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ABSTRACT

While past studies have detected heavy metals in aerosols emitted from electronic cigarettes (ECIG), they have provided little information detailing the practical implications of the findings to the Malaysian population due to variations between products. The aims of this study were to analyse heavy metals of interest (HMOI) in the aerosols emitted from selected ECIG and to evaluate potential health risks by referring to the permissible daily exposure (PDE) from inhalational medications defined by the United States Pharmacopeia Chapter 232. All four HMOI were detected in aerosols emitted from the selected ECIG in Sarawak. Among the four, Cr was present at the highest median levels (6.86 ng/m³), followed by Ni (0.30 ng/m³), Pb (0.19 ng/m³) and Cd (0.01 ng/m³). Five out of 100 combinations (5%) of ECIG and ECIG liquids were found to emit Cr that exceed the recommended PDE. Future studies examining more heavy metal variants, using a larger sample size and different analytical techniques to compare various ECIGs are recommended.

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Introduction

To date, the safety and legislation of electronic cigarettes (ECIG) continuously draws the attention of scholars, public health professionals, policy makers, governmental regulatory and public interest groups with intensive research and debate that is ongoing.^[1-3] While some countries have banned ECIG and some have approved the use and sