RESEARCH HIGHLIGHT

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FIRE EXPERIENCE, SMOKE ALARMS AND SPRINKLERS IN CANADIAN HOUSES: CMHC RESEARCH TO 2005

INTRODUCTION

Canada Mortgage and Housing Corporation has undertaken several research studies since the late 1980s, examining the need for and implications of government mandating sprinklers in new houses. Together, these studies give a broad picture of fire experience in Canadian housing, and the potential implications of smoke alarms and sprinklers in new houses. This paper outlines the main findings of this research.

1. Canada used to have a relatively high rate of residential fires—especially in one- and two-family houses

In 1980, the rate of deaths due to fire in one- and two-family houses was nearly eight per 100,000 homes. Exact figures for fire experience in one- and two-family homes are not available Canada-wide prior to 1980, but statistics for all fires suggest that they would have been at least eight per 100,000 for the previous decade as well.

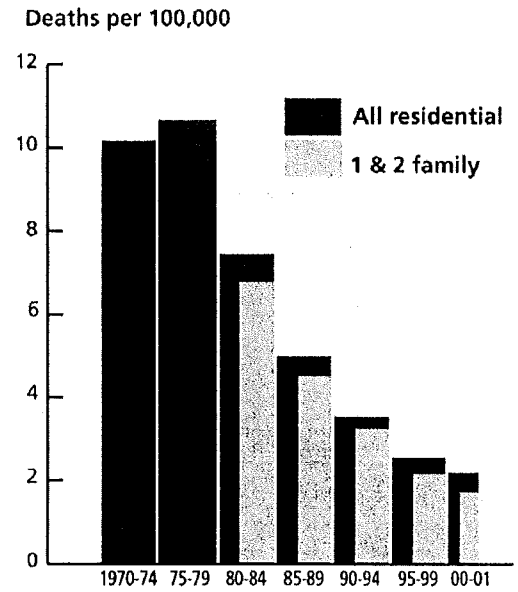
2. Today, the rate of fires, injuries and deaths is much lower

The summary report *Smoke Alarms and Residential Sprinklers: Costs and Benefits (CMHC 1991)*[1] noted that the rate of fatalities in one- and two-family houses had dropped steadily from almost eight per 100,000 homes in the year 1980 to 4.5 per 100,000 homes in 1988.

Figure 1 reflects information from the report *Canadian Housing Fire Statistics (CMHC 2004)*, plus an additional estimate for 2000 and 2001. It shows that the decreases reported in the earlier study have continued.

Canadian Housing Fire Statistics says that in the two decades between 1980 and 1999, the rates of fire incidence, injuries, property damage and death have all dropped—both for all residential fires and for fires in one- and two-family homes. By 1999, the fire death rate per 100,000 one- and two-family houses was 75 per cent lower than in 1980.

Figure 1: Average annual rate of fire deaths per 100,000 units



Source: Adapted from *Canadian Housing Fire Statistics*, with additional two-year average estimate for 2000-2001

[1] This report summarized and updated two earlier reports: *Analysis of the Costs and Benefits of Installing Fire Sprinklers in Houses (1989)*, and *The Costs and Benefits of Smoke Alarms in Canadian Houses (1990)*.

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3. The main reason is smoke alarms

Canadian Housing Fire Statistics comments: "In looking at the changes to residential units that could have resulted in increased fire safety, the (regulatory) requirements for smoke alarms, in new buildings in approximately 1980, in existing buildings in approximately 1985, and the accompanying public information campaigns, constitute the single most determining factor."

Smoke alarms alert people in the home to the presence of smoke and fire. This gives occupants the opportunity to extinguish small fires or flee larger ones. These alarms are also effective in alerting people to smouldering fires, which can produce fatal levels of smoke and carbon monoxide long before they significantly increase room temperatures.

