#1409

HAZARDOUS HEATING AND VENTILATING CONDITIONS IN HOUSING

HAZARDOUS HEATING AND VENTILATING CONDITIONS IN HOUSING

PREPARED BY
Hatch Associates Ltd.
Consulting Engineers
Toronto, Ontario

Principal Consultant: T.J. Robinson

Project Manager, CMHC: P.A.G. Russell
Technical Advisor, EMR: A.C.S. Hayden
Technical Advisor, HWC: E.S. Nicholls

This work was funded under Part V of the National Housing Act

ABSTRACT

Under certain circumstances, hazardous heating and ventilating conditions have been created in Canadian housing by the inadequate exhaust of combustion products from fuel-burning equipment. According to descriptive reports compiled from sources across Canada, these conditions have been responsible for 293 episodes of carbon monoxide poisoning from 1973 to 1983, including 145 deaths. Statistics Canada data, based on death certificates, attributes 238 deaths to the incomplete combustion of domestic fuels from 1973 to 1981; a higher number in a shorter period.

The major contributing factors in these episodes were identified in the episode reports as:

1. Equipment problems due to poor maintenance, damage and defects.

2. Collapsed, blocked, dislodged or damaged chimneys, vents and flues.

3. Downdrafting of furnaces gases in chimneys, vents and flues due to excess exhaust, inadequate air supply, and airtightness of the house envelope.

4. Improper installation of equipment, chimneys, vents and flues. Lack of understanding of combustion equipment operation and the potential problems associated with improper operation.

The data acquired in the study do not demonstrate an increase in the rate of domestic carbon monoxide poisoning in the last ten years. However, individual components of the major contributing factors may be increasing in importance, e.g., continuing steps towards airtight housing may cause more episodes of chimney downdrafting.

DISCLAIMER

This study was conducted by Hatch Associates Ltd. for the Canada Mortgage and Housing Corporation, Energy, Mines and Resources Canada, and Health and Welfare Canada. The analysis, interpretations, and conclusions are those of the consultant and do not necessarily reflect the views of the government agencies that assisted in the study and its publication.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

Note: The appendices are not included in this document, but are deposited with the Canadian Housing Information Centre, CMHC, Montreal Road, Ottawa, K1A 0P7.

There are two appendices:

Appendix 1. List of contracts made by Hatch Associates in assembling the information upon which the report is based.

Appendix 2. Typical Newspaper Clippings, Pamphlets relating to the subject.

LIST OF TABLES

LIST OF TABLES (Cont'd)

PREFACE

At the request of the Canada Mortgage and Housing Corporation, Hatch Associates Ltd. investigated the frequency, severity and causes of hazardous conditions arising in Canadian housing due to the inadequate exhaust of combustion products, specifically carbon monoxide. Funding was also provided by Energy, Mines and Resources Canada, and Health and Welfare Canada.

This report represents the first comprehensive national survey of the domestic carbon monoxide problem, and was conducted so that concerned federal and provincial groups could take appropriate corrective action.

For their indispensible advice and information, we wish to thank everyone who contributed to the content and quality of the report, especially the project advisors:

Peter Russell
Research Division
Policy Development and Research Sector
Canada Mortgage and Housing Corporation

A.C.S. Hayden
Canadian Combustion Research Laboratory
ERL/CANMET
Energy, Mines and Resources Canada

Dr. Eric S. Nicholls
Bureau of Epidemiology
Health Protection Branch
Health and Welfare Canada

EXECUTIVE SUMMARY

In the past ten years, energy efficiency has been identified as a desirable feature in housing. The design of new houses and retrofits of existing houses are incorporating more insulation and more efficient and/or less expensive sources of heat. Since air leakage can account for as much as 30% to 40% of the heat loss, houses are being made more airtight. This can result in an increase in the levels of air contaminants from indoor sources and possible detrimental effects on the comfort, health and safety of the occupants.

This study is specifically concerned with the issue of occupant safety in houses where the products of combustion are not properly exhausted. Under certain conditions, exhaust gases from combustion heating processes have caused episodes of carbon monoxide poisoning in Canada. The purpose of this survey was to analyze the situation comprehensively, on a national basis, so that concerned federal government departments could develop appropriate responses.

Two steps that the homeowner can take to conserve energy have demonstrated detrimental effects on indoor air quality in certain cases.

1. Reduced air leakage area can contribute to high concentrations of air contaminants from indoor sources, and to draft reversal in the furnace or fireplace chimney when the demand for air by fireplaces and/or furnaces and exhaust fans exceeds the air supplied by leakage area and supply ducts.

EXECUTIVE SUMMARY (Cont'd)

2. Converting from oil to gas without taking steps to prevent chimney deterioration can increase the risk of chimney blockage, draft failure and the associated release of combustion products into the house.

Although many products of combustion can cause discomfort and adverse health effects, it is carbon monoxide which presents the greatest threat to life. Virtually all reported episodes of hazardous heating and ventilating conditions in Canada have been due to carbon monoxide poisoning. Reductions in air leakage area and heating system conversions may have contributed to the incidence of these episodes.

The descriptive reports of 293 episodes of carbon monoxide poisoning due to hazardous heating and ventilating conditions in houses, including 145 deaths, were found for the period from 1973 - 1983, i.e. 14 deaths per annum. Statistics Canada data show 238 deaths due to the incomplete combustion of domestic fuels, in the period 1973-81, i.e. 26 per annum. This higher figure may also be an underestimate of the true number since carbon monoxide poisoning is difficult to diagnose and in certain cases, the episode reports involve more deaths than are accounted for by the Statistics Canada data. A conservative calculation of the Fatal Accident Frequency Rate (FAFR) based on the Statistics Canada data results in a FAFR of 0.013. A FAFR of 0.001 has been proposed by authors in the safety field as acceptable for involuntary risks to the general public.

EXECUTIVE SUMMARY (Cont'd)

The episodes illustrate many combinations of contributing factors. Each region of Canada has characteristics that have affected their episode history, such as the condition of the housing stock, weather conditions, type of equipment and fuel used for heating, and the awareness of the residents of the potential problems.

The major contributing factors found in recorded episodes across Canada were:

1. Equipment problems due to poor maintenance, damage and defects.

2. Collapsed, blocked, dislodged, or damaged chimneys, vents and flues.

3. Downdrafting of furnace gases in chimneys, vents and flues due to excess exhaust, inadequate air supply, and airtightness of the house envelope.

4. Improper installation of equipment, chimneys, vents and flues. Lack of understanding of combustion equipment operation and the potential problems associated with improper operation.

The data acquired in the study do not demonstrate an increase in the rate of domestic carbon monoxide poisoning in the last ten years, however, each of the major contributing factors has the potential to increase its influence in the future.

1. Emergence of new technology with new equipment problems, e.g. improper use and maintenance of unvented kerosene space heaters.

EXECUTIVE SUMMARY (Cont'd)

2. Deterioration of existing substandard chimneys.

3. Continuing steps towards airtightness.

4. Lack of steps taken to increase awareness of the potential for problems.

None of the episodes analyzed presented insurmountable technical problems, and potential problems may be successfully avoided in the future, if the low level of awareness encountered during the study can be overcome.

1.0 INTRODUCTION

The primary purpose of housing is to provide shelter from the elements. In its most rudimentary form, shelter in intemperate climates is nothing more than an enclosure with a source of heat, usually combustion. Of course, much more is required from housing, but these are the basic requirements.

Today, the house is expected to provide an artifically created indoor climate. The success of the house's design is dependent on the degree of comfort, health and safety enjoyed by the occupants. When a new feature is considered valuable enough to add to the house, the possible effects on the indoor climate should be evaluated.

In the past ten years, energy efficiency has been identified as a desirable feature in housing. The design of new houses and retrofits of existing houses are incorporating more insulation and more efficient, less expensive sources of heat. Since infiltration of outside air can account for 30 to 40% of the heat loss in a typical house, houses are being made more airtight. This can result in an increase in the levels of air contaminants from indoor sources and possible detrimental effects on the comfort, health and safety of the occupants.

This study is specifically concerned with the issue of occupant safety in houses where the products of combustion are not properly exhausted. Under certain conditions, exhaust gases from combustion heating processes have caused episodes of carbon monoxide poisoning. Reductions in infiltration rates and heating system conversions may have contributed to these episodes.

1.0 INTRODUCTION (Cont'd)

Until now there has not been a national survey of the cause, frequency and severity of these episodes. Reports have not been assimilated by one central agency. The purpose of this survey was to analyze the situation comprehensively, if not exhaustively, on a national basis, so that concerned federal government departments could develop appropriate responses.

Death and injury in the home due to carbon monoxide poisoning is an easily avoided tragedy. It is hoped that this survey will contribute to the effective coordination of action aimed at eliminating the hazard.

1.1 Information Sources Utilized

The initial contact with a potential source was made by telephone. The researchers introduced themselves as researchers under contract to the Canada Mortgage and Housing Corporation, investigating the incidence of hazardous heating and ventilating conditions in housing. Without trying to discourage a source's offer of general information, the researchers made clear the emphasis on episodes due to the inadequate exhaust of combustion products, especially carbon monoxide.

A successful contact resulted in:

(a) Oral transfer of episode information
(b) Arrangements to inspect records personally
(c) Transfer of episode information by mail
(d) Referral to other potential sources.

A list of types of potential sources contacted is displayed in Table 1.

As the survey progressed in a region, the following pattern of information retrieval emerged:

1. Contact potential sources according to initial list.
2. Proliferation of potential sources by referral.
3. Confirmation of important sources by number of referrals, quality of information received.
4. List of episodes developed from important sources, corroborated by other sources.
5. Related information from many sources fitted into the picture where possible.

TABLE 1

TYPES OF INFORMATION SOURCES

I Government Organizations, Ministries, etc.

eg. Federal energy
Provincial housing
Provincial health
Municipal health
Municipal building inspectors
Provincial environment
Provincial occupational health and safety
Provincial energy
Fire Marshall's office
Coroner's office
Hospital statistics
Statistics Canada

II Public and Private Utilities

eg. Hydro
Gas
Oil

III Media Reports, Newspaper Clipping Files

eg. Librarians
Science editors
Consumer advisors

TABLE 1 (Cont'd)

IV Universities (Departments)

eg. Building research, civil engineering, mechanical engineering
Environmental studies
Occupational health and safety
Biostatistics
Law Library

V Associations, Professional, Business, Consumer

eg. Air Pollution Control Association
Occupational Hygiene Association of Ontario
Housing and Urban Development Association of Canada
Consumers Association of Canada
Insurance companies

VI Technical Research Groups, Consultants, Laboratories

eg. Saskatchewan Research Council
Centre for Research and Development in Masonry

VII Published and Unpublished Reports

VIII Persons with Established Reputations in the Field

1.2 Media Appeals

Newspaper and radio were used as a means of soliciting information from the public regarding experiences that may have been due to the inadequate exhaust of combustion products.

A national newspaper article was followed by a series of radio interviews in Ontario and the Maritimes, appealing to homeowners for information about episodes across a wide area.

The specific area of Guelph, Ontario was also targeted in a separate series of local newspaper and radio exposures.

In both cases, an attempt was made to develop an estimate of the number of minor, unreported episodes that have occurred in a specific region so that a ratio of deaths to injuries to minor unreported episodes could be derived. Although the response to media appeals was not sufficient to develop such a ratio, many illuminating episodes were uncovered.

2.0 HAZARDOUS CONDITIONS

2.1 Energy Conservation vs. Indoor Air Quality

In the past ten years an energy conscious world has searched for ways to reduce its dependency on conventional non-renewable energy resources. Since the heating of residential buildings represents a significant consumption of energy, many governments have taken the logical step of encouraging improvements in the energy efficiency of these buildings. This goal is shared by the homeowner, who pays the heating bill.

Other than turning down the thermostat, three energy-conserving steps often taken by homeowners are:

1. Reduce the infiltration of outside air.
2. Increase insulation values.
3. Convert to different or combined sources of heat.

In Canada there are a number of government assistance programs available to encourage these steps and many homeowners have taken advantage of the opportunity.

Unfortunately, each of these three steps can have a detrimental effect on the quality of air within the house. For example:

1. Reduced infiltration rates can contribute to high concentrations of air contaminants from indoor sources.

2.1 Energy Conservation vs. Indoor Air Quality (Cont'd)

2. The installation of urea formaldehyde foam insulation can result in the release of formaldehyde gas into the living space.

3. Converting from oil to gas without taking steps to prevent chimney deterioration can increase the risk of chimney blockage, draft failure and the associated release of combustion products into the house.

There is a great deal of research being conducted throughout the world to attempt to define the proper balance between energy conservation and indoor air quality. By contrast this study has a narrow scope, related to the issue of occupant safety, rather than long term health effects.

2.2 Carbon Monoxide

Although many products of combustion (e.g. oxides of nitrogen, aldehydes, carbon dioxide and sulphur dioxide) can cause discomfort and adverse health effects, it is carbon monoxide which presents the greatest threat to life. As the survey progressed it became apparent that most reported episodes of hazardous heating and ventilating conditions in Canada were due to carbon monoxide poisoning.

When carbon monoxide is inhaled it produces an effect which is referred to as chemical asphyxiation. Injury is due to the combination of carbon monoxide with the available hemoglobin in the blood to form carboxyhemoglobin (COHb), lowering the oxygen carrying capacity of the blood. The body immediately attempts to compensate by increasing cardiac output and flow to critical organs.

The most common symptoms of carbon monoxide exposure are headache, dizziness, nausea, increased cardiac output, fatigue, flashes before the eyes, and ringing in the ears. The effects depend on the length of exposure, ambient concentration and activity of the person exposed. Levels of carbon monoxide sufficient to cause these symptoms have been encountered in houses with inadequate exhaust of combustion products, (see Table 2).

2.2 Carbon Monoxide (Cont'd)

Most of the symptoms attributed to carbon monoxide are temporary. It is not clear at what point permanent damage might be sustained by a victim of asphyxia, but there is a relatively small factor of 10 between the concentration that is nontoxic for one hour and that at which fatality may occur.

TABLE 2

Symptoms of Carbon Monoxide (CO) Poisoning and Approximate Corresponding Concentrations	Percentage Carboxy-hemoglobin in blood by weight	Carbon monoxide parts per million in air by volume
Low concentrations; - shortage of breath on moderate exertion - slight headache	10	50
Higher concentrations; - severe headache - mental confusion - dizziness - impairment of vision and hearing - collapse or fainting on exertion - nausea	30	600
Extreme concentrations; - unconsciousness or death	50	1,000

- compiled from references #1, 2 and 3

2.3 Recognized Contributing Factors

A number of contributing factors were recognized at the outset of the survey. If carbon monoxide is being released into the house by the heating system, at least one of the first four factors listed below must be in action. Many combinations of these eight factors may occur.

- Collapsed, damaged or blocked chimneys or flues.
- Reverse flow of exhaust in chimney or flues (down drafting).
- Inadequate exhaust of space heaters, gas ranges or other combustion appliances.
- Cracked or corroded heat exchangers, other equipment malfunctions.

- Airtightness of house envelopes.
- Other ventilation competing with normal combustion exhaust processes.
- Lack of understanding of heating and ventilating system operation on the part of installers, users, etc.
- Weather conditions.

3.0 EPISODES IN CANADA

Carbon monoxide poisonings of course occurred in housing before 1973. However, the problem may have been aggravated by energy conservation measures which have been applied to housing over the past ten years. For this reason information on episodes of carbon monoxide poisonings was gathered for the period from 1973 to 1983.

The information in the following sub-sections is of three major types.

1. Statistics Canada data from 1973 to 1981 of deaths due to carbon monoxide from the incomplete combustion of domestic fuels, presented in the tables entitled "Regional Statistics".

2. Data on regional characteristics which may affect the incidence of hazardous heating and ventilating conditions, presented in the tables entitled "Regional Statistics".

3. Descriptive reports of carbon monoxide episodes from each region, presented in the tables entitled "Episodes in each Region".

Information types 1 and 2 are also displayed for Canada as a whole in Table 3 entitled "National Statistics".

3.0 EPISODES IN CANADA (Cont'd)

The Statistics Canada data is based on death certificate information from the Registrar in each province and territory. Causes of death as identified by the presiding physician are classified according to their International Classification for Disease number, 8th and 9th revision.

Only the classification title is quoted here since the classification numbers change according to the revision number.

Accidental poisoning by gas distributed by pipeline.

Includes: Carbon monoxide from incomplete combustion of piped gas (i.e. natural gas).

Accidental poisoning by other utility gas and other carbon monoxide.

Includes: Liquified petroleum gas distributed in mobile containers and carbon monoxide from incomplete combustion of above gas (i.e. propane).

Carbon monoxide from incomplete combustion of other domestic fuels, coal, coke, kerosene, oil, wood, in domestic stove or fireplace (also furnace heating oil) (i.e. predominantly fuel oil).

3.0 EPISODES IN CANADA (Cont'd)

For the purposes of this study these categories roughly represent the carbon monoxide deaths associated with three major fuels.

Natural Gas
Propane gas
Oil and other fuels

To put the number of deaths into perspective, in 1981 there were 15 deaths in these three categories compared to 67 deaths due to carbon monoxide from motor vehicle exhaust.

Each region of Canada has unique characteristics that have affected their episode history, and will have an effect on the potential for, and control of, future problems. These characteristics include such things as:

1. Awareness of residents, authorities, utilities, contractors, doctors, and media.
2. Type of fuels used for combustion appliances.
3. Condition of the housing stock, chimney condition.
4. Predominant weather conditions.

Finally, the descriptive reports of hazardous heating and ventilating episodes are recorded exactly as received from sources in each region, except for the removal of personal and brand names. The content, quantity and quality of these reports represent, to a certain extent, the degree of awareness and sophistication of the authorities in each region.

