

Health Consultation

**Investigation of Carbon Monoxide Exposure
in the London Bridge - Rotary Beach Area**

May 25 – 26, 2003

Lake Havasu City, Arizona

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Arizona Department of Health Services
Office of Environmental Health
Phoenix, Arizona

Introduction

Carbon monoxide is an odorless, colorless gas that results from incomplete combustion of carbon compounds. Until recently carbon monoxide poisonings were thought to occur in enclosed, poorly ventilated areas. However, open-air cases of poisoning have recently been reported including exposures from exhaust from various kinds of watercraft including houseboats, cabin cruisers and ski boats. Unlike automobiles, boat engines do not have mechanisms to reduce carbon monoxide emissions.

Large numbers of boaters use the channel of water beneath the London Bridge for recreation on weekends during the summer. There are hundreds of watercraft in the channel water at Rotary Beach on holiday weekends. The density of watercraft and the large numbers of people using the channel creates the opportunity for individuals to be exposed to excessive carbon monoxide emissions. Indeed, the Havasu Regional Medical Center Emergency Department has seen a number of patients in the last several years that have been diagnosed with carbon monoxide poisoning while recreating in or near the channel of water beneath the London Bridge in Lake Havasu City.

This exposure investigation examines the extent of carbon monoxide exposure in recreational boaters in the Rotary Beach area near the London Bridge in Lake Havasu City, Arizona during the Memorial Day Holiday in 2003 (5/24/03 – 5/25/03). The Rotary Beach area is a very popular location for recreation including boating, swimming, sunbathing, shopping and other activities.

The objective of the investigation is to determine whether a public health hazard from carbon monoxide exposure exists in an area heavily used by recreational boaters.

Methods

We examined the concentration of carbon monoxide in the exhaled air of participants recreating in the Rotary Beach area near the London Bridge in Lake Havasu City during the Memorial Day Holiday in 2003 (5/24/03 – 5/25/03). Exhaled carbon monoxide was used as a measure of the amount of carboxyhemoglobin (COHb) in the participant's blood.

Volunteers provided samples by blowing exhaled air into a single-use mouthpiece. Each mouthpiece was discarded after each individual use. A Scott/Bacharach Instrument Carbon monoxide Sniffer with a Breath Analysis Module was used to analyze the exhaled air samples. The module includes an internal mechanism to ensure that ethanol does not interfere with the analytical results.

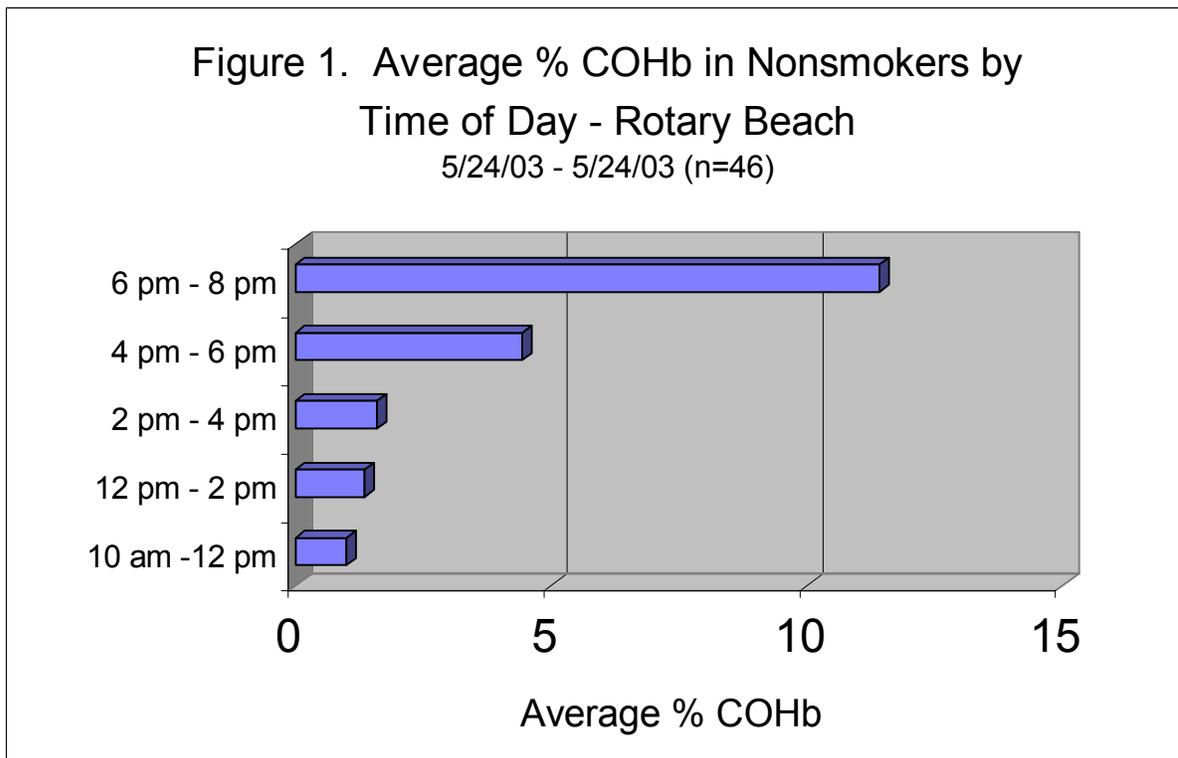
An Arizona Department of Health Services investigator administered a short questionnaire while the sample was being analyzed in the field. Participants were asked whether or not they are a smoker, what kinds of recreation activities they had been participating in, and how many hours they had been recreating in the area. The

investigator did not collect personal identifiers. A total of 62 individuals participated in the study.

The investigator recorded the time of day, the general weather conditions, and the concentration of carbon monoxide in the exhaled air of the participant. Exhaled carbon monoxide levels were converted to % COHb using a standardized conversion chart. The results were input into Microsoft Access® for analysis.

Results

The results of the analysis suggest that significant carbon monoxide exposure occurred among participants during the investigation. The % COHb among non-smoking participants increased from an average of 1% between 10 am and 2 pm to 11% between 6 pm and 8 pm (Figure 1). Similarly, among smokers, the average % COHb increased from 3% between 12 pm and 2 pm to 13% between 6 pm and 8 pm (Figure 2).



The average % COHb was greater in all participants that had been recreating outdoors in the areas for longer periods of time. The average %COHb among non-smoking participants ranged from 1.4 % for those recreating outdoors for 1 hour, to more than 5 % for those recreating outdoors for 5 hours or more (Figure 3). Similarly, the average % COHb among smokers increased from 3% after 1 hour of recreation , to 7 % for those recreating outdoors for 5 hours or more (Figure 4).

Figure 2. Average % COHb in Smokers and Non Smokers by Time of Day
5/24/03 - 5/25/03 (n=62)

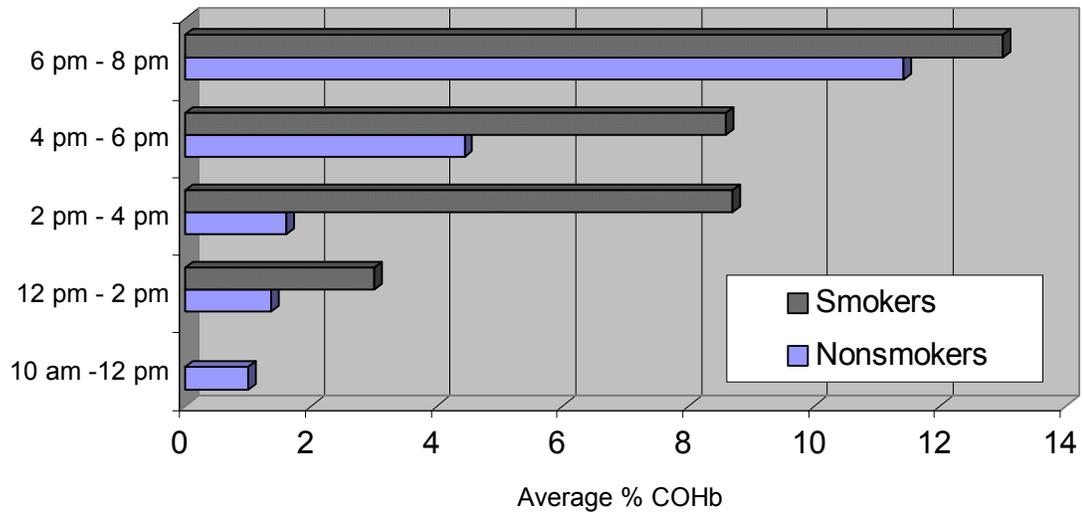
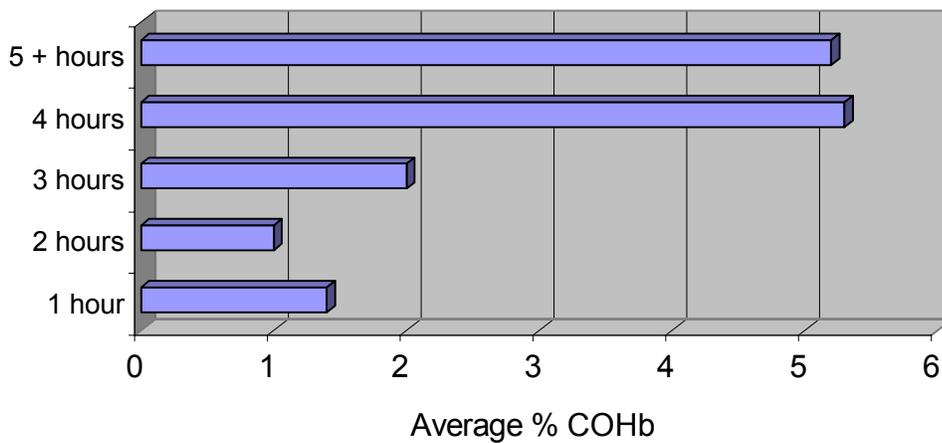
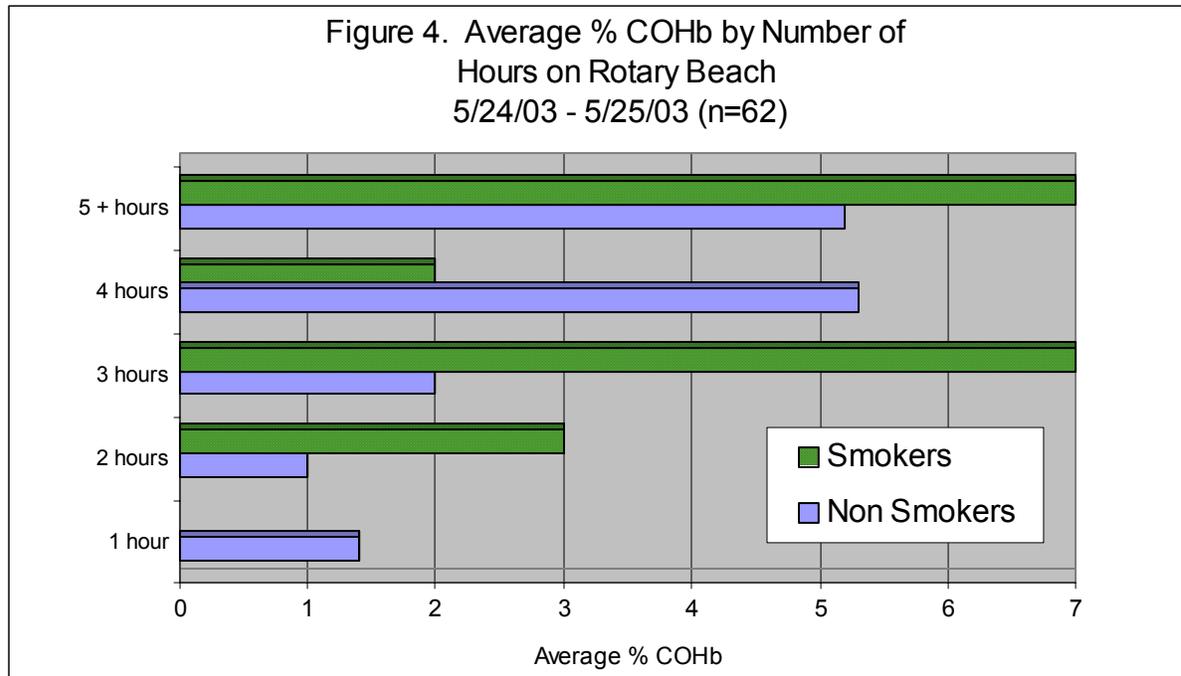


Figure 3. Average % COHb in Nonsmokers by Number of Hours at Rotary Beach
5/24/03 - 5/25/03 (n=46)





Discussion

Carbon monoxide is a colorless, odorless, tasteless gas produced by incomplete burning of gasoline. The initial symptoms of carbon monoxide poisoning may include headache, dizziness, drowsiness, or nausea. Symptoms may advance to vomiting, loss of consciousness, and collapse from prolonged or high exposure. Coma or death may occur if high exposures continue.⁽¹⁻⁶⁾ The symptoms vary widely from individual to individual, and may occur sooner in sensitive persons such as young or aged people, people with preexisting lung or heart disease, or those living at high altitudes. Table 1 displays the symptoms associated with exposure to carbon monoxide.

