Knowledge about carbon monoxide poisoning among medical and non-medical students living in Kraków — questionnaire study

Iwona Popiołek[1,7], Lech Popiołek[2], Jakub Marchewka[3,4], Grzegorz Dębski[5],
Justyna Bolech-Gruca[1], Małgorzata Szumińska[6], Piotr Hydzik[1,7]

[1]University Hospital in Kraków, Kraków, Poland
[2]Private practice, Kraków, Poland
[3]Department of Physiotherapy, University of Physical Education, Kraków, Poland
[4]Department of Orthopedics and Trauma Surgery, 5th Military Hospital, Kraków, Poland
[5]Radiology Department, 5th Military Hospital, Kraków, Poland
[6]Department of Endocrinology, Jagiellonian University Medical College, Kraków, Poland
[7]Department of Toxicology and Environmental Diseases, Jagiellonian University Medical College, Kraków, Poland

Corresponding author: Iwona Popiołek, M.D., Ph.D.
University Hospital in Kraków, ul. Jakubowskiego 2, 30-688 Kraków, Poland
Phone: +48 12 400 26 50; E-mail: idpopiolek@gmail.com

Abstract: O b j e c t i v e s: Accidental exposure to non-fire related carbon monoxide (CO) in young people is largely unquantified. Our aim was to estimate the possibility of exposure to CO and the awareness of intoxication in the population of students living in Kraków, one of the largest academic cities in Poland. M e t h o d s: Anonymous questionnaires about CO poisoning were distributed among medical and non-medical students living in Kraków.
R e s u l t s: 1081 questionnaires were collected — 16% of study participants knew a person who had been poisoned with carbon monoxide, 51.2% of students using a bathroom water heater believed that they had no risk of CO poisoning. Medical students gained significantly higher scores in the CO-poisoning knowledge test than non-medical ones.
C o n c l u s i o n s: There is still unsatisfactory awareness of CO poisoning among non-medical students in Kraków.

Key words: carbon monoxide, CO intoxication, CO poisoning, toxicology, students.

Introduction

Epidemiology

Carbon monoxide (CO) is the most frequent cause of gas poisonings in Poland. Although an educational campaign focusing on the dangers of CO is conducted annually, the number of Toxicology Unit admissions associated with CO poisonings remains stable [1–3]. According to the data from Toxicology Unit in Kraków, approximately 1/3 of patients admitted to the hospital after CO intoxication between 2011 and 2015 was under 25 years old. Most of them were students living in rented apartments. These apartments were usually equipped with a gas water heater.

Kraków is one of the largest academic cities in Poland, with 21 Higher Education Institutions [4]. During academic year 2013/2014 there were 172 848 students [4] living in Kraków.

There is no official data about the number of rented apartments in Kraków. There is also no reliable data specifying the number of gas water heaters. According to the Polish Central Statistical Office, in the year 2014 over 568 300 people living in Kraków (74.6%) used a domestic natural gas heating system [4].

Main sources of CO in Kraków

Carbon monoxide is often produced in the process of incomplete combustion of natural gas. The combustion is incomplete when there is not enough oxygen to allow the natural gas to react completely and produce carbon dioxide and water. This situation may occur when all the windows in house equipped with gas heating system are sealed. Incomplete combustion is also more common when free outflow of exhaust gases from the heating device (usually gas water heater) is disturbed. The best way to reduce CO production in gas heating devices it to provide constant supply of fresh air to apartments [5, 6].

Symptoms of CO poisoning

The symptoms, signs and prognoses of acute CO poisoning are associated by many authors with blood carboxyhemoglobin (COHb) level. COHb levels below 10% are usually not related to any symptoms [7]. At higher COHb levels, neurological symptoms of CO poisoning (headache, dizziness, weakness, nausea, confusion, disorientation, and visual disturbances) can occur [8, 9]. Exertional dyspnea, tachycardia, tachypnoea and syncope are observed with continuous exposure [10]. In cases of extreme poisoning, coma, convulsions, and cardiopulmonary arrest may occur [11]. What is interesting — thorough investigations in this field show, that clinical symp-

toms of CO poisoning correlate poorly with the level of COHb measured in the blood at the time of arrival at the hospital [5].

