN THE ODDS OF A FIRE BEING AN ELECTRICAL FIRE WITH JURISDICTION TYPE, BASEMENT, AND ROOM TYPE, ADJUSTING FOR RESIDENTIAL TYPE FOR THE FULL MODEL AND BASEMENT-ONLY MODEL (SIGNIFICANT EFFECTS IN BOLD).

	Full Model	Basement Only
Variable	**Odds Ratio (95% CI)**	**Odds Ratio (95% CI)**
Jurisdiction Type		
City	1.678 (0.902, 3.121)	6.994 (0.946, 51.699)
Municipality	1.853 (0.990, 3.468)	5.707 (0.755, 43.114)
Regional District	1.755 (0.935, 3.293)	5.315 (0.699, 40.408)
First Nation	0.954 (0.418, 2.180)	N/A (too few counts)
Basement		
Basement vs Non-basement	**1.390 (1.228, 1.573)**	N/A
Unknown vs Non-basement	**0.657 (0.505, 0.854)**	N/A
Rooms		
Common Living	**1.166 (1.017, 1.338)**	0.787 (0.547, 1.131)
Bedroom	1.015 (0.869, 1.186)	0.689 (0.452, 1.051)
Bathroom	**1.528 (1.205, 1.937)**	**0.173 (0.041, 0.726)**
Kitchen	**0.363 (0.321, 0.409)**	**0.133 (0.079, 0.225)**
Laundry	**1.426 (1.163, 1.748)**	0.892 (0.609, 1.304)
Garage	**1.856 (1.533, 2.248)**	0.412 (0.156, 1.089)
Passageway	1.051 (0.838, 1.319)	0.653 (0.325, 1.314)
Residential Type		
Townhome/condo vs Single detached	1.050 (0.907, 1.216)	**2.627 (1.667, 4.139)**
Apartment vs Single detached	**0.668 (0.589, 0.757)**	1.019 (0.666, 1.558)
2-, 3-, 4-plex vs Single detached	1.099 (0.929, 1.302)	0.853 (0.540, 1.348)

Summary

Taking the descriptive and modeling results together, there were a number of variables that were significant in both analyses. Basement, common living space, bathroom, laundry, and garage had elevated risk for electrical fires, while kitchens had lower risk. There was not enough evidence to indicate that jurisdiction type had an effect on prevalence for electrical fires. When just looking at basement fires, none of the rooms carried significantly higher risk for electrical fires, while bathrooms and kitchens had lower risk.

BURDEN OF ELECTRICAL FIRES

Descriptive Analysis

The 2,635 electrical fires in British Columbia between 2004 and 2017 resulted in a total of 150 casualties (combined deaths and injuries) and just over $150 million in damages. Human casualties from electrical fires were found to be lower, on average, than non-electrical fires (5.7 vs 8.5 per 100 fires), however electrical fires demonstrated higher material loss ($68,706 vs $52,399, on average) when compared to non-electrical fires (Table 6).

TABLE 6: COMPARING CASUALTY RATES AND MATERIAL LOSS RESULTS FOR ELECTRICAL AND NON-ELECTRICAL FIRES (SIGNIFICANT EFFECTS IN BOLD).

Electrical Fire	N	Casualty Rate (per 100 fires) (95% CI)	Material Loss ($) (95% CI)
No	21725	**8.5 (8.0, 9.0)**	**52,399 (47,477, 57,320)**
Yes	2635	**5.7 (4.5, 6.9)**	**68,706 (57,807, 79,605)**
Unknown	3800	10.9 (9.3, 12.5)	163,529 (129,011, 198,047)
Overall	28160	8.6 (8.1, 9.0)	68,921 (62,810, 75,032)

When looking at electrical fires, jurisdiction type did not have an effect for either human or material cost (Table 7). Basement electrical fires also did not differ from non-basement fires for both human and material costs (Table 8). Kitchen fires showed lower casualty rates and material losses when compared to an average electrical fire. Laundry fires resulted in reduced material losses but no difference in casualty rates when compared to an average electrical fire. None of the other rooms showed a difference in burden (Table 9). When looking at just basement electrical fires, none of the room types showed a difference in burden when compared to the average basement electrical fire (Table 10).

