hourly employees and the start of programs for salaried employees encouraging early retirement and separation from the corporation.[10] The number of inactive employees (retirees and surviving spouses) grew twice as fast as the active workforce. Dependents, who comprise over half of the GM population,[7] accounted for much of the growth. The number of spouses grew for all employee types except active salaried employees, and grew very rapidly, nearly 3.5 percent per year. In contrast, the number of children hardly grew at all.

Discussion

This is the first study to examine demographic change in a population provided health benefits by a major corporation. It has documented rapid growth, faster than in the US, in this large group. If current trends continue, this population will become larger, older, and have a greater percentage of women.

National health care utilization statistics[11–12] suggest that these demographic changes alone increased GM hospital days of care by 10 percent and physician visits by 7 percent from 1983 to 1987. Consequently, it is not surprising that GM's health care costs rose from $2.2 billion in 1983[5] to nearly $3 billion in 1987.[6]

The trends identified in this study may or may not predict future demographic conditions. Future investigations should estimate the impact on growth rates of employment conditions, sociodemographic processes influencing population growth, and administrative changes.

This study has found that despite increased employment, dependents, particularly spouses, were responsible for most of the population growth. This finding demonstrates that much remains to be learned about how individuals, particularly nonworkers, become eligible for employer-sponsored health coverage. Case studies of employers, such as this one, can illuminate findings from general population surveys about the link between employment and health care coverage.[13] In response to potential legislation that increases the cost of health benefits, employers could pay more attention to who is eligible for these benefits in their efforts to provide cost-effective coverage.

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Fatal Unintended Carbon Monoxide Poisoning in West Virginia from Nonvehicular Sources

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Abstract: Based on medical examiner reports and state vital records, 1978–84, nonvehicular carbon monoxide (CO) caused 62 unintended deaths, representing 42 percent of all unintended fatal CO poisonings in West Virginia. Sources were almost always heating or cooking appliances associated with incomplete combustion of fuels (methane, butane, or propane) not commonly recognized for their potential to produce CO. Hazards included failure to provide recommended venting, neglected maintenance, or use in small areas without natural ventilation. (*Am J Public Health* 1989; 79:1656–1658.)

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Introduction

Carbon monoxide (CO) is the agent most often responsible for fatal, unintended poisoning in the United States.[1] Motor vehicle exhaust causes the majority of cases, but a substantial number occur in domestic or recreational settings[1] where sources are not adequately identified in national mortality statistics[2] or by death certificate review.[3] While heating appliances are recognized as important sources of CO exposure,[3–9] their overall role and specific hazards have not been carefully examined in a population-based study.

Using data obtained principally from the Office of the Chief Medical Examiner (OCME), we have reviewed all deaths in West Virginia attributed to unintended CO exposure from nonvehicular sources during a seven-year period.

Methods

The West Virginia Medical Examiner has jurisdiction over all homicidal, suicidal, accidental, and unattended natural deaths in the state and maintains a centralized case record file. When indicated, analyses for blood alcohol concentration (BAC) and percent carboxyhemoglobin (COHb) are performed by standard methods.[10,11]

We reviewed the files for the period 1978–84 to identify all certified unintentional deaths attributed to CO from nonvehicular sources, excluding uncontrolled fires. We also reviewed vital statistics for in-state deaths coded "accidental poisoning from gases and vapors" during 1978 (ICD-8 codes E870-7) and 1970–84 (ICD-9 codes E867-9) to identify any additional unintended, nonvehicular CO deaths not reported to the OCME. Data recorded included each victim's age, sex, BAC, and percent COHb, along with date and place of death, and the alleged CO source. Hazards identified at the site of exposure were recorded from information either in the OCME record or acquired through special request to local police or fire departments.

Results

From 1978–84, there were 62 unintentional deaths in West Virginia attributed to CO from nonvehicular sources (two were recorded by vital statistics alone). These deaths occurred in 38 domestic episodes (51 deaths) and in seven recreational settings (11 deaths). On the death certificates, 31 (50 percent) fatalities were not specifically attributed to CO and one was mistakenly associated with motor vehicle exhaust (Table 1).

Postmortem COHb was measured in 47 victims and ranged from 50–88 percent. For eight victims who were not tested, death from CO was determined by association with confirmed cases (three deaths), by CO-positive environmental samples (three deaths), or by elevated premortem COHb (two deaths). For seven remaining victims, CO was assumed the cause based on observations at the scene.

Fatal episodes increased sharply in the fall and peaked during the winter (Figure 1). The male to female victim ratio was almost 4:1 (Table 2). Death rates were highest in young adults and the elderly. Blood alcohol was tested in 40 (70 percent) of the 57 victims ≥15 years of age. Nine (22.5 percent) tested positive, with BAC ranging from 2–46 mmol/L; only three (7.5 percent) had levels consistent with legal intoxication (22 mmol/L).

