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ENHANCEMENT OF RADON EXPOSURE IN NARGHILE (WATER PIPE) SMOKING AREAS

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SUMMARY: Narghile, one of the names for water pipe, is an instrument for tobacco smoking that has become a trend among the youth in Saudi Arabia. The mistaken opinion that smoking narghile is not as dangerous as smoking cigarettes makes the youngsters and their parents take it lightly and contributes to the expansion of its use. The link between tobacco smoke and cancer has long been established. Smokers are ten times at greater risk of developing lung cancer than that of non-smokers. Narghile smoking has become fashionable worldwide. Its tobacco pastes generally contains 30–70% tobacco. Tobacco contains minute amounts of radiotoxic elements which are inhaled via smoking. Radim-226 is a significant source of radon-222, an inert radioactive gas, which enters buildings through soil, construction materials or water supply. When tobacco smoke is present, the radioactivity attached to airborne smoke particles and the radioactivity concentration in the room, increases very much compared to a smoke-free room. It remains suspended and available until inhaled as 'secondhand' smoke by anyone in the room. Thus, smoking indoors greatly increases lung cancer risks to all inhabitants. To investigate whether the narghile tobacco itself is a potential source of indoor radon, the level of radon and thoron from radioactive decay were measured in fifteen different brand narghile tobacco paste samples using CR-39 solid state nuclear track detectors (SSNTDs). The results showed that the ^{222}Rn and ^{220}Rn concentrations in these samples ranged from 129 to 273 Bqm^{-3} and 55 to 142 Bqm^{-3}, respectively.

Key words: Radon, thoron, tobacco, effective dose, narghile, CR-39, nuclear track detectors.

INTRODUCTION

Tobacco is used for smoking in many ways (e.g. cigarette, cigar, pipe and narghile) and the health consequences vary accordingly (1). The cigarette is the most popular and worldwide consumed tobacco product. Narghile, or water pipe smoking (WPS), has been practiced extensively for ~ 400 years. In recent years, there has been a revival of WPS, notably among youth. Its tobacco pastes, known as moassel and juark, are not standardized and generally contain 30-70% crude type of tobacco, molasses/juice of sugarcane, various species and dried fruits (particularly in juark) and, in the case of moassel, glycerol and flavoring essences (2).

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Radon is classified as a human carcinogen by various US agencies, including the National Toxicology program (NTP), the International Agency for Research on Cancer (IARC), the Agency for Toxic Substances and Disease Registry (ATSDR) (3). Radon-222 is a radioactive gas that forms from the decay of naturally occurring uranium-238. Uranium-238 is present throughout the earth's crust; as such, the presence of radon is also universal. As a gas, radon is relatively harmless, and only a small fraction of the inhaled gas is absorbed. In contrast, radon decay results in solid particles that readily settle within the airways. These decay products, including polonium-218 and polonium-214, mediate injury by emitting alpha radiation. Alpha radiation is classified as high linear energy transfer (LET) radiation, which means that although it has a low penetration distance, it transfers more energy to the target, thus causing a greater number of ionizing events. This process leads to more severe cell damage.

In support of this theory, a recently published study found that the effective dose of inhaled radon progeny was amplified 2 times in heavy, long-term smokers, a result of impaired mucociliary clearance and changes in ventilation (4).

Water pipe (WP) use is increasing globally, particularly in the Eastern Mediterranean region, where perceptions regarding health effects and traditional values may facilitate use among women and children. Water pipe smoke contains harmful constituents and there is evidence linking water pipe smoking to a variety of life threatening conditions including pulmonary disease, coronary heart disease, and pregnancy related complications (5,6).

While many narghile smokers may consider this practice less harmful than smoking cigarettes, narghile smoking carries many of the same health risks as cigarettes (6). Water pipe users even physicians have believed that smoking through a water pipe filters out the toxic components of tobacco, making it less harmful than smoking cigarettes. A recent systematic review of the evidence concerning the health effects of narghile smoking shows that narghile smoking more than doubles the risk of lung cancer, respiratory illness.