Table 1. Health Effects from Overexposure to Carbon Monoxide

% COHb	Symptom
< 5%	None
5-10%	Slight headache, decreased exercise tolerance
10-20%	Mild dyspnea on exertion, headache
20-30%	Throbbing headache, mild nausea, some impaired judgment
30-40%	Severe headache, nausea and vomiting, impaired judgment
40-50%	Confusion and syncope
50-60%	Syncope, coma, seizures
60-70%	Coma, seizures, cardiorespiratory depression, death
>70%	Failing hemodynamic status, death

Exposure to carbon monoxide limits the ability of the blood to carry oxygen to the tissues by binding with the hemoglobin to form carboxyhemoglobin. Once exposed, the body compensates for the reduced blood borne oxygen by increasing cardiac output, thereby increasing blood flow to specific oxygen-demanding organs such as the brain and heart. This ability may be limited by preexisting heart or lung diseases that inhibit increased cardiac output.

Blood has an estimated 210-250 times greater affinity for carbon monoxide than oxygen. Carbon monoxide in the blood interferes with oxygen uptake and delivery to the body. Once absorbed into the bloodstream, the half-life ranges from 2 to 6.5 hours.⁽⁷⁾ If oxygen is administered to the exposed person, as happens in emergency treatment, the half-life time is decreased again by as much as 75% (or to as low as approximately 40 minutes). Delivery of oxygen under pressure (hyperbaric treatment) reduces the half-life to approximately 20 minutes.

The average % COHb among non-smoking participants was low (1% COHb) between 10 am and 2 pm and among those non-smokers that had spend less than 2 hours recreating outdoors. These participants were below symptom thresholds. However, the average % COHb among non smoking participants increased to 11% between 6 pm and 8 pm, suggesting that these persons may have had a headache or decreased exercise tolerance as a result of their exposure to environmental carbon monoxide.

Smoking participants showed a similar increase in COHb over time. However, smoking cigarettes and other tobacco products increases COHb, and the increase in COHb levels in these participants is likely due to both environmental exposures and active smoking of tobacco products. These persons likely experience chronic mild symptoms of carbon monoxide exposure including headache or decreased exercise tolerance as a result of their active smoking.

The maximum COHb level observed for non-smokers was 23% COHb, and the maximum for smokers was 26%. These participants were likely experiencing more significant symptoms of carbon monoxide exposure including more severe headache, nausea, and impaired judgment. These data suggest that while the average COHb concentrations found were still in the mild carbon monoxide poisoning range, some individuals may have significantly more exposure, resulting in the potential for more serious consequences such as drowning. A 31-year-old drowning victim during the weekend of this investigation had a 47 % COHb concentration at the time of autopsy, suggesting that his death was at least partially due to carbon monoxide exposure.

Alcohol consumption was common among the participants. Alcohol consumption is well documented to cause similar symptoms as carbon monoxide including headache, impaired judgment, nausea and vomiting. The combination of alcohol consumption and carbon monoxide exposure likely creates a more significant health hazard. In addition, the recreational activities conducted during the investigation were predominately in or near water, creating a drowning hazard for those with impaired judgment or more severe symptoms of carbon monoxide exposure or alcohol consumption. Additional hazards in

the environment include those associated with moving propellers and other moving watercraft.

Conclusion

The results of the analysis suggest that significant carbon monoxide occurred among participants during the investigation. The cumulative carbon monoxide exposure increased as the day progressed. The COHb levels observed late in the day posed a public health hazard.

The combination of alcohol consumption and carbon monoxide exposure likely creates a more significant health hazard. In addition, the recreational activities conducted during the investigation were predominately in or near water, creating a drowning hazard for those with impaired judgment or more severe symptoms of carbon monoxide exposure and alcohol consumption.

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