CO intoxication prevention

One of the best ways to avoid dangerous exposure to carbon monoxide is to prevent high concentrations of this gas in residences and other indoor environments. This can be accomplished by: 1) frequent inspection and routine maintenance of vented combustion appliances and fireplaces; 2) not allowing automobiles to idle in closed or open garages; 3) not using unvented combustion sources (e.g. space heaters, cooking devices and tobacco products) indoors; 4) not misusing properly vented sources (e.g. using a gas oven/range for heating); and 5) installation of CO alarms [8, 12].

CO poisoning awareness among students

Polish students are people, who should have learned the basic facts about CO poisoning symptoms at their schools. They should have also had obligatory basic life support training during their education [13]. However, a study by Pach *et al.* conducted in 2010 in Nowy Sącz showed insufficient knowledge about CO poisoning symptoms and methods of basic life support after CO intoxication among Polish students [14].

Aim

The purpose of this study was to investigate the knowledge about CO poisoning among students living in Kraków.

Materials and Methods

Design, setting and participants

The study was conducted between November 2013 and May 2014. At the beginning of the study we distributed specially designed questionnaires among people studying at five universities in Kraków: Jagiellonian University, Jagiellonian University Medical College, University School of Physical Education, AGH University of Science and Technology and Tadeusz Kościuszko University of Technology. Students of the Jagiellonian University Medical College and subjects studying physiotherapy at the University School of Physical Education were classified as medical students.

Method

We developed a questionnaire with questions divided into three groups: 1) Prophylaxis and awareness of poisoning, 2) Knowledge about the symptoms, and 3) Providing first aid (basic life support) in cases of CO poisoning. Each questionnaire contained both closed-ended and open-ended questions. In case of closed-ended questions, study participants were asked to pick an answer from three possible options: "yes", "no" and "I don't know". Each correct answer was counted as one point. The answer "I don't know", or an incorrect answer did not give any points, except when someone answered incorrectly about the possibility of death after CO exposure. In this case we subtracted one point for the dangerous ignorance. The total score was counted and considered separately for medical and non-medical students.

Ethics

The study was approved by the Jagiellonian University Medical College Ethics Committee.

Statistical analysis

Statistical analysis was performed using StatSoft's STATISTICA 12.0 PL software licensed to Jagiellonian University. The statistical significance level (α) was set at 0.05. Chi-Square (χ^2) analysis was used to compare nominal variables. The Mann-Whitney U-test was applied to detect statistically significant differences between variables other than nominal. Correlation analysis was based on Spearman's rank correlation coefficients. We did not consider variability by ethnicity in this analysis, because the proportion of respondents from minority ethnic groups was very low.

Results

Study group

The study group consisted of 1081 subjects (327 men, 738 women). Enrolled individuals were studying at five different universities located in Kraków, Poland (see Fig. 1). About 44% of subjects (476 out of 1081) were classified as medical students.
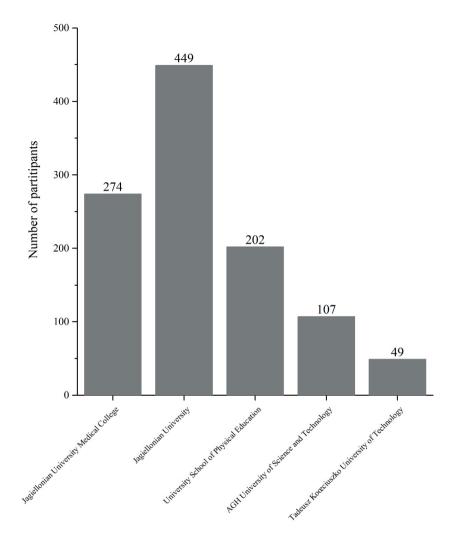
Fig. 1. Distribution of enrolled students according to university. No missing data.