TABLE 7: COMPARING CASUALTY RATE AND MATERIAL LOSS AS A RESULT OF ELECTRICAL FIRES IN DIFFERENT JURISDICTION TYPES (NO SIGNIFICANT EFFECTS).

Location Type	N	Casualty Rate (per 100 fires) (95% CI)	Material Loss ($) (95% CI)
City	1,869	6.1 (4.7, 7.5)	63,655 (49,163, 78,147)
Municipality	426	3.1 (1.3, 4.8)	72,518 (55,451, 89,584)
Regional District	315	5.7 (1.3, 10.2)	93,114 (73,915, 112,313)
First Nations	14	7.1 (0.0, 21.1)	58,800 (5,247, 112,353)
Other	11	36.4 (0.0, 107.6)	92,984 (20,863, 165,104)
Overall	2635	5.7 (4.5, 6.9)	68,706 (57,807, 79,605)

TABLE 8: COMPARING CASUALTY RATE AND MATERIAL LOSS AS A RESULT OF BASEMENT AND NON-BASEMENT ELECTRICAL FIRES (NO SIGNIFICANT EFFECTS).

Basement	N	Casualty Rate (per 100 fires) (95% CI)	Material Loss ($) (95% CI)
No	2206	5.5 (4.3, 6.7)	69,572 (56,837, 82,308)
Yes	366	7.9 (3.5, 12.3)	66,936 (54,623, 79,248)
Unknown	63	0.0 (0.0, 0.0)	48,659 (0, 110,908)
Overall	2635	5.7 (4.5, 6.9)	68,706 (57,807, 79,605)

TABLE 9: COMPARING CASUALTY RATE AND MATERIAL LOSS AS A RESULT OF ELECTRICAL FIRES THAT ORIGINATED FROM DIFFERENT ROOM TYPES (SIGNIFICANT EFFECTS IN BOLD).

Room Type	N	Casualty Rate (per 100 fires) (95% CI)	Material Loss ($) (95% CI)
Common Living	299	9.7 (6.0, 13.4)	62,363 (48,304, 76,422)
Bedroom	218	10.1 (5.2, 15.0)	79,887 (60,640, 99,133)
Bathroom	90	6.7 (0.0, 13.5)	62,451 (8,253, 116,649)
Kitchen	389	**2.8 (1.2, 4.5)**	**29,810 (20,212, 39,407)**
Laundry	128	9.4 (0.0, 20.6)	**35,766 (19,556, 51,975)**
Garage	150	10.0 (3.6, 16.4)	99,638 (73,054, 126,223)
Passageway	94	2.1 (0.0, 5.1)	52,421 (25,131, 79,712)
Others/Unknown	1267	4.2 (2.7, 5.6)	81,540 (60,340, 102,740)
Overall	2635	5.7 (4.5, 6.9)	68,706 (57,807, 79,605)

TABLE 10: COMPARING CASUALTY RATE AND DOLLAR LOSS AS A RESULT OF BASEMENT ELECTRICAL FIRES THAT ORIGINATED FROM DIFFERENT ROOM TYPES (SIGNIFICANT EFFECTS IN BOLD).