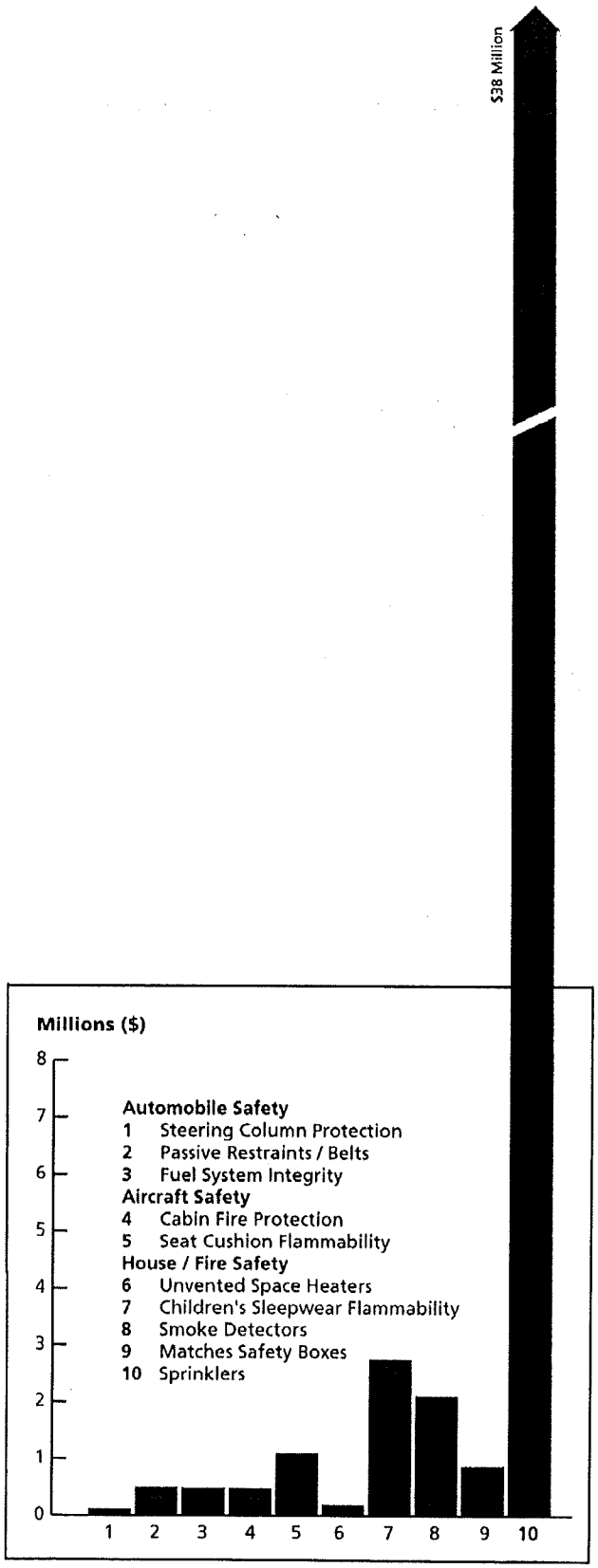
The *Canadian Housing Fire Statistics* report shows that the number of reported fires ignited by cooking equipment, heating equipment, and electrical equipment and appliances, and the number caused by building-related deficiency, malfunction or misuse have all decreased between 1980-1999, while external fire exposure has increased as an ignition source. While the study only looked at building-related causes, it is important to note that the top non-industrial cause of fatal fires in Canada was smokers' materials and open flame. In Ontario (more details provided than the national report) the top four causes of fatal home fires are smokers' materials, cooking equipment, matches/lighters and candles.[2]

In addition, *Smoke Alarms and Residential Sprinklers: Costs and Benefits* mentions safer home construction, heating appliances, improved furniture fabrics, decreased crowding, and a decreased percentage of smokers as having an impact on fire safety, along with smoke alarms.

4. Sprinklers could produce a fire safety improvement in new one- and two-family homes, but costs are much higher than for other safety measures

Sprinklers respond to the high heat of open flames, spraying water in the room affected to control and suppress fires. CMHC's smoke alarms and residential sprinklers cost benefits studies estimated that sprinklering new one- and two-family homes could produce a further decrease in fatalities, injuries and property damage. For example, they estimated that fire deaths could be reduced by 0.77 per 100,000 houses by adding sprinklers, as compared to houses with wired-in smoke alarms.

Figure 2: Mandatory Regulations, Cost per Life Saved



Source: *Analysis of the Cost Benefits of Installing Sprinklers in Houses*

[2] See *Fire Losses in Canada*, 2001 Annual Report of the Council of Canadian Fire Marshals and Fire Commissioners (Chart 5), http://www.ccfmfc.ca/stats/en/report_e_01.pdf, and *Preventable Home Fires, Five Causes – 1999-2003*, Ontario Office of the Fire Marshal (Chart 4), http://www.ofm.gov.on.ca/english/Publications/Statistics/cause/default.asp

The purchase, installation and maintenance of sprinklers produce a comparatively high cost per life saved. *Analysis of the Costs and Benefits of Installing Fire Sprinklers in Houses* calculated in 1989-1990 that the cost of saving one life by mandating sprinklers would be more than $38 million. This figure is significantly higher than the cost of other life safety requirements imposed by governments: see Figure 2.