Mean age in the study group was 20.9 years (SD = 1.75), minimal age was 18, maximal age was 27. Before coming to Kraków, the study participants were living in the following areas: large cities above 100,000 inhabitants (32.4%), towns below 100,000 inhabitants (34.1%), and in the countryside (33.5%).

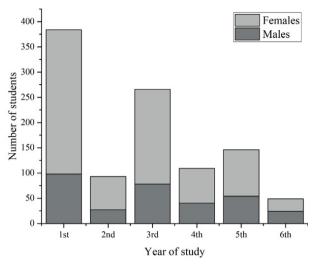The majority of study participants were studying three years or shorter (see Fig. 2).

Fig. 2. Demographic structure of the study group. N=1081, Missing data — 34 (18 no data about year of study, 16 — no data about sex).

Potential sources of exposure

Participants were asked twice if they had a gas water heater. Surprisingly, 11% of respondents answered inconsistently. Finally, 44.3% of participants (479 individuals) answered unequivocally that they had a gas water heater. 602 subjects did not have a bathroom gas water heater or were not aware of the source of hot water at their home (see Fig. 3).
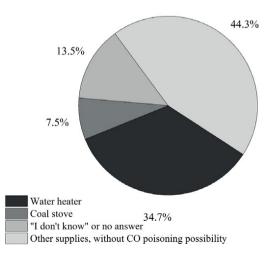

Fig. 3. Declared sources of hot water in subjects' apartments. N = 1081.

Carbon monoxide awareness

Twelve students enrolled into the study (1.11%) had history of CO poisoning. Five of them were hospitalized. 172 subjects (15.91%) reported knowing someone who had been poisoned with CO.

Generally, numerous students (30.25%) were afraid of the risk of carbon monoxide poisoning at their places of residence or work. But, what is interesting, only 198 students (18.32%) thought about the possibility of poisoning when using their water heating systems.

245 students, who declared having a gas water heater, were not aware of the risk of CO poisoning associated with this method of water heating. Moreover, about 70% of gas water heater users did not have a CO detector at home, and they were not planning to buy one.

Study participants were also asked for an opinion about the safety of their domestic gas water heaters. Most subjects rated their place of living as quite safe and modern (see Fig. 4).
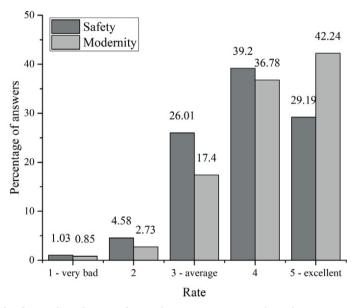

Fig. 4. Declared safety and modernity of water heating systems at subjects' apartments. Missing data: 18 for safety, 12 for modernity.

Enrolled students were also asked to choose time of year, in which the probability of CO poisoning is high. The majority of subjects indicated the winter season (which is correct). What is interesting, many enrolled individuals believed that probability of CO poisoning in spring (March, April, May) is also high.

CO poisoning preventive behavior

Subjects were divided into two groups — medical and non-medical students. We did not find any significant differences between these groups in terms of age, sex or history of poisoning and prevalence of using a gas water heater.

Participants who declared having a gas water heater were asked about their habits or conditions predisposing them to poisoning. The answers of medical and non-medical students were compared. Preventive behaviors were significantly different in both groups. The proportion of students who declared opening windows while bathing was significantly higher in the medical group than in the non-medical group (20.88% vs. 12.89%). What is more, non-medical students were more eager to lock the door during taking a bath than medical students. Other answers were similar in both groups.

One important fact to note is that only a few students in both groups (30.39% vs. 25.89%) had CO detectors at their apartments.