TABLE 3 NATIONAL STATISTICS

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS $x10^3$	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
8281	36	15	79	33	123	52	238

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
32	6.7

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
21.5	36.2

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
32	38	57	34	6	24	5	4

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
75	69	6	21	17	7	2	3

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

Value for Canada: 4685.7

3.1 British Columbia

There were three good sources of episode information in British Columbia.

- Gas Safety Branch, Ministry of Labour
- Fire Commissioner's Office
- Inland Natural Gas Co. Ltd.

Fourteen deaths were described in these reports from 1973 to 1981, while Statistics Canada data for the same period show forty-one deaths. As well, two deaths in this period were described as involving natural gas while Statistics Canada data do not show any deaths involving that fuel.

TABLE 4 REGIONAL STATISTICS - BRITISH COLUMBIA

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS $x10^3$	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
997	0	0	11	27	30	73	41

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
40	5.5

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
13.6	20.0

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
41	46	47	26	7	23	5	5

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
79	72	7	19	11	6	2	4

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

Value for Canada: 4685.7

368.8 (7.9% of total for Canada)

TABLE 5

BRITISH COLUMBIA EPISODES

	Collected Episode Data				Statistics Canada
	# of Episodes	# of Injuries	# of Deaths	% of Episodes Involving Death	# of Deaths
1973	0	0	0	0	8
1974	1	0	2	100	10
1975	2	9	6	50	8
1976	2	+	0	0	3
1977	7	+	6	43	2
1978	3	9	0	0	6
1979	0	0	0	0	1
1980	5	5	0	0	2
1981	2	9	0	0	1
TOTAL	22	32+	14	23	41
1982	4	7	0	0	
1983	1	1	0	0	
TOTAL	27	40+	14	19	

TABLE 6 EPISODES IN BRITISH COLUMBIA

British Columbia

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	24/7/74 Propane	Prince George	2 deaths	Malfunctioning Propane Refrigerator	Sgt. A.V. Scully RCMP, Prince George
2	1/12/75 NG	Fort St. John	4 Adults, 5 Children Hospitalized & Released	No Provision Made for Combustion Air in Fireplace Resulted in Downdraft	Gas Safety Branch, Ministry of Labour
3	6/12/75 Oil	Williams Lake	6 Deaths	Faulty Vent System in 17 Foot Trailer	Office of Fire Marshall
4	24/12/76 NG	Prince George	CO Poisonings, All Released from Hospital after Checkup	Combination of Fireplace Use and Overfired Furnace Led to Downdraft in New, Airtight Home	Inland Natural Gas Co. Ltd. Inspector's Report
5	26/12/76 NG	Prince George #205 - B44 Jackpine Ave.	CO Poisonings, No Hospitalizations	Combination of Fireplace Use and Overfired Furnace Led to Downdraft in a New, Airtight Home	Inland Natural Gas Co. Ltd. Inspector's Report
6	6/1/77 NG	Prince George 7264 Imperial Cres.	CO Poisonings, No Hospitalization	Combination of Fireplace Use and Overfired Furnace Led to Downdraft in a New, Airtight Home	Inland Natural Gas Co. Ltd.

TABLE 6 (Cont'd)

British Columbia

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
7	8/4/77 Propane	Lamplighter Motel, Revelstoke	2 Deaths	Plugged Gas Vent on LPG Heater	Revelstoke Fire Chief & Sgt. Bill Bishop, RCMP R.F. MacIsaac 754-2361
8	25-26/4/77 Propane	Mile High Lake, Kamloop Area	2 Deaths	Malfunctioning Propane Refrigerator	Cpl. Dennis Morgan, RCMP, Logan Lake
9	9/10/77 NG	Castlegar	3 Hospitalized & Released	500 ppm CO Cause Unknown	Ministry of Labour Gas Safety Branch
10	27/11/77 NG	405 McGowan, Kamloops	2 Deaths	Sealing Gasket Between Fan Compartment and Burner Compartment was Faulty Lack of Combustion Air for Fireplace Masking Effect of Existing Paint Odor	C.O. Alexander Regional Gas Inspector's Report
11	1/12/77 NG	Prince George 7792 Newton Cres.	No Injuries	Downdrafting Caused by Two Operating Fireplaces Without Adequate Combustion Air Supply	Inland Natural Gas Co. Ltd.
12	25/12/77 NG	No Location Given	CO Poisonings	Two Operating Fireplaces Caused a Downdraft - Combustion Air Was Piped into Return Air but No Supply Air Vent Near Fce.	Inland Natural Gas Co. Ltd.

TABLE 6 (Cont'd)

British Columbia

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
13	21/2/78 NG	1175 McLean St., Kamloops	General Health Complaints of Family Identified by Doctor as Possibly due to CO	Initial Testing Showed No Problem. Furtner Testing with Fireplace and Dryer Operating Showed Downdrafting. Outside Air Supply to the Fireplace Solved Problem	Inland Natural Gas Co. Ltd.
14	10/10/78 NG	Cranbrook	Near Death of 1 Adult + 2 Children	Combustion-air Vent Plugged at Exterior of Residence B-vent Acting as Air Inlet Rather Than Venting System Inlet due to Above	Ministry of Highways & Public Works Safety Engineering Services Division Gas Safety Branch
15	19/12/78 NG	Dawson Creek	3 Children & 3 Adults Hospitalized & Released	Vent Not on Collar on Space Heater 100% Spillage Cracked Heat Exchanger	Gas Safety Branch Ministry of Highways & Public Works
16	31/1/80 NG	5483 Moriarty, Prince George	Homeowner Complained of Strong Gas Odor Children Complained of Nausea	Gas Leak Found at Union on Water Heater	Ministry of Labour Safety Engineering Services Division Gas Safety Branch
17	5/2/80 NG	1793 Emmet Street, Prince George	Basement Suite Tenant "Near Asphyxiation"	Heating Boiler & Water Heater Located in Enclosed Laundry, No Combustion Air Duct. Primary Air Restricted by Lint. Carbon Buildup in Boiler. Neg. Pressure in Laundry Room. Spillage of CO Suite Adjoining	Ministry of Labour Safety Engineering Services Division Gas Safety Branch

TABLE 6 (Cont'd)

British Columbia

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
18	12/3/80 NG	550 - 2nd Ave. North Castlegar	Two Taken to Hospital	Combustion Chamber Carboned. Plugged Heat Exchanger. Cracked Front Top of Burner Opening.	Ministry of Labour Safety Engineering Services Division Gas Safety Branch
19	24/10/80 NG	1437 Canford Ave. Merritt	Two Taken to Hospital & Released	Space Heater Over Fired. Bracket Chimney Choked with Soot. 100% Back Venting	Ministry of Labour Gas Safety Branch
20	2/12/80 NG	Surrey	Family Suffering Headaches, Doctor Suggested Checking the Furnace	Incomplete Cold Air Return Duct made a Crawlspace Part of the Cold Air Return Circuit. Several Drains in the Crawl Space did not have Backtraps. A CO_2 Sample at the Spill Grill on the Plenum gave a High Reading of 800 ppm with the Fire on. Shutting the Gas Off but Keeping the fan going Resulted in a Reading of 750 ppm CO_2 Ruling out a Faulty Heat Exchanger. A Reading Taken in a Drain Tile Pipe in the Crawl Space was in Excess of 1500 ppm CO_2. Inspector noted that he could not check for other gases since he only had CO_2 Draeger Tubes.	Ministry of Labour Gas Safety Branch District Gas Inspector in Surrey, Nick Bosma

TABLE 6 (Cont'd)

British Columbia

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
21	14/1/81 NG	Winfield	Six Hospitalized for Weakness, Headaches, Nausea	No Evidence of CO at time of Testing	Ministry of Labour Safety Engineering Services Division Gas Safety Branch
22	25/9/31 NG	1608 - 33 Street Vancouver	Three Hospitalized & Released	Blocked Chimney Causing Spillage at Draft Hoods of Furnace & Water Heater	Ministry of Labour Safety Engineering Services Division Gas Safety Branch
23	2/1/82 NG	Dawson Creek Mother and 3 Children	On January 1st, a Doctor Diagnosed Mother as having Food Poisoning On January 2nd, three were hospitalized and released; Mother was unconscious for 13 hours.	Cold air return duct was not connected through the furnace roomwall. No combustion air was provided to the enclosed furnace room. CO was circulated through the house when chimney downdrafted.	Gas Safety Branch Ministry of Labour
24	17/2/82 NG	Kamloops		Furnace doors, return air panels had been removed. Both the furnace and the hot water tank were enclosed in a small closet with solid folding doors with a 10" x 10" grill. Combustion products were circulated through the hot air system.	Gas Safety Branch Ministry of Labour

TABLE 6 (Cont'd)

British Columbia

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
25	19/11/82 NG	Kamloops	Electrician overcome by CO	Malfunction of natural gas appliance	Gas Safety Branch Ministry of Labour
26	15/12/82 NG	Kamloops	Waitress overcome by CO	Malfunction of natural gas appliance	Gas Safety Branch Ministry of Labour
27	3/3/83	165 Robson Road East, Kelowna	CO poisonings, released after treatment	Fireplace use and improperly mounted fan compartment door.	Inland Natural Gas Co. Ltd.

3.2 Alberta

There were two good sources of episode information in Alberta.

- Gas Protection Branch, Department of Labour
- Canadian Western Natural Gas Co. Ltd.

One other potentially good source was reluctant to release information on carbon monoxide episodes.

Forty-four deaths were described in these reports from 1973 to 1981, while Statistics Canada data for the same period show forty-five deaths. No descriptions of episodes involving the other fuels category were found.

TABLE 7 REGIONAL STATISTICS - ALBERTA

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS x10^3	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
758	19	42	12	27	14	31	45

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
47	6.0

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
16.6	20.7

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
84	89	9	3	1	7	6	2

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
86	90	<1	3	11	4	2	2

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

444.3 (9.5% of total for Canada)

TABLE 8

ALBERTA EPISODES 1973-81

	Collected Episode Data				Statistics Canada
	# of Episodes	# of Injuries	# of Deaths	% of Episodes Involving Death	# of Deaths
1973	17	38	4	18	8
1974	7	11	3	20	8
1975	10	18	9	60	9
1976	5	6	7	60	8
1977	6	14	3	33	2
1978	19	27	8	37	4
1979	16	43	3	19	2
1980	9	17	3	22	2
1981	5	14	3	40	2
TOTAL	94	188	43	32	45
1982	10	16+	1	10	
1983	1	0	1	100	
TOTAL	105	204+	45	30	

TABLE 9 EPISODES IN ALBERTA

PROVINCE/YEAR: ALBERTA 1971-73

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	3/71 Natural Gas	Willingdon	One death	Furnace fan compartment door was removed. When fan operated it created a downdraft and circulated CO throughout the house.	Accounts of Alberta Supreme Court judgement denying survivors the damages assessed in a lower court. The province was not found negligent in failing to warn about the potential dangers of operating furnace with the fan compartment door removed.
2	Jan. 2/73 Natural Gas	Coaldale. Residence.	Near asphyxiation. 1 male and 1 female adult and 1 child.	Leaking furnace heat exchanger. Furnace was only two years old.	Gas Protection Branch Reported on Jan. 2/73
3	Jan. 3/73 Propane Gas	Airdrie. Residence.	2 adult males and 2 adult females. Near asphyxiation.	A brick chimney in poor condition and frosted over, allowed fumes from poorly adjusted appliances to escape into the residence.	Gas Protection Branch Reported on Jan. 2/73
4	Jan. 8/73 Natural Gas	Calgary. Residence.	1 female death by asphyxiation. 1 adult male and 2 children overcome by fumes-recovered.	A space heater installed by unqualified persons in a dugout basement had the draft diverter removed, and the vent was rusted allowing the fumes to escape. The vent and chimney were also partially plugged.	Gas Protection Branch Reported on Jan. 8/73

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1971-73

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
5	Jan. 9/73 Natural Gas	Medicine Hat. Residence.	Near asphyxiation. 2 adult males.	A converted coal and wood range was producing carbon monoxide because of dirty burners and possible lack of combustion air to the appliance.	Gas Protection Branch Reported on Jan. 9/73
6	Feb. 16/73 Propane Gas	Milk River. Residence.	Near asphyxiation. 1 male adult.	Two gas fired refrigerators venting inside the residence were producing carbon monoxide.	Gas Protection Branch Reported on Feb. 16/73
7	Mar. 9/73 Natural Gas	Granum. Residence.	Near asphyxiation. 1 adult male.	A space heater rated at 20,000 BTU sea level, was firing at 30,000 BTU's producing carbon monoxide. The heater vent had fallen off, allowing the fumes to spill into the residence.	Gas Protection Branch Reported on Mar. 9/73
8	April 18/73 Natural Gas	Calgary. Residence.	1 male death by asphyxiation.	An unvented space heater in a bedroom had been installed by an unqualified installer. Heater was modified and produced carbon monoxide.	Gas Protection Branch Reported on April 18/73
9	April 27/73 Natural Gas	Medicine Hat. Residence.	Near asphyxiation. 1 female adult and 3 children.	A space heater located in the bathrooms was vented directly through the side wall. Carbon monoxide fumes from this heater were spilling into the residence, also another space heater was vented into a bracket chimney. Loose bricks had fallen into the chimney plugging it off and causing fumes to spill into the residence.	Gas Protection Branch Reported on April 27/73

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1971-73

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
10	June 2/73 Propane Gas	Elkwater. Cabin.	Near asphyxiation. 3 adult males.	A vent on a propane fired refrigerator became plugged causing carbon monoxide to develop and escape into the cabin.	Gas Protection Branch Reported on June 2/73
11	Nov. 18/73 Natural Gas	Daysland. Commercial building.	Near asphyxiation. 1 adult female.	Vent cap on "B" gas vent had been removed, turned upside down on top of the vent and filled with snow, allowing no fumes to escape from the vent.	Gas Protection Branch Reported on Nov. 28/73
12	Nov. 18/73 Natural Gas	Two Hills. Residence.	Near asphyxiation. 2 adult females.	The furnace caused a negative pressure in the basement causing the flue products to reverse. The fumes were recirculated by a return air duct in the basement.	Gas Protection Branch Reported on Dec. 3/73
13	Dec. 3/73 Propane Gas	Rocky Mountain House. Residence.	Near asphyxiation. 2 adult males and 1 adult female.	A direct vent heater with badly cracked heat exchange and air intake covered by a piece of cardboard, also a floor furnace with a leaking heat exchanger and a poor vent connection, caused carbon monoxide to spill into the house.	Gas Protection Branch Reported on Dec. 3/73
14	Dec. 9/73 Natural Gas	Calgary	2 female adults hospitalized.	Converted furnace smothering, damper completely closed. Combustion chamber leaking 1000 ppm CO.	Canadian Western Natural Gas

TABLE 9 (Contd) .

PROVINCE/YEAR: ALBERTA 1971-73

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
15	Dec. 11/73 Natural Gas	Bellevue. Residence.	Near asphyxiation. 1 female adult.	Poorly adjusted furnace burners produced carbon monoxide which was circulated through the house by the furnace fan. The fan compartment door had been left off.	Gas Protection Branch Reported on July 12/74
16	Dec. 11/73 Natural Gas	Czar. Residence.	Near asphyxiation. 1 female adult.	A bracket chimney plugged by soot from a coal and wood range vented into the chimney along with a gas fired space heater, caused fumes to spill inside the residence.	Gas Protection Branch Reported on July 12/74
17	Dec. 19/73 Natural Gas	Edmonton. Residence.	Death by asphyxiation. 1 male adult and 1 female adult.	Improper re-installation of a gasket assembly between the circulating air and flue collector sections of a furnace, and operation of the furnace, with the fan compartment door removed.	Gas Protection Branch Reported on Dec. 20/73
18	Dec. 26/73 Natural Gas	Carmangay. Residence.	Near asphyxiation. 7 persons.	The vent lip on a homemade draft diverter on a space heater had rusted away allowing fumes to escape.	Gas Protection Branch Reported on Jan. 3/74

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1974

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Jan. 20/74 Propane Gas	Chestermere Lake. Cabin.	Near asphyxiation. 1 male and 2 female adults.	A water heater located in the furnace room was producing carbon monoxide. A furnace operating in the room with the fan compartment door removed, created a negative pressure causing the fumes from the water heater to spill out. The furnace distributed the fumes throughout the cabin.	Gas Protection Branch Reported on Jan. 28/74
2	Jan. 24/74 Natural Gas	Vegreville. Residence.	Near asphyxiation. 1 male adult.	The vent terminal of a space heater was closed over by ice. This was caused by the vent terminal being too low and being situated in the valley of the roof.	Gas Protection Branch Reported on Jan. 25/74
3	Feb. 13/74 Natural Gas	Calgary	1 adult injured but not hospitalized.	It was assumed that fireplace operation had reversed the furnace chimney draft. Furnace was producing over 3000 ppm CO. However, lab tests of the furnace produced no CO.	Canadian Western Natural Gas Co. Ltd.
4	July 12/74 Natural Gas	Calgary. Residence.	Death by asphyxiation. 1 male and 1 female adult. Near asphyxiation - 1 male and 1 female adult.	A swimming pool heater located in a furnace room was producing carbon monoxide and was back-drafting, spilling fumes into the home. The furnace fan on continuous operation for summer cooling, picked up the fumes by means of a return air duct in the furnace room and distributed them through the residence.	Gas Protection Branch Reported on July 12/74