Subjects with more years of narghile smoking had a greater risk for lung cancer. Research in India by Gupta *et al.* (7), found that the attributed risk for lung cancer among narghile smokers was identical to the risk among cigarette smokers. According to USA Today (8), people who smoked water pipes had five times the risk of lung cancer of nonsmokers. A very recent study by Koul *et al.* (9) documented that narghile smokers were nearly 6-times at risk for development of lung cancer as compared to healthy nonsmokers in Kashmir (India).

In Saudi Arabia, there has been a recent trend towards increased narghile smoking. Saudi adolescents (especially the university students), now-a-days spend part of their leisure time smoking narghile in cafes and restaurants. Narghile smoking is perceived as a leisure activity, and availability in the teenagers' places of entertainment.

Indoor radon and its decay products usually come from soil, building materials, and water supply. Radon and its daughter progeny attached to aerosols when present in the ambient air constitute an important radioactive hazard to human lungs. During respiration radon progeny deposit in the lungs and irradiate the tissue thereby damaging the cells and may cause lung cancer. Exposure to radon is considered to be the second leading cause of lung cancer death (10). Indoor cigarette smoking enhances the air concentration of submicron particles, which trap radon decay products where the attached radon progeny undergo substantial radioactive decay before clearance. Consequently, in addition to the traditional implication of smoking cigarette in lung cancer, the high incidence of lung cancer in cigarette smokers and nonsmokers may be attributed to the cumulative effect of α–radiation dose from indoor radon and thoron progeny generated and/or trapped by tobacco and its smoke. It has been known for over 20 years that all types of tobacco contain radioactive ^{210}Po ($t_{1/2}$ = 138.38 d), which emits alpha particles and radioactive ^{210}Pb ($t_{1/2}$ = 22.3 y), which emits beta particles and is a precursor of 210Po. There is a degree of consensus about how tobacco becomes radioactive. Most soil contain radioactive elements such as radium,

which decays into ^{210}Pb and ^{210}Po. In addition, phosphate ore used as fertilizer in tobacco fields may contain such isotopes in relatively high concentrations.

RESULTS AND DISCUSSION

Although a significant portion of lung cancer occurs in nonsmokers, tobacco smoking is the most common risk factor for lung cancer. However, the alpha radioactivity alone does not cause the steep rise of the carcinogenic risk; instead, it is the combined and multiplicative action of each carcinogenic and co-carcinogenic component responsible for such consequences (11). The authors estimated an increase in lung cancer risk of 16% for each incremental 100 Bqm^{-3} of ^{222}Rn from a pooling of the European residential case-control studies. They estimated that ^{222}Rn may contribute to 9% of all lung cancers in those countries on the basis of an estimated average ^{222}Rn concentration of 59 Bqm^{-3} for 29 European countries. Thousands of preventable lung cancer deaths annually in the United States are attributable to indoor residential exposure to radon. Either smoking or radon exposure can independently increase the risk of lung cancer. However, exposure to both greatly enhances that risk. At exposures to 4 pCi of radon per liter of air, the lifetime lung cancer risk attributable to radon rises from 2 cases per thousand in nonsmokers to 29 cases per thousand in smokers (12). Although a huge amount of data is available about the biological effects of tobacco smoking, here we investigate the possible involvement of ^{222}Rn derived from tobacco as a risk factor of lung cancer. The present study investigated the ^{222}Rn and 220Rn content of fifteen different tobacco samples (coded T1 – T15) used in narghile paste preparation. The data obtained revealed that sample T5 recorded the highest level of ^{222}Rn whereas T3 contained the highest level of ^{220}Rn. The lowest levels of ^{222}Rn and ^{220}Rn were found in samples T9 and T7 respectively. Compared to the background levels (79 $\pm$ 4 Bqm^{-3} and 20 $\pm$ 1 Bqm^{-3}) all samples had significantly higher ^{222}Rn and ^{220}Rn values.