The *Analysis of the Costs and Benefits of Installing Fire Sprinklers in Houses* report used cost estimates from a 1989 *Cost Study of Sprinkler Installations* prepared by J.C. Weibe for Alberta Municipal Affairs. That report found that per square foot costs for a 1,940 square foot (total sprinklered area, including unfinished spaces) side-split home in an urban location would range from $1.43 (plastic) to $2.37 (copper). The cost in rural locations would be higher: $2.47 and $3.67, respectively.

In 1998, *Costs and Benefits to Municipalities of Mandatory Residential Fire Sprinklers* found typical installation costs averaged $1.70 per square foot for singles, semis and townhouses (and $1.45 per square foot for apartments). In this case, costs to sprinkler a small 1,500 square foot single family home with a total sprinklered area including unfinished basement of 2,000 square feet, would total $3,400.[3]

5. Municipal savings are outweighed by costs to new homebuyers

The net impact on fire service costs of municipalities requiring sprinklers in all new residential developments was an unanswered question in 1998. CMHC commissioned the report *Costs and Benefits to Municipalities of Mandatory Residential Fire Sprinklers (CMHC 1998)* to provide an impartial assessment, technically justified on economic grounds. It looked at changes in costs in five municipalities and one First Nation.

This report found that some municipalities might achieve savings in direct costs. Key to achieving savings were: the expectation of significant new greenfield development located outside the areas presently served by existing stations; sprinklers in all new buildings (residential and non-residential); acceptance of longer fire service response times; and fire services which concentrate on fire suppression, providing only secondary support for non-fire emergencies when requested.[4]

The study went on to calculate the costs of sprinklering the new homes, including initial installation, ongoing maintenance and inspection, and somewhat higher property tax assessments (if the value of sprinklers was reflected in assessed value). These costs were reduced, as appropriate, to account for lower development charges, municipal property tax rates (reflecting the expected municipal costs savings), and possible reductions in home insurance.

"In each of the cases studied," the report concluded, "potential savings to the municipality would be less than the additional costs for the installation of sprinklers."

To assess the influence of system costs, the study prepared a second calculation where sprinkler installation costs were reduced by half. The gap between sprinkler-related costs and sprinkler-related savings would be narrowed, it said, "but in no case would the results be switched such that the savings would outweigh the costs."

Table 1 below shows the net present value of costs and savings over the study's 20-year forecast period. Because Kawacatoose First Nation band council acts as the municipal government, the land developer, the home builder and the homeowner, the cost allocation to different parties does not apply. The final row has been added, to show net cost to society.

Table 1: Costs and Benefits of Mandatory Residential Sprinklers – Net Present Value Summary

	Burlington	Barrie	Edmonton	Pitt Meadows	Gatineau	Kawacatoose First Nation
Savings to municipality	0	$7.40 million	$38.49 million	$2.76 million	$8.89 million	net cost to band council is $249.79 million
Costs to others	$38.10 million	$33.60 million	$118.99 million	$10.68 million	$26.72 million	
Net cost to society	$38.10 million	$26.20 million	$80.50 million	$7.92 million	$17.83 million	$249.79 million

Source: Adapted from *Costs and Benefits to Municipalities of Mandatory Residential Fire Sprinklers*, final row added.

[3] Sprinkler system costs today appear quite similar. A quick poll of firms in early 2005 found that most companies are installing plastic piping. Total cost estimates for the sprinkler system, associated piping, upgraded intake pipe, changes in other construction, schedule accommodation, etc., for a small house with 1,500 square feet finished area (2,000 square feet sprinklered area including basement), ranged between approximately $3,000 and $4,000. Larger houses would be more expensive overall, but would generally cost somewhat less per square foot. Smaller houses generally would cost more per square foot.