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1974

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
5	Oct. 8/74 Natural Gas	Cold Lake. Apartment.	Near asphyxiation. 1 male, 1 female adult and 1 child.	A negative pressure was caused by the furnace fan drawing return air out of a confined furnace room.	Gas Protection Branch Reported on Nov. 8/74
6	Nov. 2/74 Natural Gas	Medicine Hat. Residence.	Near asphyxiation. 1 adult female.	A leaking combustion chamber on a furnace allowed products of combustion to escape into the residence.	Gas Protection Branch Reported on Nov. 2/74
7	Nov. 17/74 Propane Gas	Leduc. Residence.	Death by asphyxiation. 1 male adult.	An unvented and overfired space heater produced carbon monoxide which was distributed throughout the residence.	Gas Protection Branch Reported on Nov. 17/74

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1975

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Feb. 3/75 Natural Gas	Ponoka.	1 female death. 1 male near asphyxiation.	Plugged bracket chimney caused fumes spillage at draft hood of overfired heater.	Gas Protection Branch Reported on Feb. 5/75
2	Feb. 5/75 Propane Gas	Silver Creek Park.	1 male death. 1 male near asphyxiation.	Lack of oxygen in truck camper created carbon monoxide from portable infra-red heater.	Gas Protection Branch Reported on Feb. 5/75
3	March 17/75 Natural Gas	Calgary.	Family of five injured but not hospitalized.	Plugged filter on return air of furnace caused negative pressure in furnace room. Pool heater vent downdrafted. Poorly maintained heater producing over 3000 ppm of carbon monoxide	Canadian Western Natural Gas
4	April 3/75 Natural Gas	Calgary.	1 female adult and 1 female child hospitalized.	Converted furnace smothering. Damper completed closed and combustion chamber leaking. Furnace producing over 3000 ppm of carbon monoxide.	Canadian Western Natural Gas
5	April 7/75 Natural Gas	Edmonton.	2 male deaths. 1 female death and 3 near asphyxiation.	Dislodged vent assembly permitted flue products to re-circulate through the furnace with resultant CO.	Gas Protection Branch Reported on April 7/75
6	April 7/75 Propane Gas	Calgary.	1 male death, 1 female death and 2 near asphyxiation.	Lack of oxygen in trailer resulted in carbon monoxide being formed at portable infra-red heater.	Gas Protection Branch Reported on April 7/75

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1975

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
7	Aug. 16/75 Propane Gas	Hinton.	1 male death.	Lack of oxygen in Volkswagen Camper resulted in carbon monoxide from stove.	Gas Protection Branch Reported on Aug. 16/75
8	Dec. 12/75 Natural Gas	Calgary.	1 male death. Asphyxiation	Older style stove with closed primary air and plugged vent created carbon monoxide.	Gas Protection Branch Reported on Dec. 12/75
9	Dec. 15/75 Natural Gas	Cardston.	2 male and 1 female near asphyxiation.	Plugged unlined chimney permitted flue products from furnace to spill into the house.	Gas Protection Branch Reported on Dec. 20/75
10	Dec. 20/75 Natural Gas	Medicine Hat.	2 female and 2 male near asphyxiation.	Overfired, improperly vented older heater spilled carbon monoxide into the house.	Gas Protection Branch Reported on Dec. 20/75

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1976

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Jan. 19/76 Natural Gas	Calgary	2 adults and 1 baby injured	Water heater overfired and spilling fumes. Furnace fan compartment door off and vent partially rusted.	Canadian Western Natural Gas
2	Feb. 25/76	Sherwood Park.	3 females near asphyxiation.	Negative pressure in building resulted in fumes spillage at the appliance draft hoods.	Gas Protection Branch Reported on Feb. 26/76
3	Sept. 25/76 Propane Gas	Fort Vermilion	2 female deaths by asphyxiation.	Carbon monoxide caused by malfunctioning general refrigerator.	Gas Protection Branch Reported on Sept. 27/76
4	Oct. 22/76 Natural Gas	Onoway	3 male deaths and 1 female death.	Carbon monoxide caused by an unvented water heater and improperly converted furnace.	Gas Protection Branch Reported on Oct. 24/76
5	Dec. 21/76 Natural Gas	Edmonton	1 male death.	Carbon monoxide from uncertified old style heater. Air mixer plugged with lint.	Gas Protection Branch Reported on Dec. 21/76

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1977

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Jan. 17/77 Natural	Bassano	1 male near asphyxiation.	Plugged bracket chimney prevented proper venting of a small roomheater. Due to poor maintenance of the heater the primary burner air opening was partly plugged reulting in the forming of carbon monoxide.	Gas Protection Branch Reported on Jan. 21/77
2	Feb. 3/77 Natural Gas	Rocky Mountain. Howe Rural.	1 female and 4 children near asphyxiation.	Door left off furnace fan compartment and furnace filters plugged. Products of combustion were pulled from drafthood in furnace area causing incomplete combustion and these carbon monoxide loaded gases were pulled in the heating system through the open door.	Gas Protection Branch Reported on Feb. 3/77
3	April 7/77 Natural Gas	Edmonton	3 males near asphyxiation.	Disconnected vent connector of a carbon monoxide producing poorly converted gravity type coal and wood furnace allowing the products of combustion to spill in the house.	Gas Protection Branch Reported on Apr. 12/77
4	Aug. 9/77 Natural Gas	Calgary	1 male and 1 female death by asphyxiation.	Rusted out ventpipe of floor furnace allowed the products of combustion to enter the house and by lack of oxygen, carbon monoxide was produced causing the asphyxiation.	Gas Protection Branch Reported on Aug. 10/77

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1977

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
5	Sept. 4/77 Propane Gas	Jasper	1 male, 1 female and 3 children. (Health effects not given)	A solid fuel burning fireplace created a negative pressure in a holiday cabin thereby causing downdraft in the vent of a gasfired wall heater resulting in the production of carbon monoxide.	Gas Protection Branch Reported on Sept. 20/77
6	Dec. 5/77 Natural Gas	Edmonton	1 female child death by asphyxiation.	A distorted combustion chamber of a poorly maintained room heater caused the heater to produce carbon monoxide while a partly blocked vent connector and an unused opening attributed to improper venting of the appliance.	Gas Protection Branch Reported on Dec. 12/77

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1978

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Jan. 4/78 Propane Gas	Mountain Air Lodge.	1 Calgary female near asphyxiation.	The ventline of the control valve of a wall heater caused the combustion chamber to be plugged up with carbon spilling the product of combustion of the main burner into the Lodge room.	Gas Protection Branch Reported on Feb. 28/78
2	Jan. 26/78 Natural Gas	Edmonton.	1 male and 1 female - death by asphyxiation.	Poorly maintained furnace producing high level of carbon monoxide. A 2" crack in the heat exchanger, and the draft diverter and vent connector rusted off, result in carbon monoxide infiltrating the living quarters.	Gas Protection Branch Reported on Jan. 31/78
3	Jan. 78 Natural Gas	Edmonton.	1 female and 2 children near asphyxiation.	An overfired room heater installed in a basement room produced carbon monoxide and an improper venting system caused the products of combustion to enter the room. The orificies of the heater were drilled out causing the heater to be overfired.	Gas Protection Branch Reported in Jan./78
4	Feb. 17/78 Propane Gas	Sundre Rural.	1 male - death by asphyxiation.	A heater not certified for installation in a mobile home was installed in a holiday trailer. The door cracks were sealed with paper and the vent termination on roof was closed off with a hub cap. Carbon monoxide spilled out of draft diverter into the trailer.	Gas Protection Branch Reported on June 12/78

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1978

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
5	Feb. 28/78 Propane Gas	Spruce Grove.	1 male child death by asphyxiation.	Crack in heat exchanger and closed primary air shutters on the furnace burner are the possible cause of forming carbon monoxide. Through the heating duct system, carbon monoxide entered bedroom of infant.	Gas Protection Branch Reported on Mar. 28/78
6	April 11/78 Natural Gas	Camrose.	1 male death by asphyxiation.	Blocked unlined bracket chimney in combination with tampering of the drafthood of a floor furnace causing the formation of carbon monoxide.	Gas Protection Branch Reported on Apr. 24/78
7	May 5/78 Propane Gas	Blackfoot Indian Reserve near Calgary.	1 male near asphyxiation.	A wall heater installed in a small two-room building in operation for a long period of time depleted the oxygen in the room. No provisions were made for adequate ventilation or the supply of sufficient combustion air into the building.	Gas Protection Branch Reported on May 9/78
8	May 10/78 Natural Gas	Red Deer Rural.	1 male near asphxiation.	An improper converted water heater (overfired) produced carbon monoxide. The heater was located in a basement without provision for ventilation and/or combustion air supply. The products of combustion which were spilling out of the water-heater due to the overfiring condition were entering through cracks around heating ducts in the bedroom on the main floor.	Gas Protection Branch Reported on May 25/78

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1978

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
9	June 13/78 Natural Gas	Calgary.	1 male adult dead.	Space heater overfired, producing over 3000 ppm CO. Vent separated.	Canadian Western Natural Gas
10	June 16/78 Propane Gas	Red Deer.	1 male and 2 females near asphyxiation.	Poorly maintained heater with plugged primary air shutters causing the heater to produce carbon monoxide and partly plugged vent with tree cotton fuzz causing improper venting.	Gas Protection Branch Reported on June 19/78
11	July 8/78 Natural Gas	Spring Coulee.	1 male, 1 female and 1 child near asphyxiation.	A bird nest in vent of a mobile home furnace and the vent not properly secured to the furnace causing formation of carbon monoxide which entered the living quarters.	Gas Protection Branch Reported on July 11/78
12	Aug. 21/78 Natural Gas	Thorhild.	1 male, 1 female near asphyxiation.	Burned out heat exchanger of the furnace caused formation of carbon monoxide which passed into the house through the heating duct system.	Gas Protection Branch Reported on Aug. 22/78
13	Sept. 2/78 Propane Gas	Alberta Beach Rural.	1 male death by asphyxiation.	Carbon monoxide produced by a propane fired, not properly maintained refrigerator. Fridge was located in a 16' x 24' cottage.	Gas Protection Branch Reported on Sept. 6/78

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1978

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
14	Oct. 7/78 Propane Gas	Hay Lake Rural.	1 male and 1 female near asphyxiation.	The vent cap of a venting system of a newly installed furnace was wrongly installed blocking off the termination of the vent causing formation of carbon monoxide and spilling of flue gases into the living quarters.	Gas Protection Branch Reported on Oct. 9/78
15	Nov. 16/78 Propane Gas	Calahoo Rural.	1 female and 2 children near asphyxiation.	Furnace located in a confined space without a combustion air opening or duct. Return air system not connected to the furnace fan compartment. When furnace was operated, a negative pressure was created causing downdraft in the furnace vent. Carbon monoxide was formed and distributed through open fan compartment into the living quarters.	Gas Protection Branch Reported on Nov. 21/78
16	Nov. 22/78 Natural Gas	Cochrane Rural.	1 male and 1 female near asphyxiation.	An improper propane/natural gas converted furance produced carbon monoxide due to over-firing. A partly blocked bracket chimney caused the products of combustion to spill from the appliance drafthood into the house.	Gas Protection Branch Reported on Nov. 24/78

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1978

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
17	Dec. 17/78 Natural Gas	Innisfail	1 male child and 1 female child near asphyxiation.	A woodburning fireplace caused downdraft in the vent of a gasfired boiler (no combustion air to wood burning fireplace). The boiler started to produce carbon monoxide nearly asphyxiating the chidren who were playing in front of the fireplace.	Gas Protection Branch Reported on Dec. 21/78
18	Dec. 25/78 Natural Gas	Drayton Valley	1 male death by asphyxiation.	Vent pipe of a roomheater was disconnected when the victim fell against the heater in a motel room. Due to recycling of the products of combustion, carbon monoxide was formed causing the asphyxiation.	Gas Protection Branch Reported on Dec. 29/78
19	11/78 to 5/79 Natural Gas	Edmonton	Five months of headaches, nausea, vomiting; misdiagnosed by several doctors.	Defective heat exchanger in furnace.	Personal communication

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1979

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Jan. 5/79 Propane Gas	Calgary.	1 male death by asphyxiation.	Depletion of oxygen supply. (Camper)	Gas Protection Branch Reported on Jan. 5/79
2	Jan. 7/79 Natural Gas	Calgary.	1 male adult injured.	Furnace overfired 11%. Downdraft due to negative pressure in basement caused by excessive return air. Combustion air inlet satisfactory.	Canadian Western Natural Gas
3	Jan. 13/79 Natural Gas	Edmonton.	Two CO poisonings.	Couple lived in a garage heated by a gas stove and a gas heater.	Edmonton Journal account
4	Jan. 14/79 Natural Gas	Hanna.	1 female near asphyxiation	Chimney had dropped approx. 12" and chimney iced over, causing combustion products to spill into basement.	Gas Protection Branch Reported on Jan. 16/79
5	Jan. 29/79 Natural Gas	Camrose.	3 males and 3 females near asphxiation.	Fireplace caused improper combustion in furnace due to lack of oxygen.	Gas Protection Branch Reported on Jan. 26/79
6	Feb. 2/79 Natural Gas	Town of Whitecourt.	2 males near asphyxiation.	Removal of draft diverter in furnace and furnace producing carbon monoxide.	Gas Protection Branch Reported on Mar. 1/79
7	Feb. 17/79 Natural Gas	Cochrane.	1 male, 1 female, 4 children near asphyxiation.	Blockage of concrete chimney with debris causing spillage from furnace and water heater.	Gas Protection Branch Reported on Feb. 16/79
8	Feb. 25/79 Propane Gas	N.E.-15-26-28 WA	1 male, 1 female and 2 children. (Health effects not given)	Space heater converted to propane from natural gas not vented causing carbon monoxide. (Trailer)	Gas Protection Branch Reported on Feb. 25/79

TABLE 9 (Contd)

PROVINCE/YEAR: ALBERTA 1979

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
9	March 29/79 Natural Gas	Village of Donolda.	1 female near asphyxiation	Carbon monoxide build-up possibly due to partial blockage of flue passages in furnace.	Gas Protection Branch Reported on Apr. 3/79
10	April 14/79 Natural Gas	Calgary	1 adult male hospitalized and released.	Room heater plugged with carbon. Producing 2000 ppm of carbon monoxide.	Canadian Western Natural Gas
11	April 24/79 Natural Gas	Edmonton.	2 male and 2 female near asphyxiation.	Carbon monoxide, negative pressure created by use of fireplace and kitchen exhaust fan causing a reversal of flue products (insufficient combustion).	Gas Protection Branch Reported on Apr. 24/79
12	May 25/79 Propane Gas	Church Camp Magnolia.	3 male and 2 female near asphyxiation.	Carbon monoxide entered trailer through a defective gasket. When the exhaust vent passed through the return air system.	Gas Protection Branch Reported on May 20/79
13	Sept. 7/79 Natural Gas	Town of Ponoka.	1 male death by asphyxiation.	Faulty vent connection into a lined bracket chimney.	Gas Protection Branch Reported on Sept. 7/79
14	Sept. 18/79 Propane Gas	Calgary.	1 male death by asphyxiation.	Overfired unvented appliance in a motor vehicle.	Gas Protection Branch Reported on Sept. 19/79
15	Nov. 2/79 Natural Gas	Calgary.	3 persons hospitalized and released.	Boiler vent became disconnected from chimney. CO in boiler room leaked into suite.	Canadian Western Natural Gas
16	Mar 11/79 Natural Gas	Calgary.	Seven CO poisonings hospitalized, then released.	Fireplace use in an airtight home lead to downdraft of furnace vent.	Centre for Research & Development in Masonry, Calgary.