The values for PAEC of ^{222}Rn and ^{220}Rn were calculated. The alpha activities due to the ^{222}Rn were observed to be higher than those due to the ^{220}Rn series for different investigated tobacco paste samples. This is due to the fact that the corresponding tobacco material samples contain more ^{238}U (4.468 x 10^{9} y) than ^{228}Th (1.913 y). Also, note that the half-life of thoron (^{220}Rn) is too short (55.60 s) compared to the exposure time (two months) of the SSNTD films inside the plastic container (13).

Previous studies (14) have indicated that in a smoker's lungs the ciliary action to clear the lungs is reduced to half the normal. The average length of time during which the insoluble forms of ^{210}Pb and ^{210}Po remain at the bronchial bifurcations is 3–5 months. Coincidentally, the surface tissue of smoker's bronchi at the bifurcations is replaced by damaged abnormal tissue.

The exhalation rates of both ^{222}Rn and ^{220}Rn in different tobacco paste samples have also been determined. The values of radon and thoron exhalation rates vary from 8.88 mBqkg^{-1}h^{-1} to 18.81 mBqkg^{-1}h^{-1} and from 4.12 mBqkg^{-1}h^{-1} to 10.63 mBqkg^{-1}h^{-1}, respectively.

The concentrations of ^{222}Rn and ^{220}Rn progenies measured are shown in Figure 3. The values of ^{222}Rn progeny concentration were lower in T9 (52 Bqm^{-3}) and higher in T5 (109 Bqm^{-3}). Also, the values of ^{220}Rn progeny were lower in T7 (22 Bqm^{-3}) and higher in T3 (57 Bqm^{-3}).

The epidemiological and biochemical evidence on exposure to environmental tobacco smoke, with the supporting evidence of tobacco specific carcinogens in the blood and urine of non-smokers exposed to environmental tobacco smoke, provides compelling confirmation that breathing other people's tobacco smoke is a cause of lung cancer. The excess risk of lung cancer is 24% in non-smokers who lived with a smoker (15).

Radon and thoron concentration were found to be higher in café rooms than residential houses. It is probable that the smoke-rich air of the café room enhances the presence of such elements compared to the relatively smoke-free environment. Smokers exposed to the higher indoor radon and thoron levels should experience the highest risk and the earliest incidence of lung cancer. This possibility was investigated cytogenetically by dif-

ferent researchers (16), who showed that chromosome aberrations in cultured peripheral blood lymphocytes are a sensitive measure of cumulative exposure to radon progeny. If most smokers who develop bronchial cancer are those with the highest cumulative radon progeny exposure, they should exhibit the highest prevalence of the indicator aberrations.

Lung cancer is a serious chronic health effect of tobacco smoking and indoor radon progeny may be a factor in the etiology of some of the other cancers, in particular of the larynx, pharynx, and esophagus.

With an estimated 21,000 lung cancer deaths attributable to radon in the US annually, the need for radon mitigation is well acknowledged. Radon mitigation should accompany narghile smoking cessation measures in lung cancer prevention efforts. Quitting is more effective than other measures to avoid the development of lung cancer and other smoking- related diseases. Studies show that some vegetables and fruits may help prevent lung cancer in smokers and non-smokers. The researchers discovered that smokers with a fruit and veggie diet had a 27 percent decreased risk for developing lung cancer (17). Highlights of these studies include: (i) Diets high in fruit are associated with a lower risk of lung cancer, and in fact, foods high in flavonoids, such as apples, can lower the risk of lung cancer by 50%, (ii) In women, the intake of dairy products and vegetables has been linked with a lower risk of lung cancer in smokers, and black tea with a lower risk in non-smokers, (iii) foods high in lutein, such as collard greens, spinach, broccoli, and orange juice, are associated with a lower risk of lung cancer, (iv) foods high in lycopene, such as tomatoes and especially tomato sauces, are linked with a lower risk of lung cancer, (v) Smokers that drink green tea appear to have decreased oxidative DNA damage, a genetic change that predisposes to cancer.