[4] A parallel report by the National Fire Laboratory (NFL) used a fire risk assessment computer model to estimate the level of fire safety. It concluded that risks to life would be reduced in areas with sprinklers, but with longer fire service response times. No attempt was made in either study to evaluate the impact of longer response times on medical or other non-fire emergencies, or on fires outside sprinklered buildings. These can be a very large percentage of fire service emergency calls.

This study was reviewed in 2001 as part of an evaluation of directed research at CMHC.[5] The evaluators confirmed the study methodology and incorporated discussion of risk to life, injury and property loss. They reviewed other reports presenting lower overall costs for sprinklers, and used real-world Canadian data to estimate fire risks in new, sprinklered and unsprinklered single family and multiple dwelling housing stock.

The *Directed Research Evaluation Report (CMHC 2001)* used a very high performance rate for sprinklers (95 per cent), based on reported experience in Vancouver, although it pointed out that the number of installations and the timeframes are small and there are still questions about how sprinkler effectiveness could change over time without appropriate maintenance. It also used current estimates of what Canadians are prepared to spend on safety measures.

The analysis calculated the financial impacts in two provinces, depending on whether sprinklers were required in new housing or not. It looked at new single family housing in Manitoba and all new residential housing in Ontario, over a period of 20 years. It concluded that not requiring sprinklers would save a minimum of $415 million. If the National Research Council's lower estimate of sprinkler effectiveness was used (60 per cent), the savings increased to $734 million.[6]

6. Installing and maintaining smoke alarms is very effective

The study *Smoke Alarms and Residential Sprinklers: Costs and Benefits* pointed out that the cost to install functioning smoke alarms in unprotected houses is small compared to the cost to install sprinklers—and the impact on safety is much higher. It recommended that governments consider residential sprinkler systems as voluntary for new one- and two-family houses. At the same time, it recommended that smoke alarms be installed in the estimated 18 per cent of older one- and two-family houses that didn't have them.

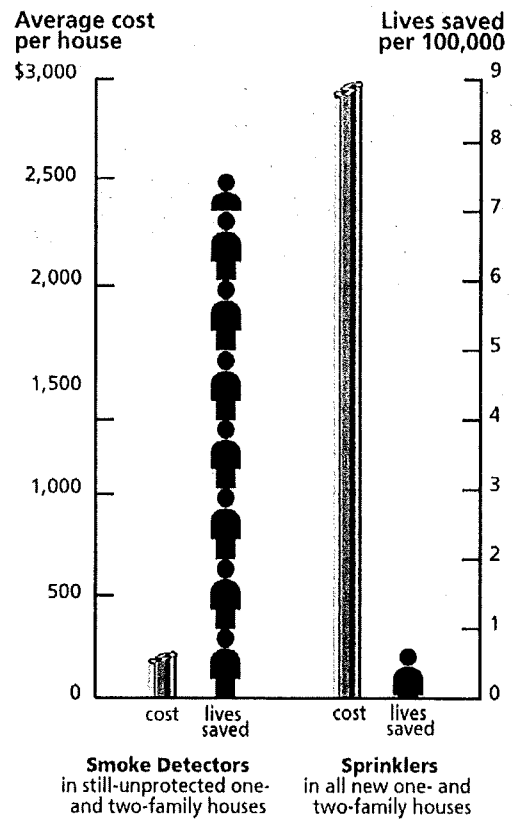
There is no current analysis of the percentage of homes with and without smoke alarms. However, Ontario fire fighters have reported that between 1995 and 2003, 20 per cent of the homes where they attended a fire did not have a smoke alarm. Almost eight per cent more had a smoke alarm that did not operate because it had no power—most because the battery had been removed; the rest because the battery was dead.

In other words, 28 per cent of the homes that had fires serious enough to result in a call to the fire department did not have a functioning smoke alarm.

For fatal fires, the percentage of homes without a functioning smoke alarm was approximately 37 per cent—19 per cent without an alarm at all, and another 18 per cent with an alarm that had no battery or had a dead battery.

This suggests that the recommendation to install and/or maintain smoke alarms in unprotected one- and two-family houses is still valid. The cost benefits from installing smoke alarms remain greater than for sprinklers in all new homes.

