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Accidental Carbon Monoxide Poisoning and Its Prevention

1. Introduction

Accidental carbon monoxide poisoning is common in countries in the temperate and frigid zones, particularly in the snowy winter season; this poisoning is a major cause of accidental deaths[1,2]. Taiwan is in the sub-tropical zone, as warm as spring time throughout the year, with the lowest average temperature, 15°C, found in January. Carbon monoxide poisoning should never occur in such a warm country, yet statistics of the Department of Health[3] show that in 1989 alone, 85 persons died on the Island of carbon monoxide poisoning, and the number of cases of intoxication from the gas could have been many times more. Taiwan has its unique weather patterns, and carbon monoxide poisoning is related to those. This report investigated the relationship and suggests ways to prevent such poisoning.

2. Methods and Materials

Persons who had telephoned the Toxicology Counseling Center of Veterans General Hospital for information on carbon monoxide poisoning between 1 December 1986 and 31 December 1991 were studied, retrospectively. A carbon monoxide case was defined based on a typical history of exposure, symptoms and abnormal increase in the carboxyhemoglobin concentration in blood (i.e., higher than 3%). All suicide cases were excluded. For all case the age, sex, date of poisoning and source of carbon monoxide were recorded. For some cases, the environment was also investigated to identify the cause and source of poisoning.

Weather information in and around the Taipei areas during the study period was supplied by the Central Weather Bureau. Data included average daily temperature, air pressure relative humidity, visibility, wind speed, cloudiness and amount of rain. The time at which special weather conditions — such as typhoon, cold front, cold currents — attacked Taiwan was also recorded. "Typhoon" can most simply be described as a tropical air current originating from low pressure areas in the South Pacific; this condition brings heavy wind and rain to Taiwan, usually in summer and early autumn. A "front" is the contact surface of various pressure belts, and cold fronts from mainland

China often visit Taiwan in autumn and winter. The weather changes, with rapid temperature drops, even more so when there is also rain. If ground temperature drops by 4°C in 48 hours, or if the lowest temperature recorded in Taipei is lower than 10°C, the cold front is called a "cold current".

The first and the twentieth days of the month were designated as "control days". The weather information for the days when poisoning cases occurred, and that on the control days was compared and statistically analyzed.

3. Findings

In the period between 1 December 1986 and 31 December 1991, there were 133 carbon monoxide poisoning cases in 65 separate events. On an average, there were two victims per event. The events, shown by month in Fig. 1, occurred primarily in winter and early spring (77.8% in December through April). By age, most of the victims were young (92% younger than 40 years; see Fig. 2). As to sources of carbon monoxide, 117 persons in 58 events (or 89% of the total events) were victims of bathroom accidents prompted by incorrect use of gas water heaters. Thirteen cases in five events (7.7%) were caused by improper use of gas stoves; of these, three events occurred in January. The remaining two events came from vehicle exhaust.

Weather information is shown in Table 1. The two groups (control days and days-of-events) differed significantly in the average temperature and air pressure (Student's T-test $p<0.005$). The prevalence rate of carbon monoxide poisoning from inappropriate use of gas water heaters or gas stoves was significantly related to the time of either cold front or cold current (χ^2, $p<0.001$, Table 2). At the time of either, the rate of carbon monoxide poisoning was 3.54 times of that in any ordinary day. Carbon monoxide poisoning was found not to be related by typhoon.

4. Discussion and Conclusion

Carbon monoxide is a colorless, odorless, tasteless and non-stimulating gas; it is a product of the incomplete burning of carbonaceous organisms. Carbon monoxide associates strongly with hemoglobin in the bodies of humans, thus impairing the normal oxygen-transporting function of hemoglobin, leading to dysfunctioning of cell tissues because of a lack of oxygen. Carbon monoxide, therefore, is a highly toxic gas[4]. In the temperate and frigid zones, people often burn wood, coal or natural gas in poorly ventilated rooms in cold weather; carbon monoxide poisoning is the first cause of accidental poisonings. In a place like Taiwan, open stoves are now seldom used for warmth; most carbon monoxide poisonings (90%) result from misuse of gas water heaters, with at least two victims in any one event. Investigations of the poisoning sites showed that the water heater was located either in the bathroom, or on a closed balcony with windows. In the colder weather of winter and early spring, windows are shut ventilation is poor and the fatal carbon monoxide produced by gas water heaters brings about accidental poisoning. In some summer-time poisoning cases, it was found that

the heater was placed next to air-conditioner air pipes. When both were used at the same time, the waste gas could go through the air pipe into the closed room to cause poisoning. In fact, it appears that many more such deaths occurred than were reported as such to the Toxicology Counseling Center, and were thus not included in the present study.

