

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Chemical Applications to Human Health

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ABSTRACT: Exposure to various chemicals occurs every day and through multiple routes such as ingestion, inhalation, skin contact and via the umbilical cord to the unborn child. Many chemicals are harmless or even beneficial; others are a threat to our health and to the environment. Chemicals production continues to increase and, with it, the potential for chemical exposure. They include pesticides, asbestos, various other household and occupational chemicals, ambient and household air pollution, second-hand tobacco smoke, lead and arsenic. Estimates of health impacts are presented for a selection of chemicals with sufficient evidence for global quantification.

KEYWORDS: chemical, exposure, health, environment, pollution, health impacts, chemical quantification

1. INTRODUCTION

Just over one third (35%) of ischaemic heart disease, the leading cause of deaths and disability worldwide, and about 42% of stroke, the second largest contributor to global mortality, could be prevented by reducing or removing exposure to chemicals such as from ambient air pollution, household air pollution, second-hand smoke and lead.¹ Chemicals such as heavy metals, pesticides, solvents, paints, detergents, kerosene, carbon monoxide and drugs lead to unintentional poisonings at home and in the workplace. Unintentional poisonings are estimated to cause 193 000 deaths annually with the major part being from preventable chemical exposures.^{1,2} The list of chemicals classified as human carcinogens with sufficient or limited evidence is long.³ Occupational carcinogens are estimated to cause between 2% and 8% of all cancers.⁴ For the general population it is estimated that 14% of lung cancers are attributable to ambient air pollution, 17% to household air pollution, 2% to second-hand smoke and 7% to occupational carcinogens.^{1,2,5}

Exposure to certain chemicals, such as lead, is associated with reduced neurodevelopment in children and increases the risk for attention deficit disorders and intellectual disability. Parkinson's disease has been associated with exposure to pesticides. Other links between mental, behavioural and neurological disorders are suspected; evidence, however, is more limited.¹ Air pollution and second-hand smoke are risk factors for adverse pregnancy outcomes like low birth weight, prematurity and stillbirths. Antenatal exposure to second-hand smoke for example was estimated to increase the overall risk for stillbirths by 23% and for congenital malformations by 13%.⁶ There are, furthermore, potential links between various chemicals and adverse pregnancy outcomes or congenital malformations, though evidence is limited.¹ Cataracts, the most important cause of blindness worldwide, can develop from exposure to household air pollution. Exposure to cookstove smoke was estimated to be responsible for 35% of cataract disease burden in women and 24% of the overall cataract disease burden.^{2,7} Second-hand smoke and air pollution are also responsible for 35% of acute lower respiratory infections, including pneumonia, bronchitis and bronchiolitis, the most important cause of mortality in children, and are also linked to upper respiratory infections and otitis media.^{1,2,5} More than a third (35%) of overall chronic obstructive pulmonary disease (COPD) burden is caused by exposure to chemicals in second-hand smoke, air pollution or occupational gases, fumes and dusts.^{2,5} Second-hand smoke and air pollution can induce reduced lung function and a predisposition for pulmonary disease in unborn and young children.¹ Second-hand smoke and air pollution can lead to the development of, and increased morbidity from, asthma. Air pollution additionally provokes asthma exacerbations and increases related hospital admissions. Asthma from occupational asthmagens is among the most frequent diseases related to the workplace.¹ Over 800 000 individuals die from suicides every year.² About 20% of suicides could be prevented through restricting access to poisons (estimate based on expert survey and limited epidemiological data). Self-poisoning with pesticides is the main means of suicide in India, China and some central American countries.^{1,2,8,9,10}