TABLE 9 (Cont'd) PROVINCE/YEAR: Alberta 1980

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Jan 14/80 Natural Gas	Calgary	2 adults and 1 child injured	Vent cap had deteriorated and fallen down to block vent. Water heater was producing CO.	Can. West. Natural Gas
2	Jan 25/78 Natural Gas	Olds	1 male and 1 female near asphyxiation	Blocked chimney and lack of ventilation caused improper combustion.	GPB reported on Jan 25/80
3	Feb 1/80 Natural Gas	Vermillion	1 male near asphyxiation	Venting tube in heater plugged with lint causing carbonizing flame. Improper combustion caused carbon monoxide.	GPB reported on Feb 1/80
4	Feb 4/80 Natural Gas	Three Hills	1 male near asphyxiation	Bracket chimney blocked off with debris. Combustion products forced into room fixtures producing carbon monoxide.	GPB reported on Feb 5/80
5	May 5/80 NG	Calgary	Eight years of head-aches, lethargy for family, low level chronic exposure to CO	Furnace combustion gases leaked into the house through a seriously damaged fireplace flue in a common chimney.	Calgary Inspector Harry Morstead, Centre for R & D in Masonry
6	June 21/80 Propane Gas	Moonlight Bay Lac La Nonne	1 female death	Using a range for heat, flames impingement on stove top toaster created carbon monoxide.	GPB reported on June 23/80
7	Oct 10/80 Natural Gas	Town of Onoway	1 male and 1 female death by asphyxiation	The chimney was plugged off with the roof cap.(trailer)	GPB
8	Nov 29/80 Natural Gas	Calgary	2 adults and 1 child hospitalized and released	Cracked heat exchanger in mobile home furnace.	Can. West. Natural Gas

TABLE 9 (Cont'd) PROVINCE/YEAR: Alberta - 1980

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
9	Dec 9/80 Propane Gas	Taber	2 male and 5 female near asphyxiation	Improper maintenance of furnace air supply to burners partially plugged therefore producing carbon monoxide. Also bracket chimney partially plugged and fan compartment door left off.	GPB reported on Dec 10/80

TABLE 9 (Cont'd) PROVINCE/YEAR: Alberta - 1981

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Jan 28/18 Natural Gas	Grande Prairie	7 boys near asphyxiation	Spillage of fumes from a furnace into a poorly ventilated room.	GPB reported on Jan 29, 1981
2	Feb 8/81 Natural Gas	Youngstown	1 male, 1 female and 1 child	Improperly converted furnace, shortage of combustion and diluted air, and a poor return air system caused combustion products to spill into a residence.	GPB reported on Feb 8/81
3	Sept 22/81 Natural Gas	Redcliff	1 male, 1 female adult and 2 children near asphyxiation	Poor space heater venting due to a plugged bracket chimney and primary air plugged with lint resulting in poor combustion and spillage of flue products into the home.	GPB reported on Sept 22/81
4	Dec 1/81	Elk Point	1 male death	Disconnected vent pipe from a floor furnace allowed products of combustion to be recirculated.	GPB reported on Dec 14/81
5	Dec 25/81 Natural Gas	Mundare	1 male and 1 female death by asphyxiation	A piece of sheet metal lodged in a furnace horizontal draft hood resulting in high level of carbon monoxide being produced which spilled into the living quarters.	GPB reported on Dec 26/81

TABLE 9 (Cont'd) PROVINCE/YEAR: Alberta - 1982/1983

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Jan 16/82 Natural Gas	Calgary	1 female and 1 male hospitalized and released	Damaged furnace casing caused air from fan to blow into draft hood and cause fume spillage.	Can. West. Natural Gas
2	Feb 10/82 Natural Gas	Black Diamond	1 female adult injured	Range pilot too high and producing 1000 ppm CO. Floor furnace - 200 ppm CO Radiant Heater - 50 ppm CO All venting in poor condition.	Can. West Natural Gas
3	Feb 22/82 Natural Gas	Edmonton	Death of 1 male adult	Oven of a gas range used for space heating purposes.	GPB reported on Mar 1/82
4	March 8/82 Natural Gas	Crossfield	1 male and 1 female adult. 1 child. Near asphyxiation	A completely plugged bracket chimney, no combustion or ventilation air in the basement and an overfired furnace resulted in high carbon monoxide contents in the flue gas to spill into the residence.	GPB reported on Mar 8/82
5	Apr 10/82 Natural Gas	Calgary	1 child hospitalized and released	Fireplace reversed draft in boiler and water heater. Child was sleeping near these appliances.	Can. West. Natural Gas
6	Nov 20/82 Natural Gas	Rosebud District	3 children and a baby-sitter near asphyxiation	Accidental disconnection of a vent from an overfired converted oil to natural gas furnace allowed fumes to be distributed through the house.	GPB reported on Nov 26.82
7	Apr 11/82 Natural Gas	Calgary	1 female and 1 male hospitalized and released	Fireplace reversed draft in furnace and water heater vent.	Can. West. Natural Gas

TABLE 9 (Cont'd) PROVINCE/YEAR: Alberta - 1982/1983

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
8	Aug 6/82 Natural Gas	Calgary	Several customers sick, not hospitalized	Health spa located in basement of dry cleaning establishment. Air inlet for spa located close to dry cleaning boiler vent.	Can. West. Natural Gas
9	Dec 8/82 Natural Gas	Calgary	Unknown number of people hospitalized and released	Door left off fan compartment created negative pressure in basement. Possible downdraft condition even though there was a combustion air inlet.	Can. West. Natural Gas
10	Dec 14/82 Natural Gas	Calgary	3 adults hospitalized for checkup	Poorly maintained pool heater downdrafted. Heater located in shed outside house but air for the blower into the spa water was taken from the shed. Heater vent also poorly placed.	Can. West. Natural Gas
11	Jan 20/83 Natural Gas	Calgary	1 female adult dead	Combustion air inlet partially blocked. Fan compartment door left off caused flame disturbance and CO production. Assumed reverse draft in vent but unable to simulate.	Can. West. Natural Gas

3.3 The North

The Territories lead the rest of Canada in total number of deaths per household due to carbon monoxide from heating, but no good sources of information were found.

Between 1973 and 1981, Statistics Canada data reveal seven deaths due to the incomplete combustion of domestic fuels. Five of these were due to oil, wood and other fuels. Two were due to bottled propane. Specific information on episodes is difficult to uncover since health and accident information is filed by name only in these low population regions.

However, the chief coroner in Whitehorse, Yukon Territories was able to recall three episodes involving six deaths.

TABLE 10 REGIONAL STATISTICS - YUKON TERRITORIES
DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS $x10^3$	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
7.6	0	0	2	50	2	50	4

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
52	8.6

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
18.8	24.3

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
2	2	79	64	3	17	17	18

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
72	66	3	15	24	13	2	6

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

6.6 (0.1% of total for Canada)

TABLE 11 REGIONAL STATISTICS - NORTHWEST TERRITORIES

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS x10^3	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
11.5	0	0	0	0	3	100	3

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
53	14.3

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
9.6	33.5

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
5	4	80	82	1	6	14	8

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
60	78	1	4	34	15	5	4

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

18.2 (0.4% of total for Canada)

TABLE 12 EPISODES IN THE NORTH

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	1982 Oil	Yukon Territories	Three deaths	Poorly vented stove used in a tent	Chief Coroner, Whitehorse
2	1979 Oil	Whitehorse Yukon Territories	One death	Oil stove in small cabin, dirty burner	Chief Coroner, Whitehorse
3	1973 Oil	Whitehorse Yukon Territories	Two deaths	Furnace chimney iced over in large house used for apartments	Chief Coroner, Whitehorse

3.4 The Prairies

There were several good sources of episode information in the prairie provinces.

In Saskatchewan:

- Gas Safety Unit, Ministry of Labour

In Manitoba:

- Mechanical and Engineering Division, Department of Labour and Manpower.
- Manitoba Public Utilities Board
- Environmental Management Division, Department of Mines, Natural Resources and Environment.

Seven deaths were described in these reports from 1973 to 1981 for Saskatchewan and Manitoba, while Statistics Canada data for the same period show eighteen deaths.

From 1978 to 1982 Saskatchewan Health records show a total of nine hospitalizations due to carbon monoxide poisoning from the incomplete combustion of domestic fuels. Three of these were due to liquified petroleum gas distributed in mobile containers (propane), and six were due to other fuels, a category which includes oil, wood and kerosene. In the same period, there were eleven hospitalizations for unspecified carbon monoxide poisoning for which no cause was given.

TABLE 13 REGIONAL STATISTICS - SASKATCHEWAN

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS x10^3	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
333	0	0	9	75	3	25	12

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
32	7.7

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
24.6	22.8

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
60	70	33	19	1	7	6	3

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
82	85	1	5	16	6	2	3

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

244.5 (5.2% of total for Canada)

TABLE 14 REGIONAL STATISTICS - MANITOBA

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS $x10^3$	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
358	0	0	2	33	4	67	6

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
30	6.9

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
22	31.9

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
54	55	32	16	7	25	7	4

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
82	70	7	22	10	4	2	3

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

270.0 (5.8% of total for Canada)

TABLE 15

PRAIRIE EPISODES 1973-81

	Collected Episode Data				Statistics Canada
	# of Episodes	# of Injuries	# of Deaths	% of Episodes Involving Death	# of Deaths
1973	1	5	0	0	5
1974	3	4	4	67	4
1975	0	0	0	0	1
1976	3	7	0	0	1
1977	1	2	0	0	4
1978	2	9	0	0	1
1979	2	3	0	0	0
1980	0	0	0	0	0
1981	3	4	1	33	2
TOTAL	15	34	5	20	18
1982	3	2	2	67	
1983	0	1	0	0	
TOTAL	18	37	7	26	

TABLE 16 EPISODES IN THE PRAIRIES

Saskatchewan

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	5/7/73 Propane	Glen Harbour Beach	Three unconscious and two semi-conscious	Carbon monoxide produced by a propane gas refrigerator in a cottage	Gas Safety Unit Ministry of Labour
2	12/10/74 Propane	Graves Island, LaRonge	Three deaths, two injuries	Carbon monoxide produced by a propane gas refrigerator in a cottage	Gas Safety Unit Ministry of Labour
3	1/11/74 NG	Saskatoon	Two hospitalized	Carbon monoxide produced by a natural gas refrigerator	Gas Safety Unit Ministry of Labour
4	16/9/81 Prcpane	Garrick Holiday cabin trailer	One death, one injury	Occupants disassembled heater to remove bird's nest from vent Improper cleaning and reinstallation resulted in carbon monoxide from the propane heater entering the trailer	Gas Safety Unit Ministry of Labour
5	18/9/81 Propane	Larigan	One injury	Defective combustion chamber in mobile home furnace affected the flame and allowed carbon monoxide to escape into the home	Gas Safety Unit Ministry of Labour

TABLE 16 (Cont'd)

Saskatchewan

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
6	16/1/82	Coronach-Rural	One death, one injury	The furnace fan chamber door had fallen off, causing reversal of chimney draft and delivery of combustion products throughout the home	Gas Safety Unit Ministry of Labour
7	5/9/82 Propane	Matheson Lake	One death	Ford van converted to camper Framing at the top of propane refrigerator did not create complete seal to interior of van permitting carbon monoxide from burner to enter van	Gas Safety Unit Ministry of Labour

Manitoba

TABLE 16 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Apr 6/72 Oil	Grandview		inspection of oil burning space heater had large accumulation of carbon inside combustion chamber and smoke pipe, also in bottom of combustion chamber and the flame diffuser ring was slightly out of place.	Dept. of Labour
2	June 1/72 Propane	Island View Mobile Bunk houses	2 men overcome in CO gas	CO produced by refrigerator by main burner. Flame from burner was not being drawn properly up the flue chamber but spilling out around the outside.	Dept. of Labour
3	Nov 29/72 Propane	Towland-Hewitson Gravel Pit. 2 mi. N of Vermillion	1 person died from CO poisoning	faulty propane heater, installed improperly. No safety controls, damaged heat exchanger and no outside vent.	Dept. Mines Natural Resources Ont.
4	Dec 5/72 Natural Gas	Redboine Drugs 1570 St. James St.	-	cracked heat exchangers reduced vent connectors - effect passage of flue gases.	Dept. of Labour Greater Winnipeg Gas Co.
5	Dec 13/72 Propane	Dawson Bay District 220 Mi. N of Mafeking	1 fatality	heater altered in respect to draft hood and main gas valve. Also method of venting was through a horizontal pipe through wall of trailer. Combustion chamber restricted flow of product of combustion to atmosphere. CO was produced and spillage resulted from use of horizontal vent that applied to heater which was originally designed for vertical vent from the draft hood connection.	Dept. of Labour Swan River RCMP Canadian Propane Swan River

Manitoba

TABLE 16 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
6	Jan 3/74 NG	Winnipeg	1 death	Contractor thawing out frozen water pipes in residence using his own temporarily installed heater. Unit was incorrectly operated and vented, causing CO buildup resulting in death of self.	Manitoba Public Utilities Board. Greater Winnipeg Gas Company report.
7	Mar 19/76 NG	Stonewall	Mother and 3 children complained of headaches	Corrosion of lower heat chamber and plugged draft.	GWG
8	Oct 17/76 NG	Winnipeg	2 adults - 1 child overcome, hospitalized	Occupant attempted to modify heat exchanger to reduce natural gas consumption, thereby producing CO. Exhaust fumes entered house due to chimney downdraft from earlier use of fireplace.	Manitoba Public Utilities Board. Dept. of Labour, Greater Winnipeg Gas Company report.
9	Nov 12/76	125 Cordova St.		Electric clothes dryer vented into chimney below breeching of boiler. Action of dryer fan prevented boiler from proper venting. Top heat exchanger became completely plugged with carbon.	Dept. of Labour
10	Nov 19/77	870 Palmerston Ave.	Mother and child hositalized with symptons of disorientation, diarrhea and vomiting	Boiler plugged with scale creating CO and no clearance for the products of Combustion to the chimney could be created. No air for combustion allowed in residence and fireplace which was being used.	Winnipeg Gas Co. Dept. of Labour

TABLE 16 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
11	Feb 1/78 Gas	984 McIvor Ave. Winnipeg	4 family members Mother and daughter hospitalized a full day, others released within few hours.	Fireplace in operation for few hours, in evening of Jan 31. It is reason to believe that a neg. condition was created and products of combustion from gas heating furnace were drawn in house. Chimney found to be blocked with ice and water.	Dept. of Labour
12	Dec 16/78 NG	Roblin	2 adults - 3 childred overcome hospitalized	Fireplace operating in a well insulated and weatherized house caused furnace chimney to down-draft. Home's roof vents were blocked with ice and snow.	Dauphin Medical Group. Dauphin Herald.
13	Apr 3/79	Seine River Gardens	Headaches, dizziness, respitory problems.	Carbon monoxide levels as high as 42 ppm in suite 223 as measured by Ecolyzer Model 2400. The suite was located directly above a parking garage. The garage fan was found to be in-operative.	Environmental Management Div., Manitoba Dept. of Mines, Natural Resources and Environment.
14	Sept 20/79 NG	Stonewall	2 adults overcome, hospitalized	CO buildup from faulty heat exchanger.	Manitoba Public Utilities Board
15	Dec 10/81 NG	Winnipeg	Frequent eye irritation	Approx. 5 ppm CO no oxides of nitrogen detected by Draeger tubes. Gas appliances required servicing. Exhaust fans recommended.	Environmental Management Div., Manitoba Dept. of Mines, Natural Resources and Environment.

Manitoba

TABLE 16 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
16	Jan 14/82 NG	Winnipeg	Headaches, respitory problems and excessive moisture on windows.	Draeger tubes showed 200-300 ppm CO and 2 ppm oxides of nitrogen on the main floor. Gas company found a bird's nest blocking the chimney.	Environmental Management Div., Manitoba Dept. of Mines, Natural Resources and Environment

3.5 Ontario

Ontario has had the highest number of deaths, the most extensive media attention and the most comprehensive recording of episodes by provincial government department, however, Ontario ranks seventh in Canada in total number of deaths per number of households.

Many good sources of information were contacted, but the Fuel Safety Branch (FSB) of the Ministry of Consumer and Commercial Relations was identified as the best source. Tables 18 and 19 compare the collected episode data with that of Statistics Canada for the period from 1973 to 1981.

For the 1981-1982 fiscal year Ministry of Health records show a total of 19 patient discharges for carbon monoxide poisonings due to the incomplete combustion of domestic fuels. Twelve of these were due to natural gas, two were due to propane, and five were due to other fuels, a category which includes oil and wood. During the same period there were thirty hospitalizations due to motor vehicle exhaust and twenty-one due to carbon monoxide from unspecified sources. The average length of stay for these patients was approximately two days. From April 1981 to March 1982, data from the Fuel Safety Branch of the Ministry of Consumer and Commercial Relations reveal a total of 14 episodes involving 38 injuries, many of which would involve hospitalization. This figure is higher than that given by the Ministry of Health.

TABLE 17 REGIONAL STATISTICS - ONTARIO

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS x10^3	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
2970	13	19	21	30	36	51	70

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
29	5.7

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
27.0	33.7

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
37	48	54	32	6	18	3	3

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
84	78	6	15	8	4	1	2

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

1550.5 (33.1% of total for Canada)

TABLE 18

ONTARIO EPISODES 1973-81

	Collected Episode Data				Statistics Canada
	# of Episodes	# of Injuries	# of Deaths	% of Episodes Involving Death	# of Deaths
1973	12	18	10	58	8
1974	14	51	6	29	12
1975	12	38	7	42	8
1976	14	35	5	21	4
1977	11	47	5	27	3
1978	9	27	4	33	8
1979	8	20	5	50	10
1980	11	34	8	36	8
1981	14	59	6	21	9
TOTAL	105	329	56	34	70
1982	17	58	3	18	
1983	2	6	0	0	
TOTAL	124	393	59	31	

TABLE 19

ONTARIO DEATHS BY FUEL TYPE 1973-81

	Fuel Safety Branch		Statistics Canada	
	#	%	#	%
Total Deaths	56	100	70	100
Natural Gas	13	23	13	19
Propane (Refrigerator)	36 (26)	64 (46)	21	30
Other Fuels, including Oil, Wood	7	13	36	51

TABLE 20 EPISODES IN ONTARIO

PROVINCE/YEAR: ONTARIO 73

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	12/2/73 NG	Toronto	4 CO poisonings	- chimney serving 2 homes - centre wall collapsed blocking vent	M of CCR
2	15/5/73 NG	Sarnia	1 dead - smoke inhalation	- fire caused by ignited floor joints by furnace flue connector	M of CCR
3	3/6/73 Propane	White Sands Camp	1 dead - CO	- defective refrigerator causing formation of CO	M of CCR
4	10/6/73 Propane	Mercutio Lake Crystal Lodge near Atikokan	4 dead	- faulty refrigerator causing CO formation	M of CCR
5	24/7/73 Propane	Surprise Lake, Parry Sound	1 dead - CO	- faulty refrigerator causing CO formation	M of CCR
6	27/8/73 Propane	Camp Narrow Lodge Devlin	2 CO poisonings	- faulty refrigerator causing CO formation	M of CCR
7	21/9/73 NG	Toronto	4 CO poisonings	- dislodged vent connector - little boy was treated for a cold by hospital day before and sent home	M of CCR

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 73 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
8	10/11/73 NG	London	4 CO poisonings	- abuse of chimney by owner led to poor combustion	M of CCR
9	12/11/73 NG	London	4 CO poisonings	- leaking heat exchanger, burned out - CO spilled out	M of CCR
10	10/11/73 Propane	Renfrew City	1 dead - CO poisoning	- space heater gas lighter grossly overfired - CO - unapproved installation	M of CCR Toronto Star
11	20/12/73 NG	London	1 dead, 1 CO poisoning	- chimney plugged with soot	M of CCR
12	26/12/73 Oil	Guelph	1 dead - CO poisoning	- chimney liner deteriorated and plugged - space heater vent pitted	M of CCR