Knowledge about CO poisoning symptoms

During the study we also assessed basic awareness of CO poisoning symptoms. Medical students had greater knowledge about the symptoms of CO poisoning than non-medical ones. A larger proportion of medical students (in comparison to non-medical ones) were aware that CO poisoning may lead to: death (98.1% vs. 95.8), weakness (93.5% vs. 87.7%), headache/dizziness (92.2% vs. 89.4%), loss of consciousness (89.4% vs. 85.7%), nervous system damage (82.4% vs. 60.6%), apnoea (75.3% vs. 73.8%.), nausea/vomiting (47% vs. 40.2%), heart palpitations (46.5% vs. 30.9%), somnolence (48.4% vs. 42.2%) and blood pressure decrease (41.7% vs. 37.5%). Moreover, non-medical students were more eager to answer that symptoms not associated with CO poisoning, such as: diarrhoea, coughing, joint damage and dermatitis may be caused by CO intoxication. Both groups of students were aware that CO poisoning may lead to syncope.

Medical students scored significantly higher than non-medical individuals in the test about symptoms of CO poisoning (10.10 vs. 8.96 points, respectively). What is more, medical students significantly less often chose the "I don't know" answer than non-medical ones (15.04% vs. 23.16%, respectively).

Knowledge about first aid in CO poisoning

Study participants were asked about first action that should be performed after finding a person that could have been CO intoxicated. Our questionnaire provided five possible actions to choose: 1) Calling for help; 2) Moving intoxicated person from the place of poisoning; 3) Opening windows and doors to allow air circulation; 4) Salvage operations (recovery position, cardiopulmonary resuscitation, etc.); 5) Assessment of intoxicated person.

Correct answer (opening windows and doors to allow air circulation) was chosen by 39% of enrolled subjects. What is surprising, almost 35% of the study group believed that moving intoxicated person from the place of poisoning should be performed before other enumerated actions. These persons were probably not aware, that this action may multiply the number of CO victims.

Medical students in comparison to non-medical ones had significantly better knowledge about first aid in CO poisoning.

Calling for help

There are a few possible telephone numbers that people in Poland can choose in case of emergency — 112 (General Emergency Number), 997 (Police), 998 (Fire Department), 999 (Ambulance) and 992 (Gas Emergency Service).

Most study participants (about 78.5%) indicated 112 as the first telephone number that should be considered after finding a person that could be CO intoxicated. It is important to notice, that medical students indicated this number more frequently than non-medical ones (82.29% vs. 75.73%).

Basic knowledge about carbon monoxide

The last question in our questionnaire was focused on general properties of carbon monoxide. Study participants were asked to indicate one correct answer out of four possibilities (see Fig. 5). More than 92% of study participants indicated correct answer (answer D). At the same time, almost 8% (7.59%) of individuals that were enrolled into the study answered incorrectly, that carbon monoxide has a characteristic taste and smell, probably mistaking it with natural gas.
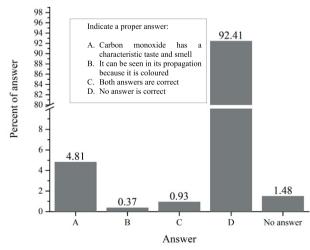

Fig. 5. Distribution of answers for the last question in our questionnaire. D is a correct answer. N = 1081.

Discussion

Results obtained during the study are ambiguous. On the one hand, almost 94% of subjects in the study answered correctly that CO is an odourless, tasteless and colourless gas. Moreover, the majority of examined students were able to point out the typical and most dangerous symptoms of CO poisoning properly. But on the other hand, some of the questions had surprising answers revealing students' ignorance in the field of their own housing conditions. For example, 13% of respondents had no idea what the source of hot water in their bathrooms was.

The study clearly showed that medical students know more about carbon monoxide poisoning than non-medical ones. This finding is, of course, in line with our expectations. A statistically significant difference between medical and non-medical students was observed in case of the total score of the questionnaire and in case of almost all specific questions focusing on CO intoxication symptoms. But what is even more interesting — medical students were more likely to report that they perform some preventive behaviours associated with CO poisoning, such as opening the windows in the apartment before bathing. At the same time, non-medical students more often admitted to behaviours increasing the probability of serious intoxication, for example closing doors and windows while bathing. This leads to the conclusion that positive health behaviours may be more common among medical students than in the non-medical population.