Residential Settings

Furnaces or space heaters were implicated in 34 (89 percent) of the 38 residential episodes. Cooking ranges were the source of CO in three (8 percent) episodes and a generator was the source in one. Thirty-six units (94 percent) were fueled by natural gas (methane) or butane (only one unit). Table 3 shows that on-site investigations found hazards related to:

- installation of large volume furnaces dependent on direct venting of combustion products to the outside;

TABLE 1—E-Code Classifications on 62 Death Certificates for Unintentional CO Poisoning from Nonvehicular Sources, West Virginia, 1978–84

E-code	Description of Accidental Poisoning	Deaths
ICD-8*		
874	CO from incomplete combustion of domestic fluids	4
875	Other CO	1
ICD-9**		
867	Gas distributed by pipeline	1
868.0	Liquefied petroleum gas in mobile containers	4
868.1	Other and unspecified utility gas	26
868.2	Motor vehicle exhaust gas	1
868.3	CO from incomplete combustion of other domestic fuels	22
868.8	CO from other sources	1
868.9	Unspecified CO	2

*in use for 1978
**in use for 1979–84

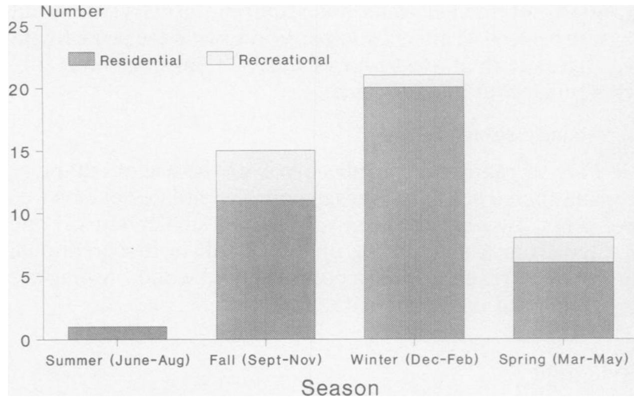

FIGURE 1—Fatal Unintentional Carbon Monoxide Poisonings in Residential and Recreational Settings by Season, West Virginia

TABLE 2—Deaths from Unintentional Nonvehicular CO Exposure by Age and Sex of Victim, West Virginia, 1978–84

	Deaths			
Age (years)	Male	Female	Total	Rate*
0–14	3	2	5	1.6
15–24	13	3	16	6.6
25–44	15	3	18	5.0
45–64	10	3	13	4.7
>65	8	2	10	6.0
All ages	49	13	62	4.5

*Deaths per 1,000,000 population per year

TABLE 3—Cause of Hazard and Fuel Responsible for Fatal Unintentional Exposure to CO from Nonvehicular Sources by Setting, West Virginia, 1978–84

Setting and Cause of Hazard	Episodes	Fuel
Residential		
Faulty installation		
Failure to install or connect vent	4	Methane (4)
Vent obstructed during installation	3	Methane (3)
Faulty vent design	3	Methane (3)
Neglected maintenance		
Burner malfunction from accumulated debris or faulty adjustment	5	Methane (4), Butane (1)
Damaged vent*	4	Methane (4)
Use in sealed or confined enclosure	13	Methane (12), Kerosene (1)
Miscellaneous	1	Gasoline (1)
Not identified	5	Methane (5)
Recreational		
Use in confined enclosure	7	Butane (2), Propane (3) Charcoal (1), Wood (1)

*Includes combustion product leakage through loose indoor vent joint (three episodes) or backflow caused by downdraft from corroded exterior vent segment (one episode).

- use of smaller units not requiring direct venting but operated in closed rooms. Windows were sealed with plastic in at least four of these 13 episodes;
- neglected maintenance.

Recreational Settings

Five recreational episodes involved the use of butane or propane-fueled heating stoves in poorly ventilated enclosures (two tents, two recreational vans, and a cellar house); one resulted from a smoldering charcoal grill in a recreational van; and one resulted from a poorly vented wood-burning fire in an enclosed outdoor shelter.

Discussion

Despite the elimination of CO from domestic gas since the 1940s and '50s with conversion to natural gas, and the widespread use of other clean burning fuels, domestic and recreational CO exposure remains an important health hazard in West Virginia, contributing 62 (42 percent) of the 149 unintended CO deaths from 1978 through 1984; 87 deaths from motor vehicle exhaust were described earlier.[12] Alcohol use was not a common predisposing factor in these exposures as it was for exposures to motor vehicle exhaust. For surveillance purposes, coded death certificates alone grossly underestimate the problem in nonvehicular settings.

While each of these episodes reflects some failure to adequately remove CO from the living or recreational environment, the vast majority are associated with fuels not commonly recognized for their potential to produce CO.[13] Unlike cruder fuels (gasoline, kerosene, wood, and coal), methane, butane, and propane normally undergo complete combustion in the presence of sufficient oxygen, producing nontoxic carbon dioxide and water vapor.[14] In most instances, CO production by these fuels had at least one obvious explanation:[14]

- operating small volume, unvented gas-burning heaters in closed spaces without natural ventilation (e.g., open windows) for replacing depleted oxygen;
- inadequate venting (removal) of combustion products, displacing oxygen from the ambient supply and/or preventing adequate air flow to the burners. While this was usually associated with faulty installation, it occasionally reflected long-term use and neglected maintenance;
- neglecting to adjust or clean burners, causing inadequate mixing of oxygen and fuel in the combustion chamber.

Prevention therefore depends largely on assuring proper function and appropriate use of gas-burning applicances and can be achieved by professional installation, annual servicing, and education to avoid burning fuels in confined or tightly sealed enclosures. A coordinated educational and inspection program involving health departments, gas companies, and appliance distributors—conducted in the late summer and early fall—would be desirable. Because there is a tendency to conserve heat by closing or sealing windows, terminating the production of unvented units has also been suggested.[7]

Nonlethal CO exposure is a significant health hazard[4,6,7] that can be overlooked when symptoms of headache, nausea, vomiting, and malaise are attributed to other conditions. Several reports of fatalities among persons who had previously consulted a physician[8,9,13] suggest that health care providers can help to identify homes with a CO hazard by recognizing symptoms of exposure.

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