Literature[5] shows that carbon monoxide poisonings, even for different reasons, occur primarily in two different age groups: younger people are more often the victims of bathroom accidents because of careless use of gas water heater, accidents resulting from use of stoves for heating, rooms on the other hand, are reported more often for the elderly.

Data, however, show that carbon monoxide poisonings in Taiwan are highly related to sudden temperature drops. The frequency of poisoning at the time of cold front or cold currents is 3.54 times more than on ordinary days (see Table 2). Take, for instance the month of January in 1990 (Figure 3): when the cold current came and the temperature dropped sharply, more carbon monoxide poisonings occurred, with doors and windows closed and more use of water heaters and gas stoves. In the United States, health authorities alert people to the risk of carbon monoxide poisoning through use of posters and TV commercials at times of snowstorms, with some effect. Immigrants, however, often with less good knowledge of the English language, tend to have more accidents. Similarly, literacy can be a problem in Taiwan, too. Though there are no snowstorms, accidental carbon monoxide poisoning can be linked to cold weather. Such poisoning can be prevented by:

1) encouraging the public to ensure that gas water heaters are installed in well-ventilated outdoor places, never in a bathroom; dealers, while installing the heater, should responsibly advise clients of the importance of ventilation. Gas water heaters should never be placed next to air pipes to avoid poisoning in closed rooms, particularly in warmer weather when air conditioners are in use.

2) urging the mass media, particularly during the winter and early spring when cold fronts and cold currents are more prevalent, to educate about, and warn the public of, the dangers of carbon monoxide poisoning.

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Figure 1. Monthly Distribution of CO Intoxication
(Dec. 1986 ~ Dec. 1991)

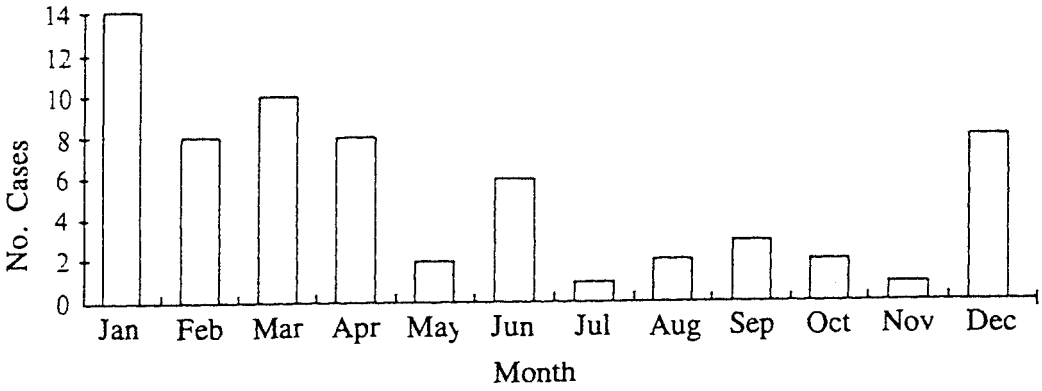

Figure 2. CO Intoxication. Age-Sex Distribution
(Dec. 1986 ~ Dec. 1991)