TAELE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 74

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	1/1/74 NG	London	4 injuries	- deterioration of unlined chimney caused partial blockage of flue gases out of the house. CO build-up as a result	M of CCR
2	6/1/74 NG	St. Catharines	3 injuries	- corroded heat exchanger caused CO accumulation in the house	M of CCR
3	11/1/74 NG	London	1 CO poisoning	- improperly repaired or replaced vent done by inexperienced personnel causing poor venting conditions	M of CCR
4	17/5/74 Propane	Conostaga Lake, Cottage	2 deaths	- self-installed unvented propane heater caused accumulation of CO in enclosed environment	M of CCR Toronto Star
5	20/5/74 Propane	Cottage, Gravenhurst	3 CO poisoning	- plugged chimney - dirty, propane fuelled space heater caused CO accumulation	M of CCR Toronto Star
6	31/5/74 Propane	Cottage Verona (Frontenac City)	2 poisoned by CO	- unserviced refrigerator caused CO accumulation in enclosed environment	M of CCR

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 74 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
7	8/7/74 Propane	Cottage, Smith's Bay	2 deaths, 2 poisoned	- unserviced refrigerator causing CO generation and accumulation in poorly ventilated environment	M of CCR
8	29/8/74 Propane	Amherst Island	1 dead, 1 poisoned	- unserviced refrigerator causing CO generation and accumulation in poorly ventilated environment	M of CCR
9	24/9/74 NG	North York	4 poisoned by CO	- poorly maintained and defective pool heater caused accumulation of CO	M of CCR
10	23/9/74 NG	Mississauga	30 CO poisonings	- inadequate combustion air for room top boiler caused the formation of CO	M of CCR
11	29/9/74 Propane	Muskoka	1 death	- improperly cleaned and serviced refrigerator gave rise to CO	M of CCR
12	1/10/74 NG	Ingersol	4 poisoned by CO	- defective furnace and damaged heat exchanger	M of CCR
13	8/10/74 NG	Toronto	1 poisoning	- over firing furnace due to defective regulator, causing CO formation	M of CCR
14	21/12/74 NG	St. Catharines	3 CO poisoned	- heating equipment was poorly installed and maintained. It over fired and caused formation of CO	M of CCR

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 75

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	18/1/75 NG	North Bay	5 treated for CO poisoning	- unlined chimney deteriorated due to condensation, plugged up	M of CCR, FSB
2	3/2/75 NG	Ottawa	2 treated for CO poisoning	- tightly sealed home with inadequate supply of ventilation/combustion air, roaring fireplace led to down draft condition - poorly adjusted furnace	M of CCR, FSB
3	23/2/75 NG	Ottawa	2 treated for CO	- tightly sealed house with inadequate ventilation/ combustion air - fireplace led to down draft condition	M of CCR, FSB
4	16/3/75 NG	Cabin near Dunnville	1 dead, 2 poisoned by CO	- unvented, overfired NG space heater	M of CCR, FSB
5	18/3/75 NG	Etobicoke	7 treated for CO	- tight house with inadequate ventilation/combustion air	M of CCR, FSB
6	28/4/75 NG	London	7 treated for CO	- tight house with inadequate ventilation/combustion air - open fireplace	M of CCR, FSB

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 75 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
7	6/7/75 NG	Orillia	5 children treated for CO	- inadequate ventilation/ combustion air for pool heater spilled combustion products into swimming pool room	M of CCR, FSB
8	24/8/75 Propane	Elliott Lake	2 dead, 2 critical due to CO	- defective refrigerator	M of CCR, FSB
9	23/9/75 Propane	Goderich	2 dead, 2 serious due to CO	- defective refrigerator	M of CCR, FSB
10	24/10/75 Oil	Burnstown	1 dead due to CO	- tight cottage space heater vent blocked by soot	M of CCR, FSB
11	17/12/75 NG	Cottage near Earlton	1 dead due to CO	- blocked pottery kiln vent allowed CO to spill into cabin	M of CCR, FSB
12	17/12/75 NG	Iroquois Falls	4 children treated for CO poisoning	- carbon blocked flue pipe	M of CCR, FSB

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 76

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	7/1/76 NG	Pembroke	4 treated for CO	- tightly sealed house with inadequate ventilation/ combustion air - oversized furnace vent led to chimney down draft	M of CCR, FSB
2	16/1/76 NG	Blackburn Hamlet	2 treated for CO	- tightly sealed house with inadequate ventilation/ combustion air - oversized furnace vent and blazing fireplace led to down draft condition	M of CCR, FSB
3	24/1/76 NG	Cobourg	2 treated for CO	- defective drafthood open fan compartment door allowed spillage of CO into home	M of CCR, FSB
4	2/2/76 Oil	Cottage, Muskoka area	1 dead due to CO	- iced over chimney, defective space heater emitting high levels of CO	M of CCR, FSB
5	29/2/76 Propane	Cottage, East Ferris	1 treated for CO	- tightly insulated dwelling with inadequate supply of ventilation/combustion air - poorly maintained propane appliances	M of CCR, FSB
6	12/5/76 NG	Oakville	4 treated for CO	- plugged chimney, rotting vent connector	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 76 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
7	26/5/76 Propane	Cottage near Thunder Bay	3 treated for CO	- unserviced refrigerator	M of CCR, FSB
8	30/5/76 Propane	Cabin near S.S. Marie	2 treated for CO	- unserviced refrigerator	M of CCR, FSB
9	13/6/76 NG	Etobicoke	3 treated for CO	- unserviced refrigerator	M of CCR, FSB
10	19/9/76 Propane	75 m N. of Sioux Lookout	2 dead, 1 serious condition due to CO	- unserviced refrigerator	M of CCR, FSB Toronto Star
11	26/11/76 NG	Toronto	2 treated for CO poisoning	- poorly maintained furnace - plugged combustion air duct - roaring fireplace resulted in chimney down draft	M of CCR, FSB
12	2/12/76 Propane	Thunder Bay	6 treated for CO	- 4 IR space heaters used in home without adequate ventilation and combustion air	M of CCR, FSB
13	6/12/76 NG	Ottawa	5 treated for CO	- poorly serviced furnace - plugged combustion air duct and roaring fireplace resulted in down drafting chimney	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 76 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
14	3/12/76 NG	Sudbury	2 dead due to CO	- unlined chimney became plugged due to condensation of flue gases, deterioration	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 77

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	12/1/77 NG	Welland	6 treated for CO	- vent plugged with ice and snow - furnace vent corrector rusted and leaking	M of CCR, FSB
2	28/1/77 NG	Hamilton	10 treated for CO poisoning	- unlined chimney partially blocked	M of CCR, FSB
3	8/2/77 NG	Barrie	4 treated for CO poisoning	- tightly sealed home with inadequate supply of ventilation (combustion air) - heat exchanger cracks allowed spillage of CO into home	M of CCR, FSB
4	8/6/77 NG	Oakville	5 treated for CO poisoning	- pool heater in house basement spilled combustion products into house	M of CCR, FSB
5	23/11/77 Wood/Coal	Matheson	5 treated for CO poisoning	- tightly sealed house - plugged flue line allowed CO to spill into home	M of CCR, FSB
6	6/12/77 NG	Niagara Falls	1 treated for CO poisoning	- overly long external vent, "adverse weather conditions" destroyed venting action of chimney - poorly maintained furnace emitted excess CO	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 77 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
7	20/12/77 NG	Cambridge	10 treated for CO poisoning	- deteriorated chimney, improperly lined led to down draft condition	M of CCR, FSB
8	12/2/77 Propane	Brockville	6 treated for CO poisoning	- poorly maintained refreigerator	M of CCR, FSB
9	20/6/77 Propane	Cabin in Kenora District	3 dead due to CO	- poorly maintained refrigerator	M of CCR, FSB
10	3/8/77 Propane	Frontenac County	1 dead due to CO	- poorly maintained refrigerator	M of CCR, FSB
11	3/8/77 Propane	Cabin, Wouerick Lake	1 dead due to CO	- poorly maintained refrigerator	M of CCR, FSB

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 78

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	10/1/78 NG	Matheson	1 treated for CO poisoning	- defective space heater emitted high levels of CO - Chimney downdrafted	Ministry of Consumer and Commercial Relations, FSB
2	28/1/78 NG	Oshawa Apartment Building	15 treated for CO poisoning	- lint from dryer blocked off furnace air supply - fan door fell off allowing CO to be circulated in building	M of CCR, FSB
3	30/1/78 NG		2 treated for CO poisoning	- unlined chimney deteriorated and blocked	M of CCR, FSB
4	16/6/78 Propane	Oneida Indian Reserve Middlesex County	2 dead due to CO poisoning	- tightly sealed residence - defective, continuously used propane range burner emitted high levels of CO	M of CCR, FSB
5	12/9/78 Propane	Cottage in District of Sudbury	1 dead due to CO poisoning	- improperly serviced refrigerator	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 78 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
6	21/11/78 NG	Hamilton	1 dead due to CO 1 treated for CO	- leaking boiler and vents spilled CO into home - poorly maintained boiler	M of CCR, FSB
7	17/10/78 NG	London	2 treated for CO	- chimney plugged partially by fly screen owner put in to keep out racoon - boiler flue passage plugged with carbon	M of CCR, FSB
8	23/11/78 NG	Thunder Bay	3 treated for CO	- deteriorated furnace - furnace vents riddled with holes	M of CCR, FSB
9	20/4/78 NG	Thunder Bay Apartment Building	3 treated for CO	- defective heat exchanger - rusted out vent connector, spilled CO into building	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 79

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	18/05/79 Propane	Jones Lake, Kenora	2 deaths, 1 injury	- overpressured propane supply line resulted in off-ratio combustion at the refrigerator burner producing CO at 2000 ppm level. Testing of the refrigerator revealed that the downstream propane pressure was about 30" W.C. instead of the required 11" W.C.	M of CCR Accident Report Summary
2	09/09/79 NG	Mount Brydges	1 death	- 41 yr old steel chimney liner rusted and is blocked completed Furnace emitting CO at a level of 1000 ppm because it was maladjusted	M of CCR. Coroner's Report
3	12/10/79 NG	Smith's Falls	5 injuries	- the maladjusted conversion burner was producing large amount of CO because of impingement and overfiring. B-vent was most plugged on Oct. 12, owner installed a circulating fan that caused gross spillage at the draft hood and circulation of CO throughout the home.	M of CCR
4	03/11/79 NG	Toronto	2 injuries	- lack of combustion air in a well caulked home - open fireplace in the house. The burner was carbon choked and the sectional flues were also largely blocked by carbon and scale because of poor combustion. Exhaust fan in the boiler room.	M of CCR

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 79 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
5	21/12/79 NG	Ottawa	3 injuries	- improper duct ventilation. An opening 18" x 6" in the upper side of the cold air return duct aggravated an existing chimney down draft resulting in distribution of CO though the above	M of CCR
6	11/11/79 Propane	Selby Twp. (Sudbury)	1 death	- unvented IR space heater caused build-up of CO in a tightly sealed environment. Deceased slept in the customized van overnight and was poisoned	M of CCR
7	07/07/79 Propane	Burleigh Falls	9 injured	- dirty and defective room space heater in cabin gave rise to CO overcoming the guests	M of CCR
8	04/01/79 Gas	Frey Twp. (Logging Camp) (Sudbury)	1 death	- defective space heater gave rise to CO. Slept in mobile mechanical shop, was poisoned by CO	M of CCR

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 80

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	29/1/80 NG	London	5 treated for CO poisoning	- very tight house with inadequate supply of ventilation/combustion air	Ministry of Consumer and Commercial Relations, FSB
2	14/3/80 NG	Toronto	6 treated for CO poisoning	- unlined brick chimney deteriorated due to condensation and became blocked	M of CCR, FSB
3	19/4/80 NG	Thunder Bay	5 treated for CO poisoning	- tightly sealed house with exhaust fans operating and inadequate supply of ventilation/combustion air resulted in a downdraft condition in chimney.	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 80 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
4	2/4/80 Propane	Cabin, Common Lake, 40 miles NW of Red Lake	2 dead due to CO poisoning	- poorly maintained propane appliances emitted high levels of CO	M of CCR, FSB
5	28/4/80 Propane	Bayview campgrounds, Thornbury	1 death due to CO poisoning	- closed Dodge van with propane fired IR heater became filled with CO	M of CCR, FSB
6	1/8/80 Propane	Aylen Lake, District of Nipissing	2 dead due to CO poisoning	- defective propane fired refrigerator	M of CCR, FSB
7	26/9/80 NG	St. Catharines	3 deaths due to CO 3 treated for CO	- unlined brick chimney greatly deteriorated and blocked with debris	M of CCR, FSB Chief Coroner's Office
8	8/10/80 Oil	Sudbury	4 treated for extreme CO poisoning	- chimney blocked - poorly serviced furnace emitted large amounts of CO	M of CCR, FSB
9	10/10/80 NG	Scarborough	4 treated for CO poisoning	- inadequate chimney capacity - inadequate combustion/ventilation air	M of CCR, FSB
10	13/10/80 Propane	cottage near Huntsville	4 treated for CO poisoning	- poorly ventilated propane heater (vent oversized)	M of CCR, FSB

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 80 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
11	30/11/80 NG	Toronto	3 treated for CO poisoning	- unlined chimney blocked by debris	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 81

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	03/01/81 NG	Windsor Park Hotel, S.S. Marie	1 died, 25 injuries	- defective, overfired boiler gave rise to CO leak around boiler flue outlet allow escape of CO which migrated through the boiler room to the pipe chase, the chase air flow was directed into the bathrooms	M of CCR Globe & Mail Coroner's Report
2	05/01/81 Oil	Kars	4 died	- cracked heat exchanger allowing gases to escape into the furnace heating fan pushed gases through the house - Soot build-up in a 4 yr old chimney system giving rise to carbon monoxide	M of CCR Toronto Sun Coroner's Report
3	06/01/81 NG	Mississauga	1 death	- heat exchanger cracked in a 20 yr old down draft gas furnace, causing the emission of CO into the home	Chief Coroner's Office
4	14/01/81 NG	Ottawa	2 injuries	- partially blocked chimney - tight insulation - carpet over return air ducts	M of CCR
5	21/04/81 NG	Waterloo	3 injuries	- tight insulation - open fireplace - reverse draft on furnace causing negative pressure condition which reversed the venting action of the gas furnace	M of CCR

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 81 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
6	14/06/81 Propane	Lower French River (Dokis Indian Reserve)	2 injuries	- restriction in flue passage on propane fueled refrigerator generated CO	M of CCR
7	17/09/81 NG	Windsor	3 injuries	- gas fuelled swimming pool heater installed in basement instead of outdoor by Union Gas - heater improperly vented	Globe & Mail
8	04/10/81 NG	London	3 injuries	- heat exchanger in 14 yr old furnace corroded - CO recirculated	M of CCR
9	25/10/81 NG	Kitchener	3 injuries	- a vent was improperly installed on a high eff. furnace, producing a condensation trap which filled with water, vent section not glued together. High press. safety switch set too high unit continued to operate allowing CO to enter house	M of CCR
10	26/10/81 NG	Kitchener	2 injured	- the vent on high eff. furnace improperly installed pressure switch set too high CO leaked at the pressure switch & fan housing connection into house - condensate housing was fitted into a 90^{o}elbow rather than a relief valve	M of CCR

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 81 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
11	14/12/81 NG	Nepean	2 injured	- improper conversion burner adjustment. CO spilled from barometric draft regulator due to negative press. in the furnace room caused by an opening in the return air duct	M of CCR
12	21/12/81 NG	Gloucester	3 injured	- well insulated house NG furnace in small room of small basement - basement fireplace used the previous night fireplace damper fully open - CO recirculated	M of CCR
13	21/12/81 NG	Gloucester	4 injured	- tightly sealed bungalow in combination furnace/laundry room - dryer operated with the door to the room close CO recirculated	M of CCR
14	12/81	Toronto	7 injured	- barbeque used indoor to cook and warm house	Toronto Star

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 82

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	4/1/82 NG	Amherstburg	2 treated for CO poisoning	- deteriorating line seam in furnace heat exchanger allowed combustion products to spill into house	Ministry of Consumer and Commercial Relations
2	7/1/82 NG	Thunder Bay	2 treated for CO poisoning	- tightly sealed house with inadequate supply of ventilation/combustion air - basement fireplace vented into half of double chimney - downdraft condition resulted	M of CCR, FSB
3	20/1/82 Oil	Willowdale	1 death due to CO	- tightly sealed house with inadequate supply of ventilation/combustion air - high efficiency "blue flame" furnace used infrequently; decorative chimney cap - as a result chimney was iced over	M of CCR, FSB Chief Coroner's Office Toronto Star
4	3/2/82 NG	Scarborough	1 death due to CO 2 treated for CO poisoning	- resident blocked vent with piece of fiberglass, presumably to conserve heat	M of CCR, FSB Chief Coroner's Office Toronto Star
5	5/2/82 NG	Sarnia	1 treated for CO poisoning	- unlined chimney deteriorated due to condensation of flue gases and became blocked by mortar, debris	M of CCR, FSB

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 82 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
6	2/2/82 NG	Orilla	5 treated for CO poisoning	- unlined chimney deteriorated due to condensation of flue gases and became blocked by mortar, debris	M of CCR, FSB
7	6/3/82 NG	Mississauga	1 death due to CO 3 treated for CO poisoning	- tightly sealed house with inadequate supply of ventilation/combustion air - maladjusted NG conversion burner - unlined chimney - fireplace going - all these resulted in downdraft condition	M of CCR, FSB Chief Coroner's Office Globe and Mail
8	6/3/82 NG	Thunder Bay	2 treated for CO poisoning	- corroded heat exchanger component allowed leakage of combustion products into home	M of CCR, FSB
9	30/3/82 NG	Toronto	5 treated for CO poisoning	- unlined chimney deteriorated and became blocked due to condensation of combustion gases	M of CCR, FSB
10	27/3/82 NG	Mississauga	4 treated for CO poisoning	- chimney liner extended above top and acted as a windscoop resulting in a downdraft condition	M of CCR, FSB

TABLE 20 (Cont'd) PROVINCE/YEAR: ONTARIO 82 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
11	24/9/82 NG	Hamilton	4 treated for CO poisoning	- unlined chimney blocked by mortar and soot - vent connector blocked with rag, paint can lid	M of CCR, FSB
12	16/10/82 NG	Toronto	2 treated for CO poisoning	- restriction in chimney - improper servicing of furnace	M of CCR, FSB
13	21/10/82 NG	Hamilton	Family dog died due to CO ihnalation	- secondary heat exhanger and blower compartment spilt CO into dwelling space	M of CCR, FSB
14	22/11/82 NG	Toronto	8 treated for CO poisoning	- vent connector elbow partially blocked by deflector cone - cracks in fire door allowed spillage of CO into living area	M of CCR, FSB
15	21/11/82 NG	Scarborough	6 treated for CO poisoning	- furnace vent connector separated from chimney	M of CCR, FSB
16	5/12/82 NG	Toronto	3 treated for CO poisoning	- poorly maintained furnace - coil in furnace covered with rust, built up heat which cracked ceramic tiles and allowed spillage of combustion products	M of CCR, FSB

TABLE 20 (Cont'd)

PROVINCE/YEAR: ONTARIO 82 (Cont'd)

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
17	9/12/82 Wood/Oil	Grand Valley	9 treated for CO poisoning	- combination wood/oil furnace improperly installed - crack in heat exchanger allowed spillage of combustion products into home	M of CCR, FSB

TABLE 20 (Cont'd) PROVINCE/YEAR 83

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	8/3/83	Paris	Five CO poisonings	Faulty furnace? No investigation results yet.	Newspaper account
2	3/83	Mississauga	Five months of illness, tightness in chest, misdiagnosed by doctor	In March an inspector was called in. Heat exchanger was found to be corroded through in several places	Personal communication

3.6 Quebec

No good sources of episode information were found despite assistance from many contacts in the province. Nine deaths were described in the episode reports found from 1973 to 1981, while Statistics Canada data for the same period show thirty-eight deaths.