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II.DISCUSSION

Industrial emission control; improved energy options; indoor tobacco smoke-free legislation. Occupational exposure to chemicals, air pollutants: workers' personal protection; education on protective behaviour; engineering approaches to reduce exposure, such as ventilation, dust suppression techniques, enclosure of pollution sources etc.; removal from sources of pollutants or other relevant exposures, regulations. Exposure to industrial chemicals (workers, consumers): legislation, treaties. Water pollution: industrial emission control. Legislative smoking bans implemented for example in various European countries, Canada and the United States reduced exposure to second-hand smoke both in public and in workplaces and also reduced hospital attendance for childhood asthma, risk of acute coronary events and preterm births and improved cardiac health. Effective control measures in the workplace to reduce exposure to hazardous chemicals and to prevent work-related cancer, pneumoconiosis, chronic obstructive pulmonary disease and asthma include enclosure of pollution sources, local exhaust ventilation, specialized ventilation systems, dust suppression techniques and worker separation. Removing workers with occupational asthma from the relevant exposure reduced asthma symptoms and increased lung function. Eliminating exposure to asthma allergens was also effective for the primary prevention of occupational asthma. Banning the use of all forms of asbestos, phase-out of mercury, harmonized chemicals management, safe handling and disposal of obsolete pesticides and other obsolete chemicals, safe and environmentally sound waste management, legislation on cancer-related chemicals. Coincidental interventions such as a closure of a steel mill (United States) and a nationwide copper smelter strike (United States) decreased air pollution levels and health impacts.^{1,2,3}

Traffic control and improved public transportation schemes; reduction of traffic congestion; replacement of older diesel vehicles, etc. Ambient air pollution legislative interventions such as the reduction of fuel sulfur content (Hong Kong SAR, China), stronger regulations during Olympic Games (United States and China), congestion charging schemes (London and Stockholm) decreased different air pollutants and measurable adverse health impacts (mainly reduced cardiovascular and respiratory morbidity and mortality). Phasing out of leaded petrol was paralleled by a steady decline in the population's mean blood lead levels in most countries globally

There are 3 ways to be exposed to chemicals and pollutants:

inhaling (breathing in)

absorption (skin and eye contact)

ingesting (eating or drinking)

Inhaling (breathing in)

You are exposed to chemicals and pollutants when you inhale (breathe in). You take over 20,000 breaths a day. This number can be much higher for infants and children. The chemicals and pollutants you inhale can end up in your lungs and blood stream. Sometimes, you can smell or taste harmful chemicals, but it isn't always so easy. Some chemicals, like radon or carbon monoxide, are odourless, tasteless and invisible.

Absorption (skin and eye contact)

You can be exposed to chemicals and pollutants by coming into contact with them through your skin and eyes. These organs can be more sensitive to chemicals and may react more quickly than the rest of your body.

Ingesting (eating or drinking)

You're exposed to chemicals and pollutants when you eat and drink. Chemicals and pollutants are found in both our food and water sources.

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Household air pollution: use of clean fuels; strategies to reduce exposure to smoke from solid fuels – implementation of WHO Indoor Air Quality Guidelines. Exposure to chemicals: safe management of chemicals in the home and community. Interventions reducing exposure to household solid fuel smoke through modern energy sources and cooking technologies reduced acute lower respiratory infections, lung function decline, respiratory symptoms and diastolic blood pressure. Home safety interventions conducted in many countries including the United States, Canada, Australia, South Africa and various European countries were effective in increasing the proportion of families storing medicines (53% increase) and cleaning products (55% increase) out of reach, and having the poison centre numbers accessible (330% increase).

Accidents or incorrect use of household chemical products may cause immediate health effects, such as skin or eye irritation or burns, or poisoning.

There can also be longer-term health effects from chemicals. When these occur, they're usually the result of exposure to certain chemicals over a long period.

Depending on the chemical, longer-term health effects might include:

cancer

organ damage

weakening of the immune system

development of allergies or asthma

reproductive problems and birth defects

effects on the mental, intellectual or physical development of children

Exposure to arsenic and other chemicals in drinking-water: implementation of WHO Drinking-water Quality Guidelines; strategies to reduce exposure to arsenic and other chemicals in drinking-water. Provide drinking-water with arsenic below 10 µg/l in areas where level is high via: • Collecting rainwater (caveat: prevent microbial contamination and mosquito breeding); • Water testing for arsenic levels; • Centralized or domestic arsenic removal systems; and • Discriminating between high- and low-arsenic water sources.^{11,12,13}