Room Type (Basement)	N	Casualty Rate (per 100 fires) (95% CI)	Material Loss ($) (95% CI)
Common Living	44	13.4 (1.5, 25.7)	72,538 (41,661, 103,415)
Bedroom	30	10.0 (0.0, 20.9)	109,028 (53,503, 164,553)
Bathroom	2	0.0 (0.0, 0.0)	450 (0, 940)
Kitchen	16	6.3 (0.0, 18.5)	47,153 (6,056, 88,250)
Laundry	41	17.1 (0.0, 46.0)	82,240 (36,647, 127,833)
Garage	5	20.0 (0.0, 59.2)	31,440 (0, 89,594)
Passageway	10	0.0 (0.0, 0.0)	68,622 (5,995, 131,248)
Others/Unknown	218	5.0 (1.2, 8.9)	59,932 (44,573, 75,292)
Overall	366	7.9 (3.5, 12.3)	66,936 (54,623, 79,248)

Modeling Analysis

Results from the Poisson model indicated that electrical fires in cities, municipalities, and regional districts had reduced casualties. However, this was likely because the few cases where the electrical fires occurred without a classifiable jurisdiction had high casualty rates, thus these variables should be interpreted with severe limitations. Jurisdiction type did not have a significant association with material loss. Burden from electrical fires did not differ between whether they originated from the basement or not. Electrical fires that originated from common living space (119%), bedroom (139%), laundry (105%), and garage (151%) all had elevated casualty rates, but did not have significant association with material loss. For basement electrical fires, jurisdiction type was not significant associated with burden. Basement electrical fires that originated from common living space (219%) and laundry (228%) had higher casualty rates, while those that originated from the bedroom resulted in higher material loss ($50,590). None of the other room types had significant associations with burden of basement electrical fires (Table 11).

TABLE 11: RESULTS FROM THE POISSON (CASUALTY RATE) AND LINEAR REGRESSION (MATERIAL LOSS) MODELS SHOWING ASSOCIATIONS BETWEEN JURISDICTION TYPE AND WHERE THE ELECTRICAL FIRE ORIGINATED FROM WITH THE CASUALTY RATE AND MATERIAL LOSS FOR RESIDENTIAL ELECTRICAL FIRES FOR THE FULL MODEL AND BASEMENT-ONLY MODEL (SIGNIFICANT RESULTS IN BOLD).

Variable	Full Model		Basement only	
	Casualty Rate	Material Loss	Casualty Rate	Material Loss
	Rate Ratio (95% CI)	Effect (95% CI)	Rate Ratio (95% CI)	Effect (95% CI)
Jurisdiction Type				
City	**0.175 (0.063, 0.484)**	-25,965 (-1195,581, 143,649)	N/A (too few counts)	9,595 (-182,414, 292,414)
Municipality	**0.093 (0.030, 0.288)**	-16,412 (-187,488, 154,662)	N/A (too few counts)	18,541 (-221,869, 258,951)
Regional District	**0.167 (0.056, 0.497)**	1,589 (-170,192, 173,369)	N/A (too few counts)	-3,785 (-244,803, 237,231)
First Nation	0.217 (0.024, 1.966)	-36,822 (-262,626, 188981)	N/A (too few counts)	N/A (too few counts)
Basement				
Basement vs Non-basement	1.463 (0.961, 2.230)	-2,763 (-35,134, 29,607)	N/A	N/A
Unknown vs Non-basement	N/A (too few counts)	-18,016 (-89,936, 53,903)	N/A	N/A
Rooms				
Common Living	**2.185 (1.386, 3.445)**	-20,926 (-57,049, 15,195)	**3.187 (1.146, 8.867)**	12,954 (-26,596, 52,505)
Bedroom	**2.389 (1.450, 3.935)**	-2,063 (-43,180, 39,053)	2.000 (0.555, 7.200)	**50,590 (4,271, 96,908)**
Bathroom	1.634 (0.696, 3.836)	-51,339 (-84,214, 18,463)	N/A (too few counts)	-41,350 (-212,647, 129,946)
Kitchen	0.708 (0.367, 1.365)	-45,902 (-98,054, 6,249)	1.617 (0.202, 12.964)	-6,398 (-69,525, 56,729)