From April 1980 to March 1982, the Quebec Electric and Gas Board investigated 362 cases none of which involved carbon monoxide. All were explosions or firing errors. From April 1982 to March 1983 only one case involving carbon monoxide was reported. The Laboratoire de Police Scientifique Publique in Montreal has investigated deaths due to carbon monoxide, but all were associated with fires.

The Quebec coroner in the Ministry of Justice is not aware of any cases of carbon monoxide poisoning due to the inadequate exhaust of combustion products, neither was the Director General of Fire Prevention in the Ministry of Municipal Affairs. The Quebec Provincial Police could recall episodes of carbon monoxide poisoning in fishing camps but no details were available. No government department was found to be investigating and recording the details of episodes in Quebec.

TABLE 21 REGIONAL STATISTICS - QUEBEC
DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS x10^3	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
2173	2	5	12	32	24	63	38

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
29	7.6

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
19.6	48.2

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
8	7	79	46	8	44	5	3

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
60	47	8	40	31	10	1	2

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

1336.5 (28.5 of total for Canada)

TABLE 22 EPISODES IN QUEBEC

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	9/73	St. Lambert de Levis	Family of six died	Summer cottage. Portable burner generated CO.	Newspaper accounts. The Montreal Star The Gazette
2	4/1/75	Chomeday 11 year old girl	One death due to CO poisoning	Poor combustion in home heating furnace.	Newspaper accounts. The Montreal Star The Gazette
3	2/12/76	Sillery	Fourteen people hospitalized	Carbon monoxide produced by an emergency generator. Building ventilation system in poor condition.	Newspaper accounts. The Montreal Star The Gazette
4	18/2/77	Verdun	Two deaths	Carbon monoxide from gas water heater due to blocked chimney.	Newspaper accounts. The Montreal Star The Gazette
5	27/10/82 Propane	Amos	Two deaths	Propane gas appliance in camper generated carbon monoxide.	Newspaper accounts. The Montreal Star The Gazette
6	28/2/83 NG	Montreal	Five hospitalized	Fan compartment door removed from natural gas furnace. Carbon monoxide circulated through house.	Quebec Electric and Gas Board Montreal

3.7 The Maritimes

There was an almost complete lack of episode descriptions in the Maritimes. The government departments and media sources contacted have no records or recollection of the deaths indicated by Statistics Canada data. Two deaths were described in the report gathered for the period from 1973 to 1981, while Statistics Canada show nineteen deaths.

No mortality or morbidity statistics related to carbon monoxide poisoning in residences were available in Prince Edward Island and no complaints or requests for testing have been registered with the regulatory agency responsible, the Department of Health and Social Services.

In Nova Scotia, the Department of Health was able to produce hospital records that showed twenty general hospital admissions due to carbon monoxide poisoning from 1973 to 1981. Six were due to natural gas, ten to propane and four to other fuels. No deaths occurred in hospital.

No government department was identified in Newfoundland that had jurisdiction over or an interest in carbon monoxide poisoning.

No useful sources were found in New Brunswick government departments.

TABLE 23 REGIONAL STATISTICS - NEW BRUNSWICK

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS $x10^3$	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
215	1	8	7	58	4	33	12

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
34	10.0

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
24.3	33.7

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
1	1	85	60	2	24	12	15

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
65	62	2	23	31	12	2	4

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

145.9 (3.1% of total for Canada)

TABLE 24 REGIONAL STATISTICS - NOVA SCOTIA

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS x10^3	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
273	1	25	2	50	1	25	4

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
30	10.1

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
0.3*	60.1

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
1	1	84	75	3	11	13	13

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
70	75	3	11	27	12	2	3

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($\leq 18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

154.5 (3.3% of total for Canada)

* This low figure is misleading since Nova Scotia did not participate in CHIP until 1982, and previous to that, had an equivalent program.

TABLE 25 REGIONAL STATISTICS - PRINCE EDWARD ISLAND

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS x10^3	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
38	0	0	0	0	0	0	0

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
33	8.7

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
0.4 *	37.6

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
1	1	87	79	1	3	12	18

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
60	79	1	2	37	17	2	3

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

23.6 (0.5% of total for Canada)

* This low figure is misleading since P.E.I. did not participate in CHIP until 1982, and previous to that, had an equivalent program.

TABLE 26 REGIONAL STATISTICS - NEWFOUNDLAND

DEATHS BY ICD #, 1973-81

1981 # OF HOUSEHOLDS x10^3	E867 (NATURAL GAS)		E868.0 (PROPANE)		E868.3 (OTHER FUELS)		TOTAL
	#	%	#	%	#	%	#
148	0	0	1	33	2	67	3

AGE AND CONDITION OF HOUSING STOCK

% Built After 1971	% Requiring Major Repairs
34	7.4

PARTICIPATION IN THE CANADIAN HOME INSULATION PROGRAM (AS OF MARCH 29/83)

Cumulative # of Grants Issued vs. # of Households, expressed as %	% of Grants Involving Air Tightening Measures
50.9	13.3

MAJOR FUELS

Piped or Bottled gas %		Oil or Kerosene %		Electricity %		Other (Wood) %	
1971	1981	1971	1981	1971	1981	1971	1981
0	0	82	51	4	34	13	15

MAJOR HEATING EQUIPMENT

Furnace %		Electrical %		Stove or Space Heater %		Other %	
1971	1981	1971	1981	1971	1981	1971	1981
45	44	4	33	48	20	2	3

POPULATION-WEIGHTED ANNUAL HEATING DEGREE DAYS

Based on 1941-1970 HDD normals ($<18^{o}C$) and 1976 Census.

(Value for Canada: 4685.7)

122.3 (2.6% of total for Canada)

TABLE 27 EPISODES IN THE MARITIMES

NO.	DATE AND FUEL TYPE	LOCATION	DEATHS AND/OR INJURIES	MAJOR CONTRIBUTING FACTORS	REFERENCES
1	Wood	Antigonish, Nova Scotia	CO poisonings	Two woodstoves and furnace operated in a tightly sealed house	Edgar LeBlanc Cooperators Insurance Co., New Brunswick
2	Oil	Bathurst, New Brunswick	CO poisonings	Chimney iced over in cold weather, flue was on the outside of house. Extra insulation solved problem	Dana Watson Imperial Oil Moncton, New Brunswick
3	1979 Gasoline	Moncton, New Brunswick	Two deaths	Gasoline powered generator in basement used as an electrical power backup unit without adequate ventilation	Dana Watson Imperial Oil Moncton, New Brunswick
4	1/82 Kerosene	Moncton, New Brunswick	Two adults and two children suffered CO poisoning on two separate incidents	Smoking kerosene heater used in 12 foot comper used as a residence	Edgar LeBlanc Cooperators Insurance Co., New Brunswick
5	1/83 Kerosene	Yarmouth, Nova Scotia	One death	Faulty kerosene heater	Edgar LeBlanc Cooperators Insurnace Co., New Brunswick

3.8 Responses to the Media Appeals

The overall response to media appeals for information from homeowners was rather disappointing. The only significant responses came from Ontario residents. Not enough information was received to develop a good idea of the number of minor, unreported episodes of carbon monoxide poisoning taking place. However, several classic descriptions of serious episodes were communicated to the researchers by letter and telephone.

Of the nineteen responses received, ten were from parties who had not had a problem but were interested in the subject for a variety of reasons.

Five responses were from people who had experienced serious problems with carbon monoxide and wished to report them.

1. A homeowner sealed the leaks in his house with a government grant in August 1982. In the fall, he went to his doctor complaining of tightness in his chest and was put on medication. He noticed that he felt better when he went away on business trips (He conducts business from his home). In March 1983, a newspaper article gave him the idea of calling to have his furnace inspected. A corroded heat exchanger was found in his 17 year old gas furnace. When a new furnace was installed with an outside air supply his health improved (Mississauga, Ontario).

3.8 Responses to the Media Appeals (Cont'd)

2. A homeowner had a bird trap attached to her chimney. Creosote build-up blocked the top of the chimney within three months, during which time she began to experience aches and extreme fatigue. She did not think to check the chimney until the smoke alarm was triggered one day (Komoka, Ontario).

3. A homeowner and family awoke one night in October 1982, feeling nauseous and vomiting. "On a hunch", the gas company was called. The furnace chimney was found to be plugged with bricks and mortar; there was no liner. In September 1982, a chimney contractor had looked at the chimney and found it acceptable (London, Ontario).

4. A homeowner and family moved into a new house in the summer of 1978. In November of that year members of the family began experiencing headaches and nausea, waking up in the middle of the night vomiting. Four doctors were consulted and each one misdiagnosed the health effects. The mother's condition was described as "hysteria" and "not coping". She began to suspect something in the house as the cause when the family's health improved away from home. The gas company was called in and she asked them to do a test for carbon monoxide. The test was positive and a defective heat exchanger was found to be the cause. The furnace manufacturer installed a new heat exchanger and the problem was solved. She was subsequently told by the city building inspector that at least 20 such defective heat exchangers had turned up in the city (Edmonton, Alberta).

3.8 Responses to the Media Appeals (Cont'd)

5. A group of people went to a house for a long weekend in the fall. After 36 hours of headaches and vomiting all were admitted to hospital and diagnosed as suffering from food poisoning. Returning to the house, the group experienced a further 24 hours of vomiting and unconsciousness. Returning to the emergency department of the hospital a second diagnosis was made correctly. Carboxyhemoglobin levels were measured and the person who reported the episode to this study's researchers had a 43% hemoglobin saturation.

4.0 ANALYSIS

The present study is a retrospective one, and its validity depends on the accuracy of the records examined. These records are of two types:

(a) Statistics Canada data on deaths in Canada, by region, by year and by cause of death, as summarized from death certificates.

(b) Descriptive reports of carbon monoxide episodes by investigators with differing technical abilities and motivations. These reports may have already been summarized and incorporated into lists by different major sources, without the benefit of the uniform reporting and interpretation format employed by Statistcs Canada.

Both types of records are incomplete. Statistics Canada reports deaths that are not accounted for in the descriptive reports and vice versa. The quantity and quality of the data in these records depends on the awareness of the original reporters.

Section 4.1 discusses the important awareness factor in greater detail. Section 4.2 analyzes the data base for significant risks and trends.

Section 4.3 discusses the regional differences that may influence the cause, frequency and severity of episodes.

Section 4.4 discusses public awareness in light of the response to media appeals made in this study.

4.1 Awareness

One factor that stands out in all regions is the importance of government, utility, and public awareness to the ultimate control of the carbon monoxide hazards. There is a great diversity in levels of awareness across Canada, which explains the poor records of episodes kept in some regions.

Even when carbon monoxide episodes are completely documented, researched and understood, a low level of public awareness can frustrate attempts to eliminate the hazard. Government and utility awareness is necessary for the development of good episode records, but it does not guarantee a reduction in the number of deaths and injuries.

The following points apply generally to the issue of government, utility and public awareness across Canada.

(a) In regions of the country where the authorities are aware of, and utility companies are sensitive to, the problem of inadequate exhaust of combustion products, deaths by carbon monoxide poisoning are often but not always investigated. Contributing factors are identified according to the competence of the investigators. When awareness is at a low level or non-existent there is usually no investigation or description of an episode to be found.

(b) Even in regions where the problem has been recognized and corrective steps taken there can be poor communication between authorities which should be informing and helping each other, and between the authorities and the public.

4.1 Awareness (Cont'd)

(c) The death certificate is the basis of Statistics Canada data for carbon monoxide deaths due to the incomplete combustion of domestic fuels. The reliability of the information pertaining to cause of death on these certificates depends on the awareness of the attending physician.

Cameron and McGoogan (Reference #5) have found discrepancies between certified clinical diagnoses and autopsy findings, indicating that attending physicians are not always aware of the true cause of death. In light of such findings, the Statistics Canada data on deaths used in this report should be interpreted cautiously.

(d) Many chief coroners had few, if any, reports of episodes or investigations to match the Statistics Canada data. A coroner's inquest can be the first step towards indepth investigation of an episode by persons qualified to identify major contributing factors. This step is not being taken.

4.1 Awareness (Cont'd)

(e) All regions of Canada have the following Installation Codes which detail the proper procedure for the installation of heating equipment.

Oil	- CSA B139
Natural Gas	- CGA B149.1
Propane	- CGA B149.2
Wood	- CSA B365

There are regional differences in interpretation and enforcement which are difficult to quantify by telephone interview.

(f) Usually when a member of the public has health complaints, has sustained injuries, or has died, a doctor is involved. The awareness of the doctor is crucial to the proper diagnosis of carbon monoxide exposure.

However, carbon monoxide poisoning is diffult to diagnose because the symptoms of nausea, headache, and dizziness resemble the symptoms of many flu-like illnesses or food poisoning.
Two questions immediately come to mind:

1. How many carbon monoxide poisonings have been misdiagnosed? (Episodes not reported.)

4.1 Awareness (Cont'd)

2. In what proportion of reported episodes were symptoms misdiagnosed which, if correctly diagnosed, would have prevented a serious outcome?

Question 1 is partly answered by the response to the media appeals conducted in this study. A small number of unreported episodes were uncovered in which the symptoms had been misdiagnosed. The true number of unreported episodes is still unknown.

In answer to Question 2, there was a small percentage of reported episodes in which misdiagnoses were made that resulted in further occupant exposure, poisoning and/or death. However, the episode reports were not written as medical records with clinical diagnosis in mind, and it is impossible to say how often physicians were involved or what percentage of episodes were preceded by recognizable symptoms. If the examination of a patient suffering carbon monoxide symptoms does not include a test for carboxyhemoglobin and/or the presence of retinal hemorrhages (see Reference #6) a misdiagnosis is quite possible, unless the doctor is aware of the potential for carbon monoxide exposure in homes.

(g) In general the homeowner is not aware of the symptoms of carbon monoxide, or any of the factors that can contribute to the build-up of the gas. The heating system is not something he necessarily understands or thinks to have inspected when he experiences health problems. As a result, episodes of subacute carbon monoxide poisoning may go unreported.

4.2 Episode Analysis

The data was arranged to address the following questions:

1. Who is at risk? When do episodes occur?

2. What is the risk of dying in Canada from carbon monoxide exposure due to the incomplete combustion of domestic fuels?

3. How does the risk vary between regions?

4. Do absolute numbers of deaths correlate with the absolute heating fuel demand created by the climate in each region?

5. What have been the major contributing factors? How severe were the reported episodes?

6. Have episodes been increasing in number?

7. Are the major contributing factors likely to increase in importance and cause an increase in the number of episodes? Which minor factors may become more important in the future?

4.2.1 Risks

There are two different populations at risk, occupants of private dwellings with combustion heating equipment, and users of combustion appliances in a recreational setting. Episodes related to heating equipment occur during the heating season and account for approximately 82% of the episodes in Canada. Episodes related to the recreational setting account for approximately 18% of the episodes in Canada and propane in mobile containers is the fuel involved in most cases.

For example, in Ontario, 28 out of 124 (23%) episodes occurred in a recreational setting. All but one episode involved propane and the majority occurred during the period from May to September. This agrees very closely with the episode timing information contained in Table 28.

As of 1981, 76% of all private households in Canada use a combustion heating system. Excluding the persons living in large apartment buildings and collective dwellings such as nursing homes and jails, approximately 17.0×10^6 persons in Canada are potentially exposed to risk. The number of people exposed to risk only because of their recreational use of propane or their use of supplementary combustion heaters in electrically heated homes should be added to this figure, and the total population at risk will be closer to 19.0×10^6 persons.

