The effects of air pollution on the health of children

Irena Buka FRCPC[1,2], Samuel Koranteng MB ChB[1], Alvaro R Osornio-Vargas MD PhD[3]

I Buka, S Koranteng, AR Osornio-Vargas. The effects of air pollution on the health of children. Paediatr Child Health 2006;11(8):513-516.

The present article is intended to inform paediatricians about the associations between ambient air pollution and adverse health outcomes in children within the context of current epidemiological evidence.

The majority of the current literature pertains to adverse respiratory health outcomes, including asthma, other respiratory symptoms, and deficits in lung function and growth, as well as exposure to ambient levels of criteria air pollutants. In addition to the above, the present article highlights mortality, pregnancy outcomes, vitamin D deficiency and alteration in the immune system of children.

Some of the data on the impact of improved air quality on children's health are provided, including the reduction of air pollution in former East Germany following the reunification of Germany, as well as the reduction in the rates of childhood asthma events during the 1996 Summer Olympics in Atlanta, Georgia, due to a reduction in local motor vehicle traffic. However, there are many other toxic air pollutants that are regularly released into the air. These pollutants, which are not regularly monitored and have not been adequately researched, are also potentially harmful to children.

Significant morbidity and mortality is attributed to ambient air pollution, resulting in a significant economic cost to society. As Canada's cities grow, air pollution issues need to be a priority in order to protect the health of children and support sustainable development for future generations.

Key Words: *Air pollution; Children; Environmental health; Health outcomes*

Les effets de la pollution atmosphérique sur la santé des enfants

Le présent article vise à informer les pédiatres des associations entre la pollution atmosphérique et les issues de santé négatives chez les enfants, compte tenu des données épidémiologiques courantes.

La majorité des publications portent sur les effets négatifs en santé respiratoire, y compris l'asthme, les autres symptômes respiratoires et les déficits de la fonction et de la croissance pulmonaires, ainsi qu'une exposition aux niveaux ambiants d'émissions de pollution atmosphérique. Outre ce qui précède, le présent article souligne la mortalité, les issues des grossesses, la carence en vitamine D et l'altération du système immunitaire des enfants.

Certaines des données sur les répercussions de l'amélioration de la qualité de l'air sur la santé des enfants sont présentées, y compris la diminution de la pollution atmosphérique dans l'ancienne Allemagne de l'Est après la réunification de l'Allemagne, ainsi que la réduction des taux de crises d'asthme chez les enfants pendant les Olympiques d'été 1996 à Atlanta, en Géorgie, en raison de la diminution de la circulation de véhicules automobiles. Cependant, de nombreux autres polluants atmosphériques toxiques sont régulièrement libérés dans l'atmosphère. Ces polluants, qui ne sont pas surveillés régulièrement et qui n'ont pas fait l'objet de recherches suffisantes, peuvent également être dommageables pour les enfants.

On attribue une morbidité et une mortalité marquées à la pollution atmosphérique, associées à des coûts économiques importants pour la société. À mesure que les villes canadiennes prennent de l'expansion, la question de la pollution atmosphérique doit être une priorité, afin de protéger la santé des enfants et de soutenir le développement durable pour les prochaines générations.

An interest in the study of the adverse health effects of ambient air pollution in children has been evident in the scientific literature in recent years. The Committee on Environmental Health of the American Academy of Pediatrics issued a policy statement in 2004 emphasizing the link between ambient air pollution and children's health (1). Children are known to be more vulnerable to the adverse health effects of air pollution due to their higher minute ventilation, immature immune system, involvement in vigorous activities, the longer periods of time they spend outdoors (2,3) and the continuing development of their lungs during the early postneonatal period (2,4).

A large number of epidemiological studies have reported an association between exposure to criteria air pollutants and several morbidity (5,6) and mortality (7,8) outcomes in children. Criteria air pollutants consist of six air pollutants that are regulated on the basis of their potential to cause adverse health and/or environmental effects: ozone (O_3), particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide and lead. In the present commentary, we intend to highlight the adverse health outcomes associated with exposure to criteria air pollutants in children. The purpose of the present article is to inform paediatricians about the current epidemiological evidence

[1]*Paediatric Environmental Health Specialty Unit, Misericordia Community Hospital;* [2]*Department of Paediatrics, University of Alberta, Edmonton, Alberta;* [3]*División de Investigación Básica, Instituto Nacional de Cancerología, Mexico City, Mexico*

Correspondence: Dr Irena Buka, Paediatric Environmental Health Specialty Unit, Misericordia Community Hospital, 3 West, #16940 – 87 Avenue, Edmonton, Alberta T5R 4H5. Telephone 780-735-2731, fax 780-735-2794, e-mail ibuka@cha.ab.ca

on the associations between ambient air pollution and adverse health outcomes in children.

ADVERSE EFFECTS OF CRITERIA AIR POLLUTANTS ON CHILDREN'S HEALTH

Mortality outcomes

Ambient air pollution has been linked to increased mortality in children (8) and adults (9). Sudden infant death syndrome, a leading cause of postneonatal mortality in Canada (10) and other developed countries (11), has been associated with exposure to criteria air pollutants (12). In a systematic review of the literature on the association between ambient air pollution and infant mortality, Glinianaia et al (7) observed a consistent and significant association between PM and postneonatal mortality due to respiratory causes, as well as sudden infant death syndrome. Other studies have reported a significant relationship between ambient air levels of criteria air pollutants and mortality in children younger than five years of age (13).