Laundry	**2.049 (1.090, 3.850)**	-45,288 (-97,412, 6,835)	**3.283 (1.258, 8.565)**	22,668 (-18,015, 63,352)
Garage	**2.510 (1.405, 4.483)**	18,279 (-30,351, 66,911)	3.278 (0.388, 27.721)	-21,528 (-130,995, 87,938)
Passageway	0.495 (0.120, 2.048)	-33,377 (-94,064, 27,308)	N/A (too few counts)	9,389 (-68,180, 86,958)
Residential Type				
Townhome/condo vs Single detached	0.860 (0.459, 1.611)	-11,967 (-50.802, 26,867)	0.438 (0.058, 3.337)	-26,527 (-70,993, 17,939)
Apartment vs Single detached	1.418 (0.906, 2.219)	27,771 (-8,993, 58,537)	2.818 (0.935, 8.492)	-7,012 (-53,039, 39,014)
2-, 3-, 4-plex vs Single detached	0.965 (0.486, 1.917)	-11,163 (-55,633, 33,307)	0.594 (0.077, 4.607)	-32,209 (-84,605, 20,187)

Summary

Electrical fires had lower human cost but higher material cost when compared with non-electrical fires. None of the variables showed consistently significant associations between the descriptive and modeling analyses, thus was concluded that there was not enough evidence to indicate that jurisdiction type, basement, or room type had an effect on the overall burden of electrical fires.

EQUIPMENT OF ELEVATED RISK

Electrical distribution equipment was the largest category and contributed to about half (50.1%) of all causes of the 2,635 electrical fires in British Columbia from 2004 to 2017. In terms of individual equipment, permanent wiring or cables were the cause of 19.9% of the cases, while cords, switches, outlets, power bars made up an additional 16.7%. Illegal electrical bypasses were the cause of only 1.9% of electrical fires (Table 12). Unclassified equipment made up between 8% and 53% of the equipment categories.

TABLE 12: PROPORTION OF ELECTRICAL FIRES THAT WERE CAUSED BY THE IGNITION OF EQUIPMENT IN THE HOME. ONLY INDIVIDUAL EQUIPMENT AND EQUIPMENT CATEGORIES THAT CAUSED AT LEAST 14 ELECTRICAL FIRE EVENTS ARE SHOWN.

Igniting Object (Overall)	Electrical Fires (#)	Proportion of All Electrical Fires (95% CI)
Cooking Equipment	196	7.4% (6.4, 8.4)
Stove, range, top burner area	64	2.4% (1.8, 3.0)
Oven of stove, rage	39	1.5% (1.0, 1.9)
Microwave oven	35	1.3% (0.9, 1.8)
Toaster, waffle iron	23	0.9% (0.5, 1.2)
Electric kettle, coffee maker	15	0.6% (0.3, 0.9)
Cooking equipment - unclassified	15	0.6% (0.3, 0.9)
Appliances and Equipment	329	12.5% (11.2, 13.7)
Clothes dryer	77	2.9% (2.3, 3.6)
Washing machine	28	1.1% (0.7, 1.5)
Individual refrigeration unit	26	1.0% (0.6, 1.4)
Television, computer monitor	14	0.5% (0.3, 0.8)
Appliances and equipment - unclassified	130	4.9% (4.1, 5.8)
Other Electrical Equipment	404	15.3% (14.0, 16.7)
Motor	69	2.6% (2.0, 3.2)
Incandescent lamp, light bulb	41	1.6% (1.1, 2.0)
Florescent lamp	29	1.1% (0.7, 1.5)
Other electrical equipment - unclassified	226	8.6% (7.5, 9.6)
Heating Equipment	201	7.6% (6.6, 8.6)
Water heater	45	1.7% (1.2, 2.2)
Stationary space heater	40	1.5% (1.1, 2.0)