During the heating season, the time span for exposure to risk is almost 24 hours a day for the duration of the heating season for those persons, such as mothers and small children, who stay home during the day. Persons attending school or

TABLE 28

CARBON MONOXIDE EPISODE TIMING

Percentage of recorded episodes (1971-1983) vs. month of occurence

	B.C.	Alberta	Prairies	Ontario	B.C.,Alberta Prairies & Ontario
January	15	20	13	17	18
February	11	15	4	8	11
March	7	4	4	7	6
April	7	11	9	5	8
May	0	4	0	6	4
June	0	4	4	6	4
July	4	2	4	3	3
August	0	4	0	4	3
September	4	6	17	9	8
October	11	4	9	10	8
November	7	10	17	10	10
December	33	17	17	14	17

Heating season for most residents October-April:

78% of episodes occur in these months

Recreational Setting for most residents May-September:

22% of episodes occur in these months

4.2.1 Risks (Cont'd)

work are not considered as exposed to the risk of carbon monoxide poisoning in the home for the time that they are away. During the recreational season, exposure time for all persons is confined mainly to weekends and holidays.

The detailed information is not available to precisely define the population at risk and their exposure time, but a conservative Fatal Accident Frequency Rate (FAFR) can be calculated using the available information on deaths due to domestic carbon monoxide exposure from Statistics Canada, the 1976 Census total Canadian population as the population at risk, and an exposure time equal to the total number of hours from 1973 and 1981, the period examined for deaths (see Table 29).

The FAFR is defined as the number of persons who have died out of a cohort of 1000 persons, each exposed to a particular hazard for 100,000 hours.

An example of the calculation for the national FAFR due to the incomplete combustion of domestic fuels is presented below.

$$\text{FAFR} = \frac{\text{deaths (1973-81)} \times 10^3 \text{ (persons in cohort)} \times 10^5 \text{(cohort exposure in hours)}}{\text{population at risk x exposure time in hours (1973-81)}}$$

Making conservative assumptions regarding the population at risk and exposure time terms in the denominator will result in an underestimate of the true FAFR.

4.2.1 Risks (Cont'd)

$$\text{National FAFR} = \frac{238 \times 10^8}{23 \times 10^6 \times 8760 \text{ hours/year} \times 9 \text{ years}}$$

$$= 0.013$$

For involuntary risks to the general public an FAFR below 0.001 is considered acceptable according to Wells, (Reference #7). The FAFR's for the provinces and territories in Canada are displayed in Table 29.

The ranking of regions according to FAFR does not take into account the great regional differences in heating fuel requirements. The territories are identified as high risk areas and this is to be expected considering the demands of the climate, if the assumption is made that the absolute numbers of deaths correlate with the absolute fuel demand. If such a test of the data is made, then poor correlation would indicate that factors other than fuel demand were in action.

This test was made by comparing the carbon monoxide episodes due to heating systems found in the recorded episodes, with population weighted annual heating degree-days, (PWAHDD) which are an excellent indicator of heating demand. Episodes in the recreational setting were not included in the analysis. Table 30 displays the results of this analysis.

TABLE 29

CARBON MONOXIDE DEATHS 1973-81

(Due to the incomplete combustion of domestic heating fuels as identified on death certificates)

PROVINCE	1976 CENSUS POPULATION	ICD CATEGORY E867 NATURAL GAS #	%	E868.0 PROPANE #	%	E868.3 OTHER FUELS* #	%	TOTAL DEATHS	FATAL ACCIDENT FREQUENCY RATE+	RANKING
NFLD	557,725	0	0	1	33	2	67	3	0.007	10
PEI	118,230	0	0	0	0	0	0	0	0	12
NS	828,570	1	25	2	50	1	25	4	0.006	11
NB	677,250	1	8	7	58	4	33	12	0.022	4
QUE	6,234,445	2	5	12	32	24	63	38	0.008	8
ONT	8,264,465	13	19	21	30	36	51	70	0.011	7
MAN	1,021,505	0	0	2	33	4	67	6	0.007	9
SASK	921,325	0	0	9	75	3	25	12	0.017	6
ALTA	1,838,040	19	42	12	27	14	31	45	0.031	3
B.C.	2,466,505	0	0	11	27	30	73	41	0.021	5
YUKON	21,835	0	0	2	50	2	50	4	0.232	1
NWT	42,610	0	0	0	0	3	100	3	0.089	2
CANADA	22,992,600	36	15	79	33	123	52	238	0.013	

* Coal, Coke, Kerosene, Wood
Statistics Canada has no separate class for oil.
It is placed in this class.

\+ For involuntary risks to the general public an FAFR of 0.001 is considered acceptable.
(Reference #7)

TABLE 30

EPISODES VS. FUEL DEMAND

Region	Heating Demand - PWAHDD		Heating Demand Supplied by Combustion	Fuel Demand	Reported Combustion Heating System Episodes	% Episodes/% Demand	
	No.	% of Canada Total	% in 1981	%	% of Canada Total	Index	Ranking
B.C.	368.8	7.9	77	6.0	10.0	1.67	2
Alberta	444.3	9.5	94	8.9	38.5	4.33	1
North	24.8	0.5	90	0.5	0.1	0.20	6
Prairies	514.5	11.0	83	9.1	7.1	0.78	4
Ontario	1550.5	33.1	83	27.4	39.8	1.45	3
Quebec	1336.5	28.5	56	16.0	1.7	0.11	7
Maritimes	446.3	9.5	69	6.6	2.1	0.32	5

4.2.1 Risks (Cont'd)

An index value of 1.00 would suggest that heating system episodes are proportional to heating fuel demand. Large differences from 1.00 would indicate the action of other factors. Unfortunately the most significant factor in this index is that regions with better episode reporting are penalized.

A valid comparison might be made between Alberta and Ontario. Both regions had good episode reporting and the higher index value for Alberta suggests a greater risk there. A look at the contributing factors in Table 31 suggests that greater problems with space heaters and improper installation/lack of understanding may account for the increased risk.

31 CONTRIBUTING FACTORS BY REGION

IMPLICATED IN EPISODE DESCRIPTION

	British Columbia		Alberta		The North		The Prairies		Ontario		Quebec		The Maritimes		Canada	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
# OF DEATHS, % EPISODES INVOLVING DEATH	14	19	45	30	6	100	7	26	59	31	11	67	3	40	145	31
CONTRIBUTING FACTORS																
Collapsed or Blocked Chimneys or Flues, Dislodged or Damaged Vents	4	15	40	38	1	33	2	9	42	34	1	17	1	20	90	31
Downdraft in Chimneys or Flues	12	44	20	19	0	0	4	17	26	21	1	17	2	40	72	25
Inadequate Exhaust of Space Heaters, Appliances	1	4	20	19	0	0	4	17	6	5	1	17	2	40	34	12
Equipment Problems, Defects, Poor Maintenance, Damaged Heat Exchangers	11	41	48	46	1	33	10	43	64	52	2	33	0	0	136	46
Episodes in Recreational Settings	3	11	12	11	1	33	6	26	28	23	2	33	0	0	52	18
Improper Installation of Equipment, Chimneys, Vents/Lack of Understanding	6	22	35	33	1	33	7	30	22	18	2	33	1	20	69	24
Exhaust Ventilation/Fireplace Competing for Air Supply	9	33	8	8	0	0	4	17	10	8	0	0	1	20	32	11
Airtightness of House Envelope/ Inadequate Combustion Air	6	22	16	15	0	0	3	13	25	20	0	0	1	20	51	17
Weather Conditions	0	0	2	2	0	0	0	0	2	2	0	0	0	0	4	1
TOTAL NUMBER OF EPISODE DESCRIPTIONS	27		105		3		23		124		6		5		293	

NOTE: More than one factor can be implicated in an episode

4.2.2 Trends

The major contributing factors identified in the reported episodes are displayed in Table 31. Equipment problems are the most important factor in Canada, followed by chimney or vent damage, downdraft in chimneys and other venting systems, and improper installation/lack of understanding. The major contributing factors are discussed by region in Sections 4.3 to 4.9.

Thirty-one percent of reported episodes involved the death of at least one occupant. There are two reasons for this level of severity. First of all, the episodes involving death are more likely to be reported and second, there is only one order of magnitude separating the carbon monoxide concentration which causes mild discomfort and that concentration which can be fatal.

As can be seen in Table 32, an increase in the number of carbon monoxide episodes due to the incomplete combustion of domestic fuels cannot be demonstrated by the quantity and quality of data acquired in the study. In Table 33 the frequency of implication in episodes, of the four major contributing factors in Canada, are listed by year for the four regions that supplied significant numbers of episode reports. Here too it is difficult to demonstrate an increase in the frequency of factor implication, however, there is evidence that some of these factors may become more important in the future.

TABLE 32

TOTAL NO. OF REPORTED EPISODES BY YEAR

In Regions that supplied significant numbers of episode reports

REGION	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	TOTAL
Britsh Columbia	0	1	2	2	7	3	0	5	2	4	26
Alberta	17	7	10	5	6	19	16	9	5	10	104
Prairies	1	3	0	3	1	2	2	0	3	3	18
Ontario	12	14	12	14	11	9	8	11	14	17	122
TOTAL	30	25	24	24	25	33	26	25	24	34	270

TABLE 33

MAJOR CONTRIBUTING FACTORS BY YEAR

FACTOR	# OF TIMES IMPLICATED IN B.C., ALBERTA, PRAIRIES & ONTARIO '73	'74	'75	'76	'77	'78	'79	'80	'81	'82	TOTAL
Equipment Problems	17	18	9	16	11	18	11	9	7	14	130
Chimney Problems	10	3	8	6	9	12	5	12	6	11	82
Downdraft	1	4	7	12	8	5	5	2	5	11	60
Improper Installation/ Lack of Understanding	10	7	5	3	4	7	8	5	8	12	69
TOTAL	38	32	29	37	32	42	29	28	26	48	341

NOTE: More than one factor can be implicated in an episode.

4.2.2 Trends (Cont'd)

1. Reverse flow of exhaust in chimneys or flues.

This condition is often caused by competing ventilation in houses that have reduced infiltration rates due to design or retrofitting. There are definite steps being taken in Canada to reduce infiltration rates to consume energy. As evidence of this, in the 1982-83 fiscal year the Canadian Home Insulation Program (CHIP) issued 524,466 grants, 188,387 (36%) of which involved airtightening measures such as caulking, weatherstripping and installing vapour barriers. CHIP has issued 1,797,400 grants for a total of $674,062,000 since September, 1977.

Downdrafting is most likely to occur in a moderate climate, in a recently constructed house in good condition, fitted with airtightening measures and a fireplace. A simple probability of downdrafting index can be calculated in the following manner.

$$\text{Probability of Downdraft Index} = \frac{\text{\% of housing built after 1971} \times \text{\% of housing with CHIP grants involving airtightening} \times \text{\% of housing with fireplace}}{\text{\% of housing requiring major repairs}} \times \text{Regional Population-Weighted Annual Heating Degree-Days}$$

4.2.2 Trends (Cont'd)

Table 34 compares the values of this index with the implication rate of downdrafting in reported episodes from the four regions with significant numbers of reports.

The results seem to demonstrate that downdrafting does occur more often in regions with a higher value for a downdraft index which incorporates a measure of the airtightening work done in those regions. Remembering the shortcomings of the database in this retrospective study, such a conclusion is tenous, but would be an interesting starting point for a prospective study.

There are no measurements available which quantify changes in airtightness over the past ten years in a representative sample of Canadian houses, so it is difficult to demonstrate the effect of increased airtightness on carbon monoxide episode rates. However, a recent discussion paper by J. White of the Research Division of the Canada Mortgage and Housing Corporation presents a comprehensive view of airtightness tests done recently across Canada by various agencies.

Contained in the discussion paper is information pertinent to the present study, the ventilation compliance distribution of nearly 200 new houses across Canada. Ventilation compliance (VC) is the slope of the flow versus pressure curve of the house envelope. The greater the flow which can be induced by a given pressure drop across the house envelope, the larger the VC value and the "leakier" the house. It is calculated

TABLE 34

Probability of Downdraft Index Vs.
% of Report Episodes in which Downdraft is
implicated as a Contributing Factor

Region	Downdraft Index	% Downdraft Implicated
Prairies	6.7	17
Alberta	11.2	19
Ontario	26.7	21
B.C.	27.3	44

NOTE: The Maritime region is not included in this table both because of the lack of information on episodes and because the CHIP progrmme, as such, has not applied in two of these provinces.

4.2.2 Trends (Cont'd)

that to prevent downdrafting of the domestic hot water heater/furnace combination when the water heater, furnace, and fireplace are operating simultaneously, the minimum allowable VC for the house envelope should be 10 l/s.Pa. The discussion paper makes it clear that an unacceptably large fraction of houses do not meet this minimum criteria for safety.

Since much of the airtightness data is as yet unpublished, further discussion is not warranted, however, there is one major discrepancy between the discussion paper data and the findings of the current study.

In British Columbia, twenty new houses were tested and found to be the "leakiest" of the nearly 200 houses tested across Canada. None of the B.C. houses had a VC of less than 20 l/s.Pa, suggesting that downdrafting is very unlikely.

However, according to the reported episodes of carbon monoxide poisoning found in the current study, downdrafting was implicated as a contributing factor in 44% of the episodes in B.C., the highest implication rate in any region of Canada for that factor.

2. Collapsed, damaged or blocked chimneys and flues.

Using Ontario as an example, there is a population of poorly constructed chimneys which have been treated to natural gas conversions. The Centre for Research and Development in Masonry has studied chimneys in Alberta and Ontario, and has concluded that a properly con-

4.2.2 Trends (Cont'd)

structed chimney will last for 30 to 40 years with either oil or natural gas. However, many of the chimneys converted to natural gas in Ontario are unlined. Recorded episodes in Ontario demonstrate that many of these chimneys have deteriorated. This population of unlined chimneys will not increase now that the gas companies require liner installations as part of a conversion, but the number of chimney blockages may increase as the exposure time for condensing conditions increases.

3. Inadequate exhaust of unvented space heaters, etc.

Unvented kerosene space heaters have enjoyed an increase in popularity recently. It is perhaps too soon to tell what effect they will have on the number of carbon monoxide poisonings, but the prior history of unvented appliances (eg. propane refrigerators) is not good.

4. Lack of understanding of heating and ventilating system operation on the part of installers, users, etc.

As new technology comes into use the potential for abuse due to ignorance increases. For example, high efficiency condensing gas furnaces have been installed so that water collected in the vent, blocking the path for exhaust. Combustion air supply ducts have been blocked by homeowners to conserve energy.

4.3 Regional Factors

In the following sections, an analysis is made of the contributing factors in carbon monoxide poisonings, based upon the episode descriptions and personal communication with sources in each region. The effect of regional trends on the recorded episodes and the potential for future problems is discussed in light of actions already taken by the authorities, and the technical resources available for control in each region.

4.3.1 British Columbia

Considering that from 1973 to 1981 the use of oil and other liquid fuels dropped from 45% to 25% of the total number of single dwellings while the use of piped natural gas increased from 45% to 55%, it is interesting that no natural gas deaths have been reported. The Gas Safety Branch of the B.C. Ministry of Labour confirms this, although they do have records of a number of poisonings over the same period, attributed to carbon monoxide from natural gas applicances.

The propane deaths are often found in cottages and recreational vehicles where mobile containers are used and regular maintenance is not practiced. The malfunctioning propane refrigerator is a common culprit.

Although 40% of the housing stock in British Colubia was built after 1971, houses are not as airtight as elsewhere in Canada due to the moderate demands of the climate. Chimneys are generally built inside the house, reducing the chances for condensation and deterioration. The moderate climate

4.3.1 British Columbia (Cont'd)

may result in a weaker furnace chimney draft, and the diurnal shift of the wind affects chimney draft in those houses built on steep slopes, typical of parts of the B.C. coast.

Supplementary heating equipment is found in approximately 25% of British Columbia households, close to the national average. Portable electric heaters account for approximately one half of this equipment. Fireplaces are found in 47% of British Columbia households, twice the national average and the highest installation rate in Canada. Since an operating fireplace represents the greatest single demand on the air supply in a house, this is an important contributing factor.

Provincial building regulations detail the requirements of the Gas Safety Branch for combustion and ventilation air supply ducts for gas appliances. The GSB has also drawn the attention of the public and media to the air demands of fireplaces.

The potential for continued problems with carbon monoxide seems to lie with the high percentage of "other fuels" episodes, for which very little information was found in this study. Much depends on the abilility of the local authorities to address the hazard in a coordinated manner, making use of the technical resources available in the province.

4.3.2 Alberta

In view of the complete dominance of natural gas as the principal heating fuel (90%), the fact that propane and other fuels together account for 58% of the deaths (Statistics Canada) indicates that the incidence of carbon monoxide deaths does not simply follow fuel demand.