The study has the following limitations: 1) It was performed among people studying at five biggest universities in Kraków. These institutions educate only 55.4% of the whole student population in the city. Smaller universities situated in Kraków were not represented in our study. 2) Female ratio in the study (68% of subjects were women) was different than female ratio in the student population of Kraków (58% of students in the city are females [4]). 3) Most study participants answered questions about their theoretical reactions to a given situation, without recourse to their experience.

According to some studies, potential exposure to carbon monoxide (CO) in private homes is largely unquantified [15]. Many people are exposed to CO and suffer from CO poisoning but remain undiagnosed or even misdiagnosed due to its non-specific symptoms, which include headache, tiredness, and nausea [16]. These finding underlines the importance of CO poisoning prevention.

Acknowledgments

Funding

No funding to declare.

Conflict of interest

We declare no conflict of interest.

References

1. *Krzyżanowski M., Seroka W., Skotak K., Wojtyniak B.*: Mortality and Hospital Admissions Due to Carbon Monoxide Poisoning in Poland. Saf Fire Tech. 2014; 33 (1): 75–82.
2. *Gomółka E., Gawlikowski T.*: Estimation of carbon monoxide poisonings frequency, based on carboxyhemoglobin determinations performed in Toxicology Laboratory in Krakow in years 2002–2010. Przegl Lek. 2011; 68 (8): 413–416.
3. *Świderska A., Sein Anand J.*: Selected data concerning acute intoxications with xenobiotics in Poland in the year 2010. Przegl Lek. 2012; 69 (8): 409–414.
4. *Jakóbik K., Chochorowska A., Czekaj A., et al.*: Statistical Yearbook Of Kraków 2015. Statistical Office in Kraków 2015.
5. *Czerski G.*: Impact Assessment of Selected Factors on the Risk of Poisoning with Combustion Products From Gas Appliances. Saf Fire Tech. 2014; 33 (1): 67–74.
6. *Earnest G., Mickelsen R., McCammon J., et al.*: Carbon monoxide poisonings from small, gasoline-powered, internal combustion engines: just what is a "well-ventilated area"? Am Ind Hyg Assoc J. 1997; 58 (11): 787–791.
7. *Meredith T., Vale A.*: Carbon monoxide poisoning. Br Med J Clin Res Ed. 1988; 6615 (296): 77–79.
8. *Chang C.*: Longitudinal study of carbon monoxide intoxication by diffusion tensor imaging with neuropsychiatric correlation. J Psychiatry Neurosci. 2010; 35 (2): 115–125.
9. *Sadovnikoff N., Varon J., Sternbach G.*: Carbon monoxide poisoning: An occult epidemic. Postgrad Med. 1992; 92 (4): 86–96.
10. *Barret L., Danel V., Faure J.*: Carbon Monoxide Poisoning, a Diagnosis Frequently Overlooked. J Toxicol Clin Toxicol. 1985; 23 (4–6): 309–313.
11. *Marchewka J., Gawlik I., Dębski G., Popiołek L, Marchewka W., Hydzik P.*: Cardiological aspects of carbon monoxide poisoning. Folia Med Cracov. 2017; 57 (1): 75–85.
12. *Lehr E.*: Carbon monoxide poisoning: a preventable environmental hazard. Am J Public Health Nations Health. 1970; 60 (2): 289–293.
13. *Krawczyk P., Cebula G., Drab E., et al.*: The impact of the European Resuscitation Council in Poland. Resuscitation. 2008; 77 (2): S60.
14. *Pach J., Ogonowska D., Targosz D., Dziuban A., Brzyski P., Pach D.*: Students knowledge on carbon monoxide. Przegl Lek. 2010; 67 (8): 583–590.
15. *Weaver L.*: Carbon Monoxide Poisoning. N Engl J Med. 2009; 360 (12): 1217–1225.
16. *Raub J., Mathieu-Nolf M., Hampson N., Thom S.*: Carbon monoxide poisoning—a public health perspective. Toxicology. 2000; 145 (1): 1–14.