Adverse pregnancy outcomes

Ambient levels of criteria air pollutants have been associated with adverse pregnancy outcomes, including premature birth, low birth weight, intrauterine growth retardation (14), abnormal birth length, abnormal head circumference (15) and small size for gestational age (16). However, no specific trimester has been identified as the most vulnerable period of gestation during which air pollution might be most harmful to the fetus.

Increased risk of birth defects

Currently, only one study has investigated the effects of ambient air pollution on birth defects. Ritz et al (17) observed a significant association between prenatal exposure to carbon monoxide and cardiac ventricular septal defects, while O_3 was associated with an increased risk of aortic artery and valve defects, as well as pulmonary artery and valve defects.

Adverse respiratory heath outcomes

Exposure to ambient levels of criteria air pollutants has been associated with several acute and chronic adverse respiratory health effects in both asthmatic (18) and nonasthmatic (19) children, although asthmatic children have been shown to be more susceptible to the adverse health effects of ambient air pollution (18). Several studies have linked ambient air pollution to an increased prevalence of asthma symptoms (20,21), as well as an increased incidence (22) and prevalence (22,23) of childhood asthma, particularly among children who regularly engage in sporting activities and those with increased asthma medication use (20,21,24), increased asthma emergency department visits (6,21,25,26) and increased hospitalization due to asthma (27-29). Other studies have documented an inverse relationship between exposure to criteria air pollutants and lung function in both asthmatic (30) and nonasthmatic (19) children. There is evidence suggesting that current levels of ambient air pollutants may cause deficits in lung function growth in children (31-33). Ambient air pollution has been associated with increased reporting of respiratory symptoms among nonasthmatic children (34), as well as increased respiratory hospital admissions (34,35) and emergency department visits (36) for children.

School absenteeism

Although the results from epidemiological studies suggest that both short-term and long-term exposure to ambient air pollution may contribute to illness-related school absenteeism, these data are not consistent. Day-to-day changes in the levels of criteria air pollutants (PM_{10}, SO_2, NO_2 and O_3) have been associated with illness-related absenteeism (37-40), while short-term changes in O_3 and SO_2 have been linked to respiratory illness-related elementary school absenteeism (37,38). However, Park et al (39) did not observe a correlation between varying ambient air levels of NO_2 and illness-related school absences. Rondeau et al (40) reported a link between long-term exposure to ambient levels of O_3 and illness-related school absenteeism, but did not find anything for acute exposure. In addition, the investigators did not find any significant association between daily levels of ambient air pollution and respiratory illness-related school absenteeism (40).

Altered immunity

Exposure to ambient levels of criteria air pollutants has been shown to cause alteration in the immune system in children. Leonardi et al (41) studied the impact of ambient air pollution on the immune system of school children between nine and 11 years of age in 17 cities in Europe and found that ambient air pollution may alter both cellular and humoral immunity in children. However, a study conducted in Chile by Ruiz et al (42) found no association between ambient air pollution and the humoral immune system in children. Emerging evidence from animal toxicological studies suggest that ambient air pollution may cause suppression of host immunity (43,44).

Increased risk of vitamin D-deficiency rickets

In the tropics, children who live in regions with higher levels of ambient air pollution have been shown to be at increased risk of developing vitamin D-deficiency rickets compared with those residing in less polluted areas (45). The amount of solar radiation in the ultraviolet B range reaching ground level has been found to be inversely related to the level of ambient air pollution (haze). Ultraviolet B radiation emitted by the sun is required for the conversion of 7-dehydrocholesterol to cholecalciferol (vitamin D_3) (45).

The effects of improved air quality on children's health

A decline in ambient air levels of SO_2 and total suspended particulates in former East Germany following the reunification of Germany led to improvements in the results of lung function studies in children and a reduction in the prevalence of respiratory illnesses such as bronchitis, sinusitis

and frequent colds (46). Children in the United States who relocated to states with lower levels of ambient air PM_{10} showed increased growth in lung function studies, while those who relocated to states with higher PM_{10} experienced decreased growth in lung function (47). A 27.9% decline in daily peak O_3 concentrations from 81.3 parts per billion to 58.6 parts per billion during the 1996 Summer Olympics in Atlanta, Georgia, resulted in a significant reduction in the rates of childhood asthma events (48). Wong et al (49) used a benefit-cost analysis framework to assess the impact of criteria air pollutants on children's health and to quantify the health and economic benefits associated with a reduction in criteria air pollutant levels; they reported substantial health and economic benefits following a reduction in air pollutant levels.

Other air pollutants

Although the present article is restricted to the health effects of criteria air pollutants, there are many other toxic air pollutants regularly released into the air that have the potential to harm children (50). Studies are appearing in the literature identifying potential exposures and health effects (51-53). The effects of air pollutants on genetic material are being investigated (54,55). Further studies may lead to a better understanding of not only childhood disorders, but possibly adult ones too.

CONCLUSIONS

Significant morbidity and mortality in children is attributed to ambient air pollution at great economic cost to society. As our cities grow and our population increases, we need to be aware of air pollution and its effects on children. Further studies are needed in Canada to improve our understanding of air pollution on the health of children to aide policy-makers in decisions that relate to the sustainability of development.

Consideration needs to be given to emerging science on nonregulated pollutants that may be affecting the health of children today and may also be endangering future generations by affecting genetic material. Local data from different environments across Canada will help paediatricians in their roles as clinicians, educators and advocates. Significant research opportunity needs to be created to collect these data. This challenge needs to be addressed if we are to protect the health of children in the coming generations.

ACKNOWLEDGEMENTS: The authors sincerely thank Bronia Heilik (BA, BLS) and Elizabeth Mortimer for library assistance, and Michelle Huculak for her administrative assistance.

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