Central heating unit	38	1.4% (0.9, 1.8)
Portable space heater	27	1.0% (0.6, 1.4)
Heating equipment - unclassified	38	1.4% (1.0, 1.9)
Electrical Distribution Equipment	1321	50.1% (48.2, 52.0)
Permanent electric wiring, cable (non-aluminum)	453	17.2% (15.8, 18.6)
Extension cord	146	5.5% (4.7, 6.4)
Switch, outlet	121	4.6% (3.8, 5.4)
Permanent electric wiring, cable (aluminum)	70	2.7% (2.0, 3.3)
Power bars, surge protector	63	2.4% (1.8, 3.0)
Panel board, switchboard	56	2.1% (1.6, 2.7)
Appliance cord	55	2.1% (1.5. 2.6)
Electrical bypass (illegal operations)	50	1.9% (1.4, 2.4)
Battery, rectifier	49	1.9% (1.3, 2.4)
Copper conductors	22	0.8% (0.5, 1.2)
Electrical distribution equipment - unclassified	226	6.9% (5.9, 7.8)
Exposure	23	0.9% (0.5, 1.2)
Miscellaneous	41	1.6% (1.1, 2.0)
No Igniting Object	22	0.8% (0.5, 1.2)
Cannot be Determined	92	3.5% (2.8, 4.2)
Overall	2635	100%

Basements, common living spaces, bathrooms, laundry rooms, and garages were found to carry elevated risk for electrical fires. Basements and common living spaces showed similar patterns where electrical distribution equipment were the cause of over half of the electrical fires (52.5% and 53.5%, respectively). The main difference between the two rooms was that clothes dryers (4.6%) were a contributing factor for basement electrical fires, while stationary space heaters (5.0%) were a contributing factor for common living space electrical fires, though both accounted for just a small proportion (Tables 13 and 14).

TABLE 13: PROPORTION OF BASEMENT ELECTRICAL FIRES THAT WERE CAUSED BY THE IGNITION OF EQUIPMENT IN THE HOME. ONLY INDIVIDUAL EQUIPMENT AND EQUIPMENT CATEGORIES THAT CAUSED AT LEAST 14 ELECTRICAL FIRE EVENTS ARE SHOWN.

Igniting Object (Basement)	Basement Electrical Fires (#)	Proportion of Basement Electrical Fires (95% CI)
Heating Equipment	38	10.4% (7.3, 13.5)
Appliances and Equipment	44	10.4% (7.3, 13.5)
Clothes dryer	17	4.6% (2.5, 6.8)
Appliances and equipment - unclassified	14	3.8% (1.9, 5.8)
Electrical Distribution Equipment	192	52.5% (47.3, 57.6)
Permanent electric wiring, cable (non-aluminum)	69	18.9% (14.8, 22.9)
Panel board, switchboard	17	4.6% (2.5, 6.8)
Extension cord	17	4.6% (2.5, 6.8)
Permanent electric wiring, cable (aluminum)	14	3.8% (1.9, 5.8)
Electrical distribution equipment - unclassified	21	5.7% (3.4, 8.1)
Other Electrical Equipment	59	16.1% (12.4, 19.9)
Other electrical equipment - unclassified	31	8.5% (5.6, 11.3)
Basement Overall	366	100%

In bathrooms, electrical distribution equipment only made up 26.7% of all bathroom electrical fires, with the only object of importance being electrical equipment with motors, which made up 17.8% of all bathroom electrical fires (Table 15). In laundry rooms, clothes dryers were the cause to almost half (45.3%) of all laundry room electrical fires, while washing machines were the cause of an additional 14.1% (Table 16). In garages, electrical distribution equipment was the cause of over half of the garage electrical fires (62.7%), with permanent non-aluminum wiring or cable (14.0%), extension cords (12.7%), and batteries (10.0%) being major contributors (Table 17).

TABLE 14: PROPORTION OF COMMON LIVING ROOM ELECTRICAL FIRES THAT WERE CAUSED BY THE IGNITION OF EQUIPMENT IN THE HOME. ONLY INDIVIDUAL EQUIPMENT AND EQUIPMENT CATEGORIES THAT CAUSED AT LEAST 14 ELECTRICAL FIRE EVENTS ARE SHOWN.