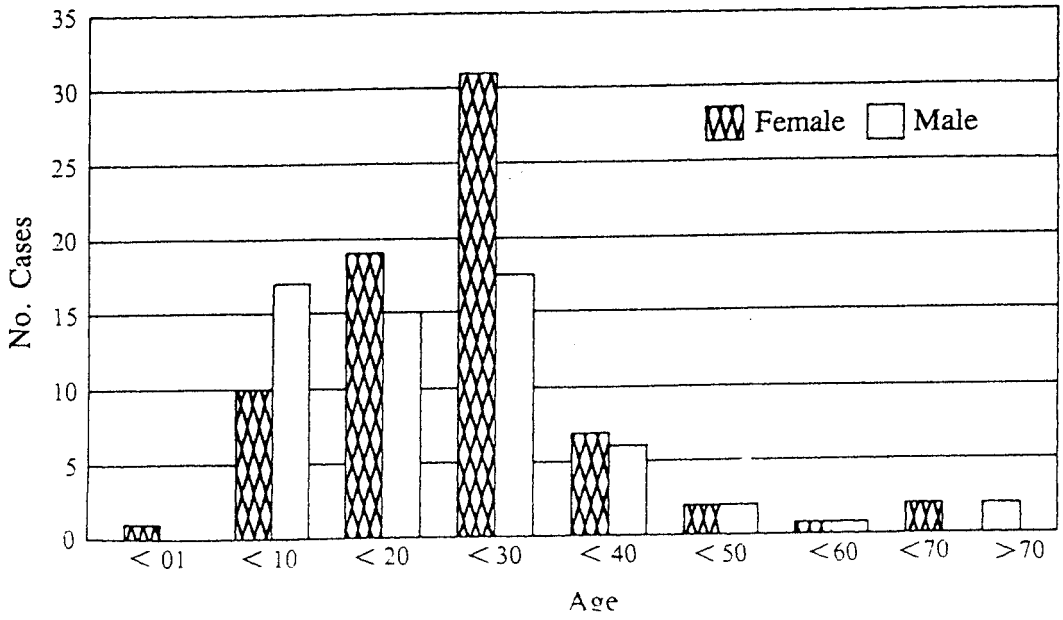

Figure 3. The relationship of daily temperature (°C) and cold fronts in January 1990

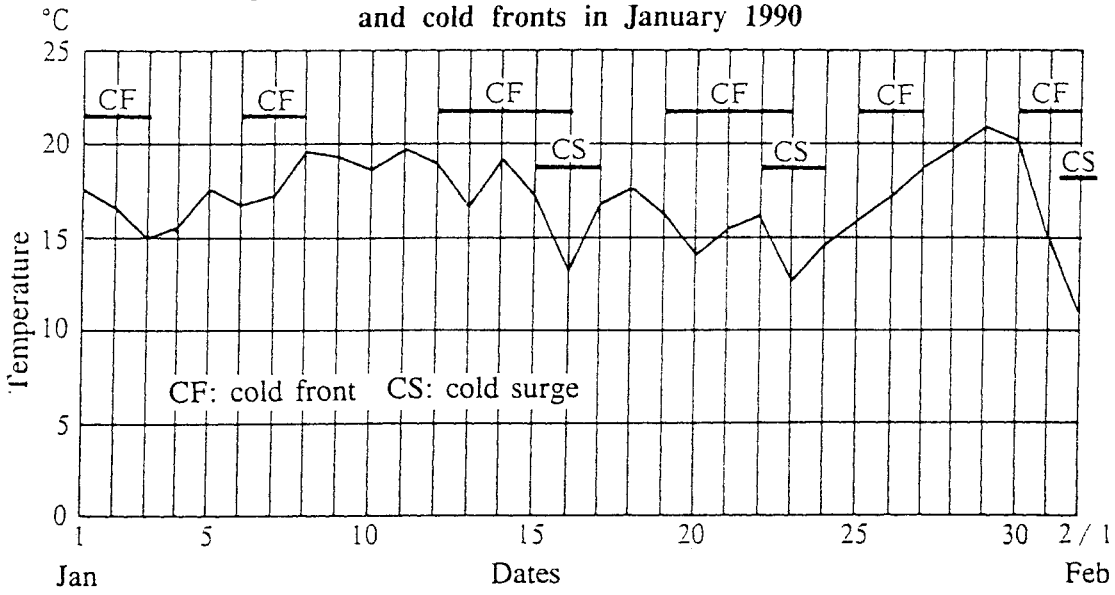

Table 1. Carbon Monoxide Poisoning and Weather

	A (n=122)	B (n=65)	C (n=58)	D (n=5)
Temperature (°C)	23.1± 5.4	20.1± 5.7*	20.5± 5.8*	17.8± 5.3@
Pressure (hpa)	1013.0± 7.3	1015.3± 7.3@	1015.1± 7.9#	1018.1± 4.5
Humidity (%)	76.8± 8.8	76.1± 9.3	75.6± 8.8	76.2±12.9
Visibility	61.2± 23.1	57.6± 21.8	57.7± 21.7	64.2±26.1
Rain (mm)	76.0±206.9	60.3±162.3	59.0±168.8	51.0±92
Cloudiness	82.2± 22.1	79.8± 26.3	79.4± 26.2	77.0±32.7
Wind speed (km/h)	30.0± 12.5	30.2± 13.9	30.7± 13.6	32.8±14.7

A: control days
B: days when cases occurred
C: days when gas water heater cases occurred
D: days when gas stove cases occurred
Students-t test and control days: *$p<0.005$, @$p<0.025$, #$p<0.05$

Table 2. Cold Front and Carbon Monoxide Poisoning in Taiwan

	CO Poisoning	Control Day #
Cold front	41*	39
No cold front	24	81

minus 2 of the control days when CO poisoning cases occurred
* χ^2 and control days: $p<0.001$, Odds ratio: 3.54