Figure 3: Impact of Policy Alternatives

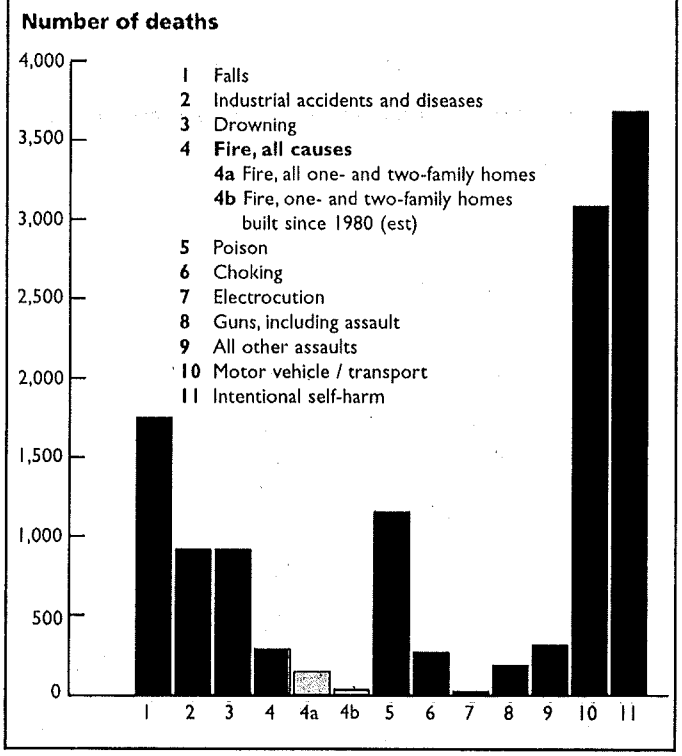


Source: *Smoke Alarms and Residential Sprinklers: Costs and Benefits*

[5] *Directed Research Evaluation Report*, prepared by KPMG Consulting Ltd. for CMHC, 2001.

[6] *The purpose of this report was to estimate the impact of CMHC research. Its authors attributed only part of the full impact (25 per cent in Manitoba and 40 per cent in Ontario) to the research program. The "attributable portion" figures shown in the report itself were $158 million and $278 million, respectively.*

Figure 4: External of causes of death, Canada 2001



Source: Statistics Canada, *Association of Workers' Compensation Boards of Canada, Canada Mortgage and Housing Corporation*

7. Overall, residential fire risks are relatively low

The report *Smoke Alarms and Residential Sprinklers: Costs and Benefits* pointed out that it is impossible to eliminate risk completely. The challenge is to use resources wisely to address high level, preventable risks.

That report included a chart showing causes of death in 1987. Figure 4 has been updated with actual numbers for 2001. Figure 4 and Figure 5 both show that the number of people who died in a fire in a new home is "much lower than the fatalities from many other activities."

8. Some groups and housing types are at higher risk

The *Canadian Housing Fire Statistics* report investigated the difference in fire experience between population groups, locations and housing types. It found some important variations. Figure 5 gives an indication of the relationship between fire experience rates. The numbers are shown as a ratio, with one- and two-family homes as 1.00. The first bar, for example, shows that fire incidence in First Nations' one- and two-family homes is 2.4 times the rate for one- and two-family homes across Canada:

8.a First Nations

The report shows that, while fire experience in First Nations' homes has been improving over the past two decades, it is still much higher than the Canada-wide rates. The fire incidence, fire injury and fire damage rates in First Nations' one- and two-family homes are 2.4, 2.5 and 2.1 times the Canada-wide rates respectively. The fire death rate is 10.4 times the Canada-wide rate.

Remote location and climate (with corresponding reliance on more hazardous heating systems) are identified as two factors leading to these higher fire death rates. The *Canadian Housing Fire Statistics* report also quotes a statistic from the Office of the Fire Commissioner for Alberta that the percentage of First Nations' homes with crowding (more than one person per room) was eight times the rate Canada-wide.

8.b Rooming Houses

For rooming and lodging houses, the fire incidence, injury and damage rates are nearly 5, 11, and 4 times the Canada-wide rate for one- and two-family houses respectively, while fire deaths are more than 12 times the Canada-wide rates.