Igniting Object (Common Living)	Common Living Electrical Fires (#)	Proportion of Common Living Electrical Fires (95% CI)
Heating Equipment	37	12.4% (8.6, 16.1)
Stationary space heater	15	5.0% (2.5, 7.5)
Appliances and Equipment	38	12.7% (8.9, 16.5)
Electrical Distribution Equipment	160	53.5% (47.9, 59.2)
Permanent electric wiring, cable (non-aluminum)	34	11.4% (7.8, 15.0)
Extension cord	26	8.7% (5.5, 11.9)
Power bars, surge protector	26	8.7% (5.5, 11.9)
Switch, outlet	23	7.7% (4.7, 10.7)
Electrical distribution equipment - unclassified	15	5.0% (2.5, 7.5)
Other Electrical Equipment	49	16.4% (12.2, 20.6)
Other electrical equipment - unclassified	26	8.7% (5.5, 11.9)
Common Living Overall	299	100%

TABLE 15: PROPORTION OF BATHROOM ELECTRICAL FIRES THAT WERE CAUSED BY THE IGNITION OF SPECIFIC EQUIPMENT IN THE HOME. ONLY INDIVIDUAL EQUIPMENT AND EQUIPMENT CATEGORIES THAT CAUSED AT LEAST 14 ELECTRICAL FIRE EVENTS ARE SHOWN.

Igniting Object (Bathroom)	Bathroom Electrical Fires (#)	Proportion of Bathroom Electrical Fires (95% CI)
Electrical Distribution Equipment	24	26.7% (17.5, 35.8)
Other Electrical Equipment	39	46.3% (33.1, 53.6)
Motor	16	17.8% (9.9, 25.7)
Other electrical equipment - unclassified	17	18.9% (10.8, 27.0)
Bathroom Overall	90	100%

TABLE 16: PROPORTION OF LAUNDRY ELECTRICAL FIRES THAT WERE CAUSED BY THE IGNITION OF SPECIFIC EQUIPMENT IN THE HOME. ONLY INDIVIDUAL EQUIPMENT AND EQUIPMENT CATEGORIES THAT CAUSED AT LEAST 14 ELECTRICAL FIRE EVENTS ARE SHOWN.

Igniting Object (Laundry)	Laundry Electrical Fires (#)	Proportion of Laundry Electrical Fires (95% CI)
Appliances and Equipment	79	61.7% (53.3, 70.1)
Clothes dryer	58	45.3% (36.7, 53.9)
Washing machine	18	14.1% (8.0, 20.1)
Electrical Distribution Equipment	29	22.7% (15.4, 29.9)
Laundry Overall	128	100%

TABLE 17: PROPORTION OF GARAGE ELECTRICAL FIRES THAT WERE CAUSED BY THE IGNITION OF SPECIFIC EQUIPMENT IN THE HOME. ONLY INDIVIDUAL EQUIPMENT AND EQUIPMENT CATEGORIES THAT CAUSED AT LEAST 14 ELECTRICAL FIRE EVENTS ARE SHOWN.

Igniting Object (Garage)	Garage Electrical Fires (#)	Proportion of Garage Electrical Fires (95% CI)
Appliances and Equipment	17	11.3% (6.3, 16.4)
Electrical Distribution Equipment	94	62.7% (54.9, 70.4)
Permanent electric wiring, cable (non-aluminum)	21	14.0% (8.4, 19.6)
Extension cord	19	12.7% (7.3, 18.0)
Battery, rectifier	15	10.0% (5.2, 14.8)
Garage Overall	150	100%

