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Current progress on understanding the impact of mercury on human health

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ABSTRACT

Mercury pollution and its impacts on human health is of global concern. The authors of this paper were members of the Plenary Panel on Human Health in the 12th International Conference on Mercury as a Global Pollutant held in Korea in June 2015. The Panel was asked by the conference organizers to address two questions: what is the current understanding of the impacts of mercury exposure on human health and what information is needed to evaluate the effectiveness of the Minamata Convention in lowering exposure and preventing adverse effects. The authors conducted a critical review of the literature published since January 2012 and discussed the current state-of-knowledge in the following areas: environmental exposure and/or risk assessment; kinetics and biomonitoring; effects on children development; effects on adult general populations; effects on artisanal and small-scale gold miners (ASGM); effects on dental workers; risk of ethylmercury in thimerosal-containing vaccines; interactions with nutrients; genetic determinants and; risk communication and management. Knowledge gaps in each area were identified and recommendations for future research were made. The Panel concluded that more knowledge synthesis efforts are needed to translate the research results into management tools for health professionals and policy makers.

1. Introduction

Mercury (Hg) is a global pollutant that affects human and ecosystem health (UNEP, 2013a, 2013b). The awareness of the health effects of Hg pollution began in the 1950s when chemical waste was released into the nearby sea by the Chisso Corporation in Minamata, Japan. This waste led to the accumulation of the more bioavailable form of Hg, i.e. methylmercury (MeHg) in fish, and as a consequence it resulted in devastating health effects to thousands of local populations who consumed the fish as their main food source (Kurland et al., 1960). It is well documented that prenatal or postnatal exposure to MeHg produces adverse neurological impacts in adults and children, now known as Minamata Disease (Harada, 1995). These patients with chronic Hg poisoning complain of distal paresthesias of the extremities and the lips even 30 years after cessation of exposure to MeHg (Ekino et al., 2007). Moreover, more recent evidence showed that even the general population exposed to MeHg in Minamata who were not certified Minamata Disease patients showed increased risk of psychiatric symptoms (e.g., impairment of intelligence and mood and behavioral dysfunction) (Yorifuji et al., 2011). With increasing awareness of environmental stewardship, an incidence of acute Hg poisoning from industrial pollution like Minamata has become rare. However, the scale of chronic exposure to a lower dose of Hg as a result of global pollution or occupational hazard has grown. For example, the Food and Agriculture Organization (FAO)/World Health Organization (WHO) identified that billions of people

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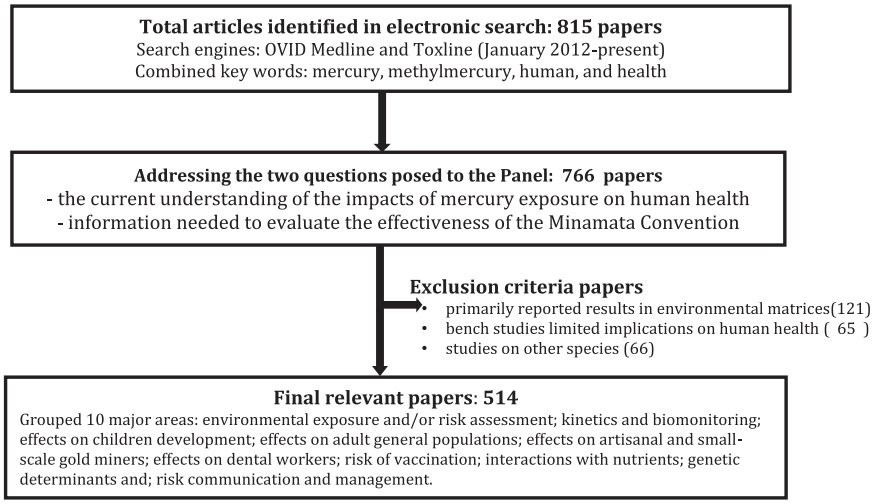

Fig. 1. Flow chart of literature search for the impacts of mercury on human health.

worldwide who rely on fish as their major source of protein in their diet are at risk of increased exposure to MeHg (FAO/WHO, 2011). Artisanal and small-scale gold mining is another major contributor to mercury consumption and emissions into the environment affecting millions of people particularly in low- and middle-income countries (Veiga et al., 2006).

These growing concerns have led to the initiation of numerous international efforts to address these issues. For example, the United Nations Environment Programme (UNEP) has implemented a number of global projects that aim to decrease human health and environmental risk from the release of Hg, as well as to improve the understanding of international Hg emissions and their transport and fate (UNEP, 2013a). Most significantly, an international treaty (Minimata Convention on Mercury) was signed in October 2013 to control the global release of Hg to the environment (UNEP, 2013b). The objective of the Minamata Convention, as indicated in Article 1, is "to protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds" (UNEP, 2013b). The Convention recognizes that anthropogenic emissions are a serious threat to human and environmental health and each signing nation will make a commitment to reduce the emission and use of Hg to protect human and environmental health. By the end of 2015, the Minamata Convention has been signed by 128 countries and ratified by 20 countries. It will go into effect after 50 countries have deposited their instruments of ratification, acceptance, approval, or accession which is expected to occur in 2017. Article 16 of the Convention relates to the concern on human health aspects. It encourages states to promote strategies to: 1) identify all the population affected by Hg pollution; 2) to adopt health guidelines regulating Hg exposure; and 3) to provide education about the dangers of Hg exposure. Countries should provide appropriate health-care for treatment and care for people who are already exposed to Hg compounds. It is clear that more scientific knowledge is needed to fully understand effects of Hg emission reduction on environmental concentrations and identify other factors leading to reduced human exposure and resulting in the prevention of adverse outcomes. Moreover, integration of science with national and international policy efforts is needed to target efforts in the implementation of the intervention and to evaluate the effectiveness of the Convention on improving health.

The authors of this paper were invited by the organizing committee of the 12th International Conference on Mercury as a Global Pollutant held in Korea in June 2015 to be members of the Plenary Panel on Human Health. The Panel was challenged to prepare presentations to address two questions: what is the current understanding of the impacts of Hg exposure on human health and what information is needed to evaluate the effectiveness of the Minamata Convention in lowering exposure and preventing adverse effects. This review paper is prepared based on the presented materials and discussions at the Conference. In addition, a systemic review of the literature was conducted to assured all the most recent publications are included in our attempt to address these questions.

2. Methods

A literature search was conducted in OVID Medline (January 2012-present) and Toxline (January 2012-present). The search strategy combined terms for mercury, methylmercury, human, and health. The rationale for the choice of inclusion period was based on the publication of the latest review paper of this nature by Driscoll et al. (2013) that cited bibliography published until the end of 2011. The included papers were grouped into the following 10 major areas: environmental exposure and/or risk assessment; kinetics and biomonitoring; effects on children development; effects on adult general populations; effects on artisanal and small-scale gold miners; effects on dental workers; risk of vaccination; interactions with nutrients; genetic determinants and; risk communication and management. Selected publications were included in this critical review in the context of addressing the two questions posed to the Panel (Fig. 1).

3. Results

The literature search found a total of 815 papers published between Jan 1, 2012 to present. A screening found that 514 are relevant (Table 1). The others primarily reported results in environmental matrices, bench-based studies that have limited immediate implications on human health, or studies on other species.

The relative number or percentages of publications in the 10 different areas of Hg research may reflect the recent research focus. It is not surprising that the highest number of papers (21%) was on environmental monitoring and exposure assessment. This is the first step of hazard identification in many regions around the world. There was almost an equal number of studies reporting effects of Hg on maternal-child health (15%) and adult fish

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