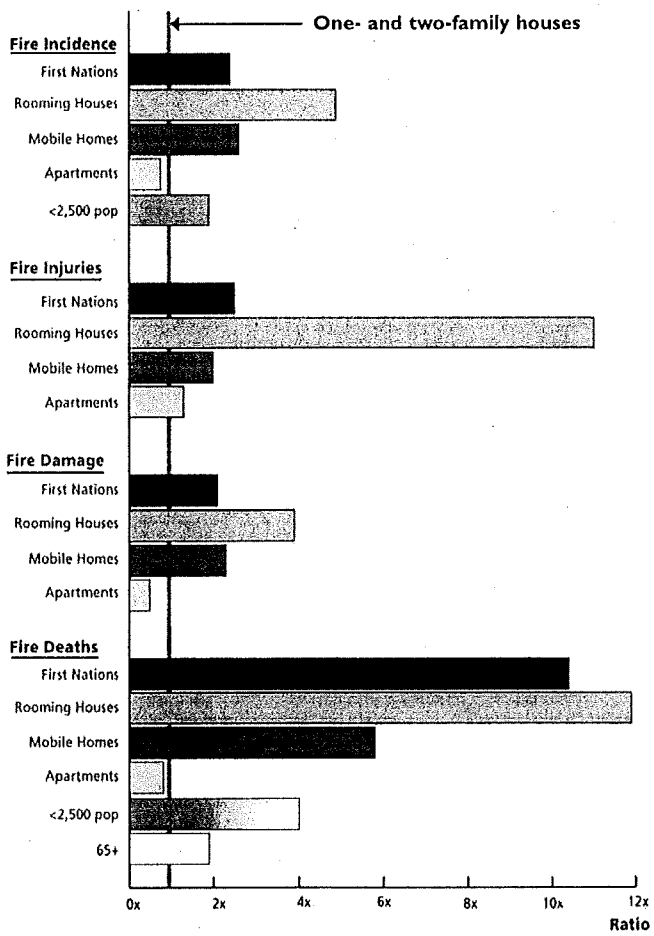
8.c Mobile Homes

Canadian Housing Fire Statistics reports that for mobile homes, the fire incidence, injury and damage rates are 2.6, 2, and 2.3 times the Canada-wide rate for one- and two-family houses respectively, while fire deaths are 5.8 times the Canada-wide rate.

8.d Remote/Rural Areas

There are no Canada-wide figures that can be compared to show the difference in fire experience between rural and urban areas. Communities with populations of less than 2,500 are sometimes used as proxies for "rural" areas. British Columbia, Alberta and Ontario collect similar data for this size of community. Using those figures, *Canadian Housing Fire Statistics* estimated that rural communities have fire incidence rates up to twice the level experienced in larger communities, and fire death rates between two and four times the level in larger communities.

Figure 5: Fire experience of selected areas and groups as compared to Canada-wide levels for one- and two-family houses (ratio)*



* Figures for communities <2,500 population relate to all fires and are compared across communities (BC, AB and ON only), and the figure for persons age 65+ is compared to rates in residential fires and across the whole population, rather than just in one- and two-family houses (AB, ON, QC only)

Source: Adapted from *Canadian Housing Fire Statistics*

8.e Persons 65+

It was not possible to compare figures on a Canada-wide basis, so the report compared available information (fatalities) from Ontario, Alberta and Quebec. It found that the rates of fire deaths for persons 65 years of age and over "were approximately twice what would have been expected, based on their percentage of the population."

These results suggest that initiatives targeted directly at high-risk groups and housing types could have a beneficial impact on fire experience.

NOTES ON COMPARING DATA

The studies for CMHC have identified several cautions about data and assumptions. In trying to assess different statements about fire experience, risks, costs and benefits, it is important to understand some of these differences. Benchmarks in 1. – 6. are discussed in detail in the *Canadian Housing Fire Statistics* report.

1. Population Benchmark

This is probably the most commonly used benchmark. It measures fire experience—incidence (reported fires), injuries, deaths and property damage—as a ratio of the total number of people. This can be a ratio of the entire population of Canada, or of different provinces, etc. It gives a measure of the risk per individual. It tends to give lower numbers per 100,000 population and flatter trend lines than the other benchmarks.

2. Residential Units Benchmark

This measures fire experience as a ratio of the number of residential units. It can be thought of as "risk per household." It includes old homes and new ones, in all forms from rooming houses to single family homes to high-rise apartments. Since many units are occupied by two or more people, ratios per 100,000 units tend to give somewhat higher numbers than ratios per 100,000 population. This benchmark shows a greater reduction in fire incidence and fire deaths than the population benchmark, and a comparable level of property damage.