III.RESULTS

Agriculture • Estimated annual illness costs of acute poisonings in Nepalese farmers due to pesticide use was nearly one third of total annual health-care costs. • In Paraná, Brazil, for each dollar spent on pesticides, approximately US\$ 1.28 may be spent on health care and sick leave due to occupational poisoning. Industry/Commerce • In Hong Kong SAR, China, annual direct costs of medical care, long-term care and productivity loss from second-hand smoke were estimated at US\$ 156 million. • In the United States, the yearly treatment costs for ischemic heart disease from second-hand smoke were estimated between US\$ 1.8–6.0 billion. • Introducing smoke-free legislation in all United States workplaces would result in an estimated US\$ 49 million savings in direct medical costs. • Implementing smoke-free workplaces was estimated to be about nine times more cost-effective per new non-smoker than free nicotine replacement therapy programmes. • Cleaning-up polluted industrial sites and hazardous waste dumps to prevent health effects in the Campania region in Italy was judged as cost-beneficial. • Occupational cancer deaths in Italy were estimated to cost around €360 million in indirect economic loss and €456 million for health care. Occupational lung and bladder cancer cost the Spanish national health system €88 million. In France occupational respiratory cancers were also shown to be a considerable economic burden. • Total costs of occupational asthma in the United Kingdom were estimated at between £95–135 million. TRANSPORT • In Taiyuan, China, the total health damage from air pollution (particulate matter) was estimated to amount to 2.4–4.9% of the city's GDP. • For Mumbai, India, the total costs of health impacts were estimated at US\$ 113 million for a 50-mg/m³ increase in PM₁₀, and US\$ 218 million for

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a similar increase in NO₂. • For Barcelona, Spain, reducing PM₁₀ exposure from 50 mg/m³ to 20 mg/m³ was estimated to lead to 3 500 fewer deaths, 1 800 fewer hospitalizations for cardio-respiratory diseases, 5 100 fewer cases of chronic bronchitis among adults, 31 100 fewer cases of acute bronchitis among children, and 54 000 fewer asthma attacks among children and adults and related savings of €6 400 million per year. • For Denmark, the potential health-care system savings from reducing ambient air pollution (PM_{2.5}) and the resulting cost reductions for coronary heart disease, stroke, chronic obstructive pulmonary disease and lung cancer were estimated at €0.1–2.6 million per 100 000 people. The productivity costs from leaving the labour market due to those four diseases from exposure to PM_{2.5} were estimated at €1.8 million per 100 000 people aged 50–70. • Annual childhood asthma-related costs attributable to air pollution in two United States communities were estimated at US\$ 18 million and were mainly borne by the children's families. Exposure to PM_{2.5} was furthermore positively associated with increased costs of childhood asthma hospitalizations. • The economic cost of premature deaths from ambient and household air pollution was estimated to amount to US\$ 1.5 trillion in the European Union. The health risks of chemicals and pollutants depend on several factors, including:

the amount you're exposed to

the type of chemical or pollutant

when and how long you're exposed

your age and general state of health

how you're exposed (through air, products, food, water and soil)

People that may be more sensitive to or more harmed by exposures from chemicals and pollutants include:

children

seniors

pregnant people

Indigenous Peoples^{8,9,10}

IV.CONCLUSIONS

Lead-safe window replacements in all pre-1960 homes in the United States would yield a net benefit of at least US\$ 67 billion; additional benefits would include, for example, avoided attention deficit hyperactivity disorder, reduced crime and delinquency, and associated long-term costs of climate change. • Lead paint hazard control in homes to prevent children's exposure would yield a net saving of US\$ 181– 269 billion in the United States if considering costs of health care, lifetime earnings, tax revenue, special education, attention deficit hyperactivity disorder and direct costs of crime associated with elevated lead exposure. Investing in such control measures, especially targeted at early intervention of lead poisoning in communities most likely at risk, would be very cost-effective. • Various interventions replacing solid fuels for cooking and heating or investing in cleaner cookstoves were evaluated as cost-effective. • Regulations on residential wood burning in California, United States, were estimated to save between US\$ 200–400 million mean annual mortality costs and between US\$ 6–27 million morbidity costs from cardiovascular and respiratory diseases per metropolitan area.^{12,13}

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