

ppm for 5 min and 2,500-4,000 ppm for 30 min (for an adult engaged in light activity) (ISO 1989). From the documents, it was concluded that the published values are for normal, healthy adults and that the values were based on animal data (especially monkeys; Purser and Berrill 1983); the documents did not discuss the issue of subpopulations at higher risk for lethal effects.

### 2.1.1. Case Studies

Nelson (2006a) reported data on unvented space heaters related to human lethality and CO poisoning. Sixteen of 22 lethal cases had COHb concentrations more than 40%. Six of 22 cases had COHb concentrations of  $\leq 40\%$ , and two of six cases had pre-existing conditions, such as arteriosclerotic disease and cardio-respiratory failure. A 1942 fatality study reported by Nelson (2006a) summarized COHb data for 68 victims that were found dead in a gas-filled room or in a garage containing exhaust gases at high concentrations. CO concentrations were not provided. Sixty-seven percent of the 68 lethal cases had COHb concentrations of 40-88%. Three-percent of those cases had concentrations of 30-40%. A summary of another fatality study from Poland showed a similar trend of COHb concentrations (Nelson 2006a). Individual data were not provided, and the CO source was not discussed. However, the Polish study considered 321 lethal CO poisonings from 1975 to 1976 and provided COHb concentrations for 220 survivors and 101 fatal cases. The survivors had a mean COHb level of 28.1% (standard deviation [SD] = 14.1), whereas the lethal cases showed an average COHb level of 62.3% (SD = 10.1). Over 80% of the survivors had COHb levels below 40%. In contrast, about 90% of the deceased had COHb levels above 50%. Similar percentages of survivors and deceased were observed at COHb levels of 40-50%, with a slight increase in the number of survivors when compared with that of the deceased. These three studies showed a trend that most lethal cases occurred at COHb concentrations higher than 40% and that survivorship was likely to be seen at concentrations below 40%.

Another study from the Center of Forensic Sciences in Canada evaluated 304 fatal cases from 1965 to 1968 (Nelson 2006a). The mean lethal COHb level was  $51 \pm 12\%$  with a majority range between 40% and 59% and the highest single frequency range at 45-59%. A report on CO exposure from exhaust fumes in the state of Maryland during 1966-1971 showed COHb levels in the 40-79% range for 98% of lethal cases (Nelson 2006a). The Institute of Forensic Medicine in Oslo reported a study of COHb levels in 54 automobile-exhaust victims. The mean fatal COHb level was 70%, and 40% was the minimum COHb level exhibited by less than 2% of the cases (Nelson 2006a). Another forensic study (Nelson et al. 2006) examining 2,241 fatalities from 1976 to 1985 found that the mean COHb level of all the cases was 64.20% with a SD of 17.47. The data showed that 34% of victims had COHb levels of less than 60%. Of those who died in fires, 41% had COHb levels of less than 60% compared with 22% of the nonfire deaths.