Since lung cancer is among the cancers with the highest incidence and has the highest mortality rate of cancer worldwide, the means of reducing its impact are urgently needed. Increased physical activity has been associated with decreased lung cancer risk. Emerging evidence shows that physical activity plays an etiological role in lung cancer risk reduction. A meta-analysis found that people who participated in higher levels of recreational physical activity have a lower risk of lung cancer (18). According to researcher Michele Forman, “gardening is one of the few activities that people with lung cancer report doing.” Former smokers who gardened reduced their lung cancer risk by 45 percent, while current smokers who gardened reduced their risk by 33 percent. Former smokers who gardened and who also ate four or more servings of green salads per week reduced their risk by 67 percent. Among current smokers, the risk reduction from both gardening and high salad intake was 71 percent (18).

The smoke from narghile has carbon monoxide and other particulate matter. As well, when tobacco is burned, it contains the same cancer-causing chemicals as cigarettes. Smoking narghile or breathing the secondhand smoke can cause lung cancer, respiratory illness, decreased lung function, gum disease, heart disease, decreased fertility and low birth weight. The charcoal used to heat the tobacco in narghile can also expose the user to metals and cancer-causing chemicals. There have been case reports of carbon monoxide poisoning after narghile smoking. Narghile smoking is usually carried out for long periods at each use. A typical one hour session of narghile smoking exposes the users to 100 to 200 times the volume of smoke inhaled from a single cigarette. Repeated exposure to the tobacco can lead to addiction. The US centers for Disease Control fact sheet on narghile smoking emphasizes that it is as dangerous as cigarette smoking. Narghile smokers are at risk for the same kinds of diseases as are caused by cigarette smoking. A fact sheet from The American Cancer Society also points out that “smoking narghiles as well as breathing secondhand smoke from narghiles can be presumed to have similar effects as exposure to cigarette smoke.” Secondhand smoke has been classified by the U.S. Environmental Protection agency (EPA) as a Group A carcinogen, which is known to cause cancer in humans. There is no established safe level of exposure to this class of carcinogens (19).

Secondhand smoke from narghile is a mixture of tobacco smoke and smoke from the fuel (usually charcoal) used to light the tobacco. It puts non-users, workers and patrons alike, at risk for the same types of diseases as secondhand smoke from cigarettes. A typical narghile session lasts from 20-80 minutes, with narghile smokers taking up to 200 puffs. In contrast, cigarettes are typically smoked in 5-7 minutes with 8-12 puffs. As a result, a single narghile causes significantly higher levels of secondhand smoke than a cigarette. Research regarding the contents of secondhand smoke produced by narghile demonstrates that levels of particulate matter can build up to toxic levels similar or even more than measured in traditional secondhand smoke. In one study, the mean particulate matter increased by 553% for narghile (increase from 55 to 365 mg/m^3) compared with 447% for cigarettes (increase from 52 to 287 mg/m^3) (20).

Secondhand smoke is poisonous and causes death and disease in adults and children. Protecting people from tobacco smoke, including exposure to secondhand smoke, is one of the World Health Organization's top six policy priorities for tobacco control. The World Health Organization recommends that the only form of adequate protection from secondhand smoke is to eliminate it completely using 100% smoke-free environments. All people have a right to breathe clean air. There is no safe level of exposure to secondhand smoke, which causes heart disease, cancer and many other diseases. Even brief exposure can cause serious damage. Smoke-free legislation is popular wherever it is enacted, and these laws do not harm businesses. Any country, regardless of income level, can implement effective smoke-free legislation. Only a total ban on smoking in public places, including all indoor workplaces, protects people from the harms of secondhand smoke, helps smokers quit and reduces youth smoking. Guidelines to Article 8 of the WHO Framework Convention on Tobacco Control (FCTC) help countries know exactly what to do to protect their people from secondhand smoke. Article 8 of the WHO FCTC mandates all signatory countries to "protect citizens from exposure to tobacco smoke in workplaces, public transport and indoor public places." Even though there has been great progress in the implementation, still most of the world population remains exposed to secondhand smoke (SHS). Additional research is needed to reach final conclusions for diseases where evidence is only suggestive of causality. The only solution to SHS exposure in public places is banning smoking indoors. Aside from indoor bans, additional research is needed for outdoor and multiunit housing bans and in support of measures that protect children and other vulnerable populations. Tobacco smoke harms babies, even before they are born. It harms children, too, because their lungs and bodies are still growing. When children breathe secondhand smoke, it is like they are smoking, too. No amount of secondhand smoke is safe. Even when you can not smell it, cigarette smoke can still harm your child.