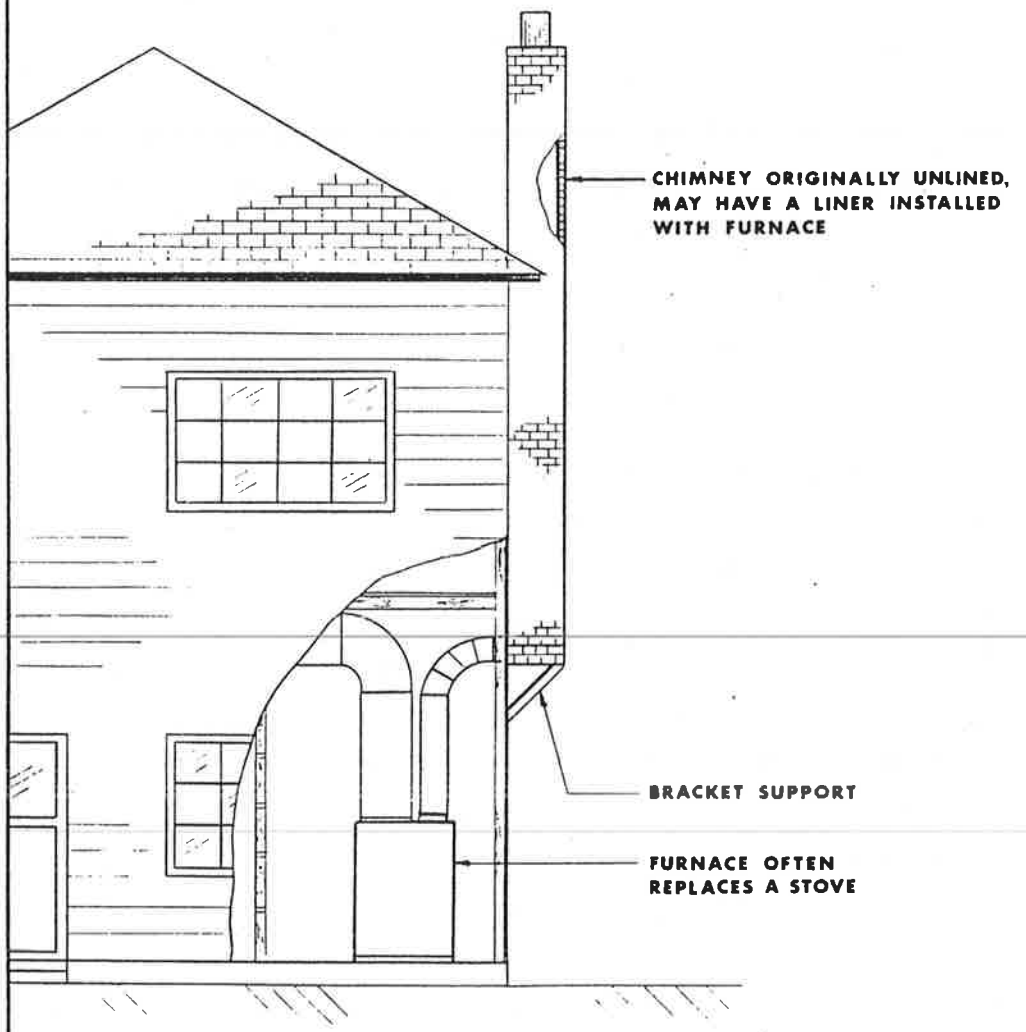
Only 16% of Alberta households use supplementary heating equipment and of those that do, two thirds are electric heaters. Approximately 23% of Alberta households have fireplaces, slightly less than the national average. The climate demands that houses be well sealed and insulated.

A major contributing factor found in episodes investigated by the Gas Protection Branch (GPB) was collapsed, blocked, dislodged and otherwise damaged chimneys, flues and vents. Out of 37 episodes involving chimney problems 19 (50%) were due to unlined masonry chimneys and bracket chimneys. Bracket chimneys are an old, poorly conceived design in which the chimney, usually brick and sometimes unlined, starts from and is supported by a bracket attached to the house approximately 1 metre below kitchen ceiling level. There is often no room to attach a cleanout door and little leeway for debris to build up before the vent is blocked (see Figure 1).

The Centre for Research and Development in Masonry, Calgary, maintains that chimney problems are not a major factor in Alberta since there are more metal chimneys than masonry ones and the masonry chimneys are well constructed. The discrepancy may be explained by the fact that, although bracket chimneys figure in many of the episodes described by the GPB, the contact at the Centre was not familiar with this chimney type.

BRACKET CHIMNEY DESIGN

FIGURE NO. 1



OFTEN FOUND IN HOUSES WITHOUT BASEMENTS

4.3.2 Alberta (Cont'd)

Other major contributing factors found by the Gas Protection Branch were equipment problems due to damage, defects or poor maintenance, and improper installation or lack of understanding. Although almost half of the housing stock (47%) has been built since 1971, airtightness was not implicated as a major factor.

There has been an Alberta Supreme Court case involving carbon monoxide from a furnace which killed a doctor in 1971. This case is described in Section 3.2, Table 9. Other cases are before the courts at present and for legal reasons the authorities involved do not wish to release their episode information.

4.3.3 The North

Heating requirements are very high in the Yukon and Northwest Territories. The heating season is the longest in Canada and infiltration rates are high. The movement of the permafrost causes structures to shift and develop cracks. Chimneys are usually prefabricated metal and icing of flues does occur. Woodstoves are common well below the tree line and portable liquid fuel heaters are widely used. Over 50% of the housing stock has been built since 1971.

The potential for future problems depends upon changes in housing construction in the north. If methods are used to prevent structural damage from permafrost shifting then the airtightness of houses can be maintained. This will reduce the margin of safety that presently prevents a larger number of carbon monoxide deaths from occuring in a region of Canada that uses the greatest amount of heating fuel per capita.

4.3.4 The Prairies

Approximately 30% of the housing stock on the prairies has been built since 1971, close to the national average. The use of oil and other liquid fuels has dropped approximately 20% to similar levels in both provinces. Fireplaces are not common in the prairies, being found in less than 15% of all households. Supplementary heating equipment is found in 24% of all households and 80% of these are portable electric heaters.

The preponderance of propane deaths in Saskatchewan is confirmed by information from the Gas Safety Unit of Saskatchewan Labour. Out of a total of seven episodes on file, five involve propane used in a recreational setting such as cottage or trailer. Propane gas refrigerators were featured in three of the episodes, propane heaters in the other two.

The Gas Safety Unit does not keep records of episodes which did not result in death or injury. They note that episodes of natural and propane gas furnaces and water heaters producing carbon monoxide as a result of poor maintenance are not uncommon and that there have been numerous discoveries of defective combustion chambers, some resulting in the production of carbon monoxide. In only one case was downdrafting in a gas furnace chimney the cause of a carbon monoxide buildup, and the removal of the circulating fan chamber door was identified as the major contributing factor.

4.3.4 The Prairies (Cont'd)

In Saskatchewan the authorities are aware of carbon monoxide poisonings, and although they do not have information on all deaths indicated by Statistics Canada, the technical resources exist within the province to deal with the problems. Propane deaths in the recreational setting may require a consumer education campaign.

In Manitoba, the Statistics Canada data point to other fuels as the most frequent cause of death followed by propane, then natural gas. The episode reports indicate the reverse, natural gas has the most frequent involvement, followed by propane, then oil. This demonstrates the danger of making conclusions based on small sample sizes. Poor maintenance, improper installation and lack of understanding are mentioned as contributing factors in the majority of cases. Three out of sixteen episodes involved downdrafting due to fireplace use.

The authorities are aware of carbon monoxide poisonings in Manitoba although their records cannot account for the majority of deaths indicated by Statistics Canada data.

4.3.5 Ontario

From 1972 to 1982 the use of oil and other liquid fuels in Ontario declined from 54% to 32% while the use of piped natural gas increased from 37% to 48%. Fireplaces are found in 25% of households and supplementary heating equipment is found in 74% of households. Portable electric heaters comprise two thirds of this equipment.

About 30% of Ontario's housing stock has been built since 1971, close to the national average. The majority of Ontario households, located in Southern Ontario, experience a moderate climate. Only the southern part of British Columbia and the west coast have a lower annual degree-days total. The moderate climate reduces heating requirements but also results in a weaker furnace chimney draft. The northern parts of Ontario, however, have much more severe winters.

A report from the Centre for Research and Development in Masonry indicates that chimney design and construction are often inadequate in Ontario. Chimneys are frequently built on an outside wall with three sides exposed. Liners are not always used, and when they are, construction methods sometimes allow the gases to leak into the outside cavity of the chimney. Condensation and freezing of the mortar ensues, resulting in chimney damage and sometimes blockage. Fuel Safety Branch data identify collapsed or blocked chimneys or flues as contributing factors 42 times out of a total of 124 investigations. Although properly constructed masonry chimneys can perform well with either natural gas or oil, there are more problems with unlined natural gas chimneys.

4.3.5 Ontario (Cont'd)

Setting aside the propane refrigerator episodes, the major contributing factors found in investigations by the Fuel Safety Branch were collapsed or blocked chimneys and flues, equipment problems due to damage, defects or poor maintenance, and the airtightness/competition for air supply/downdraft scenario. Unlined or improperly lined chimneys on natural gas furnaces account for approximately one third of the damaged chimney episodes.

The potential for continued problems with carbon monoxide lies with several factors. Conversions to natural gas will continue to take place, as will efforts to reduce air infiltration. A significant population of poorly designed chimneys will continue to cause problems. Houses with combination heating systems will require special attention to prevent the problem of insufficient flue temperatures, due to short duty cycles.

It is apparent from this study that even in a province where there has been considerable media and government attention to the problem, homeowners and doctors are not well aware of the danger, or the characteristic symptoms of domestic carbon monoxide poisoning.

4.3.6 Quebec

Piped or bottled natural gas is used as the principal heating fuel in less than 10% of private dwellings in Quebec and this has not changed significantly from 1971 to 1981. However, oil and kerosene use has dropped from 79% to 46% and electricity use has increased from 8% to 44% in the same period. Due to an increase in the total number of dwellings, the drop in absolute numbers of households using oil is not as great as is suggested by the percentages and it is not clear if there has been a significant drop in deaths related to other fuels (oil, kerosene, wood) during this period.

Supplementary heating equipment is used in 28% of Quebec households. Wood stoves make up approximately 50% of this equipment, portable electric heaters, 40%. Fireplaces are found in 17% of Quebec households, less than the national average.

Episodes involving propane almost always occur in a recreational setting where mobile containers are used and regular maintenance is not practised. Information on episodes involving other fuels was not available from any source. No government department was found that has endeavored to stay abreast of the issue.

Although the trend in Quebec is to switch from oil to electricity, the low level of awareness and continuing efforts to reduce air infiltration are a source of potential problems in the future. Availability of natural gas is increasing rapidly, and information to increase awareness on potential hazardous conditions should be disseminated as soon and as widely as possible.

4.3.7 The Maritimes

Oil or kerosene is the major fuel in 51-79% of Maritime households, depending on the province. Natural gas is used in less than one percent of households. The use of wood and coal is higher than anywhere else in Canada with the exception of the Yukon. Approximately 15% of Maritime households use wood or coal as a principal heating fuel, an increase in both absolute numbers and percentage in the last ten years.

Considering percentages only, the trend has been to move from oil to electricity. However, due to population increases the absolute numbers of residences using oil has increased in Prince Edward Island and Nova Scotia.

Approximately 35% of Maritimes' households have supplementary heating equipment, the highest usage among the provinces. Wood burning stoves account for half of this equipment.

Houses in the Maritimes are older on average and require more major repairs than elsewhere in Canada.

Considering the possibility of natural gas from the east coast being widely distributed throughout the Maritimes, it is very important that the local governments become aware of and take actions to prevent a repeat of the problems which have occurred elesewhere in Canada. More than one source expressed concern about the construction and condition of chimneys. Whether the older housing stock can be retrofitted to the point where airtightness is a problem is not known. Certainly any new construction associated with an "oil boom" will have much lower infiltration rates.

4.4 Responses to Media Appeals

The results of the Ontario media campaign make it clear that public awareness of the problems addressed by this study is still quite low, even in a province where there has been a significant amount of media attention to several carbon monoxide deaths. First of all, the response was very light, and second, those that did respond knew nothing about the potential problems unless they had been learned through experience. The authorities are well enough coordinated to produce a comprehensive list of investigated episodes and the utilities have an understanding of the problems and policies for dealing with them. Both government and utilities have produced and distributed consumer pamphlets. However, within the last six months incidents have taken place that demonstrate a lack of awareness on the part of the homeowner, and sometimes the family doctor, of the potential for and symptoms of carbon monoxide poisoning in the home.

This lack of awareness may be understandable in light of the low number of deaths compared to other more visible hazards. Also, the symptoms of carbon monoxide poisoning are easily confused with those of a cold or flu, and are not likely to cause a homeowner to suspect his heating and ventilating system unless he has previous knowledge of the potential hazard.

5.0 CONCLUSIONS

1. Virtually all reported episodes of hazardous heating and ventilating conditions due to the inadequate exhaust of combustion products have featured carbon monoxide as the agent.

2. Reports were compiled for 293 episodes of carbon monoxide poisoning, including 145 deaths, for the period from 1973 to 1983.

3. Statistics Canada data based on death certificates show 238 deaths due to the incomplete combustion of domestic fuels from 1973 to 1981.

4. A conservative calculation of the Fatal Accident Frequency Rate (FAFR), using Statistics Canada data, results in a FAFR of 0.013. A FAFR of 0.001 has been proposed by safety experts as acceptable for involuntary risks to the general public.

5. The major contributing factors in Canada, as identified in the episode reports, were:

   - Equipment problems due to poor maintenance, damage and defects. (implicated in 46% of episodes)

   - Collapsed, blocked, dislodged or damaged chimneys, vents and flues. (31%)

   - Downdrafting of furnace gases in chimneys, vents and flues due to excess exhaust, inadequate air supply, and airtightness of the house envelope. (25%)

5.0 CONCLUSIONS (Cont'd)

- Improper installation of equipment, chimneys, vents and flues. Lack of understanding of combustion equipment operation and the potential problems associated with improper operation. (24%)

6. The data acquired in the study do not demonstrate an increase in the rate of domestic carbon monoxide poisoning in the last ten years, however, each of the major contributing factors has the potential to increase its influence in the future.

   - Emergence of new technology with new equipment problems e.g. improper use and maintenance of unvented kerosene space heaters.

   - Deterioration of existing substandard chimneys.

   - Continuing steps towards airtightness.

   - Lack of steps taken to increase awareness of the potential for problems.

7. The major contributing factors in British Columbia are equipment problems and chimney downdraft due to fireplace operation. The major contributing factors in Alberta and Ontario are equipment problems and chimney damage. The major contributing factors in the Prairies are equipment problems and improper installation/lack of understanding. Data from other regions in Canada were insufficient to identify major factors.

5.0 CONCLUSIONS (Cont'd)

8. Significant regional biases identified include:

   (a) British Columbia's high fireplace use and high percentage of "other fuels" episodes.

   (b) Alberta's high percentage of heating system episodes vs. the percentage of heating fuel demand.

   (c) The North's lack of episode descriptions in light of a high FAFR for carbon monoxide deaths due to the incomplete combustion of domestic fuels.

   (d) The high percentage of propane related deaths in a recreational setting in the Prairies.

   (e) Ontario's unlined chimney population and propane refrigerator episodes.

   (f) Quebec's high electricity use and lack of episode descriptions. No government department found to be following the issue. Statistics Canada data could not be explained by officials.

   (g) The Maritime's high use of supplementary heating equipment and lack of episode descriptions. No government department found to be following the issue. Statistics Canada data could not be explained by officials.

5.0 CONCLUSIONS (Cont'd)

9. In British Columbia, Alberta, Saskatchewan and Ontario, actions such as regulations and consumer information campaigns have been undertaken to varying degrees. These provinces also have technical resources available locally. Manitoba, the North, Quebec and the Maritimes seem to have no technical resources and no coordinated action to address the problem.

10. Carbon monoxide episodes in a recreational setting account for 18% of all episodes in Canada and 23% in Ontario from 1973 to 1983. The majority of these episodes involved propane refrigerators. After the release of a consumer information pamphlet in 1974 by the Ontario Ministry of Consumer and Commercial Relations, the number of propane refrigerator, carbon monoxide episodes dropped in Ontario from 2-4 per year from 1973 to 1977 to 0-1 per year from 1978 to 1982.

11. There were great differences in the quality and quantity of provincial records of carbon monoxide poisonings. These differences appeared to reflect the level of awareness of the problem in each region.

12. Hundreds of contacts across Canada are now aware of the carbon monoxide hazard in housing as a result of this study.

REFERENCES

1. Casarett, L.J. and John Doull, editors, TOXICOLOGY, The Basic Science of Poisons, Macmillan Publishing Co., Inc., New York 1975.

2. Documentation of the Threshold Limit Values, 4th edition, American Conference of Governmental Industrial Hygienists Inc., Cincinnati, Ohio, 1980.

3. Criteria for a Recommended Standard ... Occupational Exposure to Carbon Monoxide, National Institute for Occupational Health and Safety, Rockville, Maryland, 1972.

4. Hamilton, A. and H.L. Hardy, Industrial Toxicology, 3rd edition, PSG Publishing Co., Inc., Littleton, Massachusetts, 1974.

5. Cameron, H.M. and E. McGoogan, A Prospective Study of 1152 Hospital Autopsies, Section I, Inaccuracies in Death Certification, J. Pathology, Vol. 133, pp 273-283, 1981.

6. Kelley, J.S. and G.J. Sophocleus, Retinal Hemorrhages in Subacute Carbon Monoxide Poisoning, Exposure in Homes with Blocked Furnace Flues, JAMA, Vol. 239, pp 1515-1517, April, 1978.

7. Wells, G.L., Safety in Process Plant Design, John Wiley and Sons, New York and Toronto, 1980.

8. Primeau, R.J. and H. Morestead, Chimney Retrofits due to Fuel Changeover, prepared for Ontario Ministry of Municipal Affairs and Housing, ISBN 0-7743-7054-8, Toronto, Ontario, Canada 1981.

REFERENCES (Cont'd)

9. Taylor, B.L., Population-Weighted Heating Degree Days for Canada, Atmosphere and Ocean, 19(3), pp 261-268, 1981.

10. Steel, F., Airtight Houses and Carbon Monoxide Poisoning, National Research Council Canada, CBD 222, 1982.

11. Steel, F., Domestic Chimneys and Gas Vents, National Research Council Canada, CBD 217, 1981.