3. Residential Unit Type Benchmark

This measures the experience separately, by type of housing unit. The *Canadian Housing Fire Statistics* report gives fire experience per 100,000 one- and two-family dwellings, rooming and lodging houses, mobile homes and apartments. This captures the much higher level of risks/problems in rooming and lodging houses, and in mobile homes, than in one- and two-family dwellings.

4. Age of Residential Unit

A building's age can help identify which code requirements it would have been built under, and may be a proxy for building condition. Unfortunately, it is very difficult to get information about fire experience based on the age of the residential units. Figures are collected in some provinces, but not on a comparable basis. The report attempted to approximate the influence of housing unit age, by calculating a "median" age of housing for each province. Then, it checked whether provinces with a higher median age of housing also had higher fire losses. This suggested a slight increase in fire incidence with age. Reliable specific data would be preferable—and the report has recommended fire reports be changed to collect it.[7]

5. First Nations' Experience

Canadian Housing Fire Statistics also prepared a separate set of results for all of these benchmarks, based on loss statistics collected from First Nations communities. In some provinces, the same data may be included in the provincial report. The figures show much higher level of deaths, and appreciably higher levels of injury and property losses per 100,000 one- and two-family dwellings than for Canada as a whole. As mentioned above, two possible contributing factors are crowding and remote location.

6. Fire Incidence Benchmark

This measures fire experience as a ratio of the number of fires. "One significant disadvantage of the fire incidence benchmark is its reliance on reported fires," the report says. "As more fires are discovered from early warning smoke alarms and extinguished earlier, fewer are reported to municipal fire departments thus giving an indication that, on a per fire basis, loss rates are increasing." Even so, death rates per 1,000 fires have decreased over the 1980-1999 period. Given the shortcomings, though, "it is suggested that this benchmark not be used extensively in determining fire risk unless improved reporting of all fires can be achieved," the paper says.

7. Net Costs of Sprinklers

Different reports use different approaches to determine the cost of sprinklers. It is important to make sure they include the same elements. For example, in addition to the costs of the pipes, sprinkler heads and heat alarms, and installation, initial sprinkler system costs may include possible extra costs for larger water supply lines, cumulative extra work and delay for other trades, changes to above-ceiling heights, insulation, coordination and approvals. Total costs include maintenance as well.

There is also the issue of "residual" value—which some authors[8] include in the calculation of net costs. The *Directed Research Evaluation* report identified two fundamental problems with subtracting a residual value from sprinkler costs: homeowners can only realize the residual value if they sell to a purchaser willing to pay full incremental cost—and if the purchaser does pay the full incremental cost, then the cost to society as a whole does not drop.

[7] Other specific data the authors recommended be collected includes: more complete information on First Nations' fire experience; insurance company data on fire losses, which may include smaller fires that don't involve the fire services; separate data for housing types, particularly row/townhouse and low-rise/high-rise apartments; ages of victims; and greater detail on fatal fires.

[8] See, for example, *Review of CMHC Reports on Costs and Benefits to Municipalities of Mandatory Residential Fire Sprinklers*, 1999, prepared by Banjar Management Inc. and Frederick Culbert, P.Eng. for the Fire Chiefs' Association of British Columbia.

CMHC Studies referenced in this report

Analysis of the Costs and Benefits of Installing Fire Sprinklers in Houses

Phases 1 and 2, prepared by A.T. Hansen and R.E. Platts, Scanada Consultants Ltd. for CMHC, Ottawa, 1989

The Costs and Benefits of Smoke Alarms in Canadian Houses

Phase 3 of above, prepared by A.T. Hansen and R.E. Platts, Scanada Consultants Ltd. for CMHC, Ottawa, 1990

Smoke Alarms and Residential Sprinklers: Costs and Benefits

Summary report prepared by Rowena E. Moyes for CMHC, Ottawa, 1991

Costs and Benefits to Municipalities of Mandatory Residential Fire Sprinklers

Summary report prepared by Arencon Inc., Architects + Engineers, with the assistance of Clayton Research Associates Ltd., Graham Harmsworth Lai & Associates Ltd., and J.G. Henderson & Associates for CMHC, Ottawa, 1998

Directed Research Evaluation Report

Report and case studies prepared by KPMG Consulting Ltd. for CMHC, Ottawa, 2001

Canadian Housing Fire Statistics

Report prepared by Ken Richardson Fire Technologies Inc., in collaboration with Fuller Information, for CMHC, Ottawa, 2004

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