Waterpipe smoking is common specially in the countries in Eastern Mediterranean region (EMR), as it is believed that 20% of the adult people living in these countries smoke waterpipe. Although little data is available regarding the prevalence of waterpipe smoking in EMR, existing data is worrying. A national survey conducted in Kuwait indicates that 57% of men and 69% of women had smoked waterpipe at least once throughout their lives. Nowadays Eastern Mediterranean Region (EMR) suffers from a new epidemic which did not exist a few years ago, namely women smoking and high numbers among youth taking up tobacco in all its different forms. The prevalence of current waterpipe smoking among school students is the following: Arabic Gulf region (9%-16%), Lebanon (25%), Saudi Arabia (33%) (21). A study conducted in Israel reported that about 22% of children between 12 and 18 years of age smoked waterpipe at least once every weekend (79). The prevalence of waterpipe smoking among university students is: Arabic gulf region (6%), Syria (15%), Lebanon (25%), and Pakistan (33%). Group waterpipe smoking is: Lebanon (5%), and Egypt (11-15%). In Lebanon, 5%-6% pregnant women reported smoking waterpipe during pregnancy. Approximately three quarters of female uni-

versity students in Egypt prefer smoking tobacco via a waterpipe than smoking cigarettes because they believe it is less harmful. The total prevalence rate of waterpipe smoking in university students of Turkey is found to be 32.7%.

Narghile smoking is spreading rapidly among boys and young women and the Region needs to combat it. Immediate social, economic and legislative measures need to be implemented to control its spread that were also strongly recommended by WHO in its advisory note on narghile/shisha released 2006. Tobacco control in the EMR has gone through many important developments during the last 2 decades. Although the evidence that legitimizes policies adopted by the FCTC and the global tobacco control report – recommended policies (MPOWER) are well established at international level, a similar situation does not exist in the Region (22). In 2005, the Regional Committee of the EMR adopted the first 'Regional Strategy on Health promotion'. Based on the Ottawa Chapter (22), the definition of health promotion was 'the process of enabling people to increase control over and to improve their health'. Seventeen Member States of the EMR are party to the WHO FCTC. Although there is still no formal evaluation of the impact of implementation of the Convention, the provisions and adopted guidelines of the treaty provide an indication of how far the WHO FCTC has come as a tool for change in health promotion. It is based on the previously published Tobacco Control Scale and using MPOWER measures of the WHO Tobacco Free Initiative and the Tobacco Atlas. Only 3 of the 21 countries scored higher than 50 out of 100: Islamic Republic of Iran, Jordan and Egypt. More than half of the countries scored less than 26. The low mean total score in EMR countries (29.7) compared with European countries (47.2) highlights the need for better future planning and policy-making for tobacco control in the region. The findings of several studies indicated that people who smoked waterpipe carried a higher risk for poorer health-related quality of life. Countries are advised to take a more comprehensive approach in implementing the FCTC rather than a step-by-step approach. Countries of the region are now at a historically critical moment. There is strong momentum for tobacco control: the political situation is in favour of tobacco control; the international atmosphere is supportive of tobacco control; taking this chance at this right moment is vital. Undermining this potential will result in non-reimbursable losses for decades. And our loss of lives will continue due to this destructive epidemic.

The WHO's Study Group on Tobacco Product regulation (TobReg) urges consideration of the following public health initiatives to reduce narghile smoking and associated disease (23).

1. Narghiles and narghile tobacco should be subjected to the same regulation as cigarettes and other tobacco products.

2. Narghiles and narghile tobacco should include strong health warnings.

3. Claims of harm reduction and safety should be prohibited.

4. Misleading labelling, such as "contains 0 mg tar", which may imply safety should be prohibited.

5. Narghiles should be included in comprehensive tobacco control efforts, including prevention strategies and cessation interventions.

6. Narghiles should be prohibited in public places consistent with bans on cigarette and other forms of tobacco smoking.

7. Education of health professionals, regulators and the public at large is urgently needed about the risks of narghile smoking, including high potential levels of secondhand exposure among children, pregnant women, and others.

8. The TobReg recommends that a full document be produced in the WHO Technical Report Series to evaluate thoroughly the health effects of narghiles and to develop recommendations.

The social, health and economic burden of tobacco use costs the Kingdom of Saudi Arabia up to five billion Riyals nearly per year (1.3 billion US$). The Saudi Arabian Tobacco Control Program came to stand against this. The Tobacco Control Program (TCP) is considered one of the most important means of the Ministry of Health to stand against all types and forms of tobacco use, where the program provides services in

several fields, such as awareness, scientific and consultation issues concerning tobacco use and its harms and ways to stand against it. Also the program established a series of Tobacco Control clinics all over the Kingdom. The details of TCP in Saudi Arabia can be seen from the " Report on Tobacco Control Program of Ministry of Health in Saudi Arabia".

Saudi Arabia has in the past had almost no restrictions against smoking. However, on 20 June 2010, the Council of Ministers urged the General Authority of Civil Aviation (GACA) to restrict smoking at all airports and their facilities in the Kingdom, and strict rules were imposed. It also advised GACA to impose a fine of US$53 on people who violate the new regulations. Many commercial buildings and work places banned smoking at offices in an attempt to stop smoking in public places

CONCLUSION

Smoking a narghile involves many health risks including lung cancer. There are a limited number of studies concerning narghile smoking compared with those on cigarette smoking. The aim of this study was to shed more light on the radon concentration in moassel tobacco that is used for narghile smoking. The results of this study indicate the existence of a wide range of variations in ^{222}Rn and ^{220}Rn contents in moassel tobacco that could be due to the non-standard manufacture procedure and/or their variation in tobacco. The highest concentrations of ^{222}Rn and ^{220}Rn were observed in T5 and T3 samples respectively. This is mainly attributable to the soil and fertilizers, which are the source of the isotopes. Annual equivalent doses due to radon, thoron and its short-lived daughters from the inhalation of various moassel tobacco smoke have been evaluated. The radon and thoron concentrations have been found to be higher in smoke-rich air than the smoke-free environment.

The application of fertilizers in the soil to enhance the crop yield enhances the activity concentration, radon and radium concentration and radon exhalation rates. Efforts should be made at national and international level to reduce Ra-226 activity in the fertilizers, like extracting uranium from phosphoric acid by solvent extraction method, so that the fertilizers are more eco-friendly. Radon mitigation should accompany narghile smoking cessation measures in lung cancer prevention efforts. Both former and current narghile smokers should be advised to eat lots of fruits, fresh vegetables and green salads everyday and also to participate in physical activities regularly.

Unfortunately, there is an extreme dearth of research on the activity concentration of natural radionuclides in moassel tobacco that is used for narghile smoking. We wish to emphasize on the urgent needs for more research on the activity concentration of natural radionuclides in tobacco products especially moassel and juark, their behavior during smoking, the effect of different parameters, such as temperature, water filter, pH and others, and on their concentration in smoke and smokers' intake.

The impact of narghile smoking on the incidence of type 2 diabetes mellitus can also be investigated since smoking increases the incidence of type 2 diabetes. Waterpipe smoking posed a higher risk for poorer health-related quality of life and should therefore be of high priority for health planners.

In order to reduce narghile smoking, action should be taken through different interventions. The health professionals, educators, and parents should be made aware of harmful effects of naghile smoking. The media should be used to convey the message that smoking a narghile is at least as dangerous as smoking cigarettes. Public health authorities should lead the struggle against narghile smoking as the impact of its use is expected to affect the health and life of many. Research should focus on the behavioral aspects of the young population who are exposed to narghiles. Behavioral modification techniques, change in cultural attitudes towards narghile use, and legislative actions should be applied in concert to find the way to the hearts and minds of narghile users. Finally, since people fear everything that is radioactive, measures must be taken for the placement of a clear indication about the radioactivity content on narghile tobacco packages.

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