Discussion

PREVALENCE AND BURDEN OF ELECTRICAL FIRES

It was found that electrical fires made up approximately 9.4% of all residential fires in British Columbia. Unfortunately, there has been no Canadian data published regarding electrical fires, thus data from the United States were used for comparison purposes. Proportion of electrical fires in British Columbia was lower than the 13% reported between 2007 and 2011 in the United States. However, when comparing casualty rates, electrical fires in British Columbia resulted in a higher casualty rate (5.7 vs. 4.2 casualties per 100 fires) than the United States (Hall, 2013). The average cost of damage in British Columbia was also higher at $68,706 per electrical fire incident compared

to the Canadian dollar equivalent of $36,000 in the United States (Hall, 2013). This discrepancy in dollar value of loss is likely due to the higher property value in British Columbia compared to the United States in general and may also be related to differences in insurance coverages and systems.

Basement fires made up 9.6% of all residential structural fires, which is much lower than the 18.1% reported in the United States (Yung & Lougheed, 2001), and made up 13.9% of all electrical fires in British Columbia. Kitchen fires made up 30.4% of all fires, which is similar to the 25.6% reported in the United States (Yung & Lougheed, 2001), but only 4.5% of all electrical fires in British Columbia.

Both the descriptive and modeling analyses showed that fires that originated from basements, common living spaces, bathrooms, laundry rooms, and garages had a higher chance of being an electrical fire. Conversely, fires that originated in kitchens had lower chance of being an electrical fire. This may be a function of attention and neglect, as residents pay more attention to electrical equipment in the kitchen, but less so in other less accessed locations, such as the basement. This was evident in terms of the areas of the home, where a gradient was seen where rooms with the highest odds of being an electrical fire (order: garage, bathroom, laundry, common living space, bedroom, passageway, kitchen) was also likely the order of the area of home from least accessed to most accessed. This is further strengthened by the fact that electrical fires resulted in lower casualties (5.7 vs. 8.5 per 100 fires), but higher property damages ($68,700 vs. $52,400) when compared to non-electrical fires. As electrical fires occur more often in less accessed areas of the home, it is less likely for people to be injured by the fire and more likely for the fire to cause more damage.

The fact that burden, in terms of both human and material costs, of the electrical fire was not affected by the jurisdiction type, whether it originated in the basement or different rooms of the home show that the burden of electrical fires can be reduced by reducing the prevalence of electrical fires. Taken together, this suggests that an inspection scheme would be effective in reducing the overall burden of electrical fires in British Columbia. Less accessed rooms, including basements, should be inspected with higher priority. Basements should be inspected as a whole, as no specific basement rooms carried elevated risk for electrical fires.

EQUIPMENT OF ELEVATED RISK

As expected, electrical distribution equipment was the category found to be the largest culprit and were responsible for about half of the electrical fires. Over half of these were equipment that are permanent fixtures in the home, such as permanent electrical wiring, outlets, and switchboards. Another quarter of these electrical distribution equipment were items that are more mobile, such as extension cords, power bars, and appliance cords. Other leading causes of electrical fires included clothes dryers and electrical equipment with motors. These types of equipment should take priority when homes are inspected.

The leading causes were found to be different for the different rooms with elevated risk for electrical fires. In basements, permanent wiring, switchboards, and extension cords would be the focus of inspection, while also paying attention to clothes dryers. In common living spaces, permanent wiring, extension cords, outlets, and surge protectors should take priority, with space heaters being another item to be aware of. In bathrooms, electrical components with motors, such

as fans and hairdryers, should be the focus of inspection. In laundry rooms, clothe dryers and washing machines should be the focus of inspection. In garages, permanent wiring, extension cords, and batteries should be the focus for inspection.

Lastly, it is interesting to note that illegal electrical bypass was responsible for less than 2% of all electrical fires. This may indicate that although inspections should help reduce electrical fires, but these *under the radar* secondary suites may not need to be the primary targets of inspection. However, since electrical distribution failure was the most likely cause of basement electrical fires, basement suites should still be a target for inspection.

LIMITATIONS

There were a few limitations to this study. The two main components affecting the interpretations of the results were the fact that around 50% of electrical fires had no identified room of origin and that unclassified equipment made up between 8% and 53% of equipment categories. However, this was still the best data to date and conclusions formed would be useful for safety inspection purposes.

Conclusions

Prevalence for electrical fires was found to be elevated for fires that originated in basements, common living spaces, bathrooms, laundry rooms, and garages. Jurisdiction type did not have an effect on the prevalence of election fires. Burden of electrical fires were mixed with electrical fires having higher material costs but lower human costs. Jurisdiction type, basement, and rooms in the home did not affect the burden of electrical fires in terms of both human and material costs. Taken together, this suggests that an inspection scheme would be effective in reducing the overall burden of electrical fires in British Columbia. Electrical distribution equipment was responsible for about half of all electrical fires, thus should take priority for inspections overall. Different equipment should also take priority when inspecting the different areas of the home that carry elevated risk for electrical fires.

Recommendations

In terms of areas of the home for electrical safety inspectors, the order of priority is recommended to be: garage, laundry, bathroom, basement, common living space, and then other areas of the home. For garages, permanent wiring, extension cords, and batteries should be the focus. For laundry rooms, clothe dryers and washing machines should be the focus. For bathrooms, electrical components with motors should be the focus. In basements, permanent wiring, switchboards, extension cords, and clothes dryers should be the focus. For common living spaces, permanent wiring, extension cords, outlets, surge protectors, and space heaters should be the focus. Overall, permanent wiring, extension cords, outlets, surge protectors, appliance cords, and electrical equipment with motors were the leading causes of electrical fires.

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Appendix

VARIABLES CODING USED

Variable	Description	Coding
Residential		
PC3100	Residential - row, garden, town housing, condominium	Residential
PC3200	Residential - apartment	
PC3400	Residential - single detached	
PC3500	Residential - duplex, 3-plex, 4-plex	
Others	Others	Non-residential
Electrical Fire		
AO4400	Electrical short circuit	Electrical
FH2000	Spark, electrical (includes arc, discharge)	
FH3000	Spark, static electrical (includes lightning)	
AO0000	Act of Omission - cannot be determined	Unknown
AO0008	Act or Omission - not applicable	
FH0000	Form of Heat - cannot be determined	
FH0009	Form of Heat - unclassified	
Others	Others	Non-electrical
Basement		
LV1000	Basement, sub-basement	Basement
LV0000	Cannot be determined	Unknown
Others	Others	Non-basement
Rooms		
OA1400	Lounge, living room (includes music room, common room, TV room, den, recreation room, family room, sitting room)	Common living
OA2100	Sleeping - under 5 occupants (includes patients' room, bedroom, cell, lockup)	Bedroom
OA2500	Washroom, locker area (includes checkroom, cloakroom, rest room, bathroom, powder room, toilet, shower room, sauna bath)	Bathroom
OA3100	Kitchen, cooking area	Kitchen
OA3200	Laundry area (includes wash house)	Laundry
OA4700	Vehicle storage (includes garage, carport)	Garage
OA1010	Hallway, corridor	Passageway
OA1020	Stairway, exterior (includes fire escape, ramp)	
OA1030	Stairway, interior (includes ramp)	
OA1040	Escalator	
OA1050	Lobby, entrance way	
OA1060	Elevator (includes shaft and machinery room)	
Others	Others	Others/unknown
Igniting Objects		
IG1020-1900	Cooking equipment	Cooking
IG2100-2900	Heating equipment	Heating

IG3100-4990	Appliances and equipment	Appliances
IG5100-5900	Electrical distribution equipment	Electrical Distribution
IG6100-6900	Other electrical equipment	Other Electrical
IG7110-7900	Smoker's material and open flame	Open flame
IG8100-8900	Exposure	Exposure
IG9000-9990	Miscellaneous	Miscellaneous
IG1010	No igniting object	No Igniting object
IG0000	Cannot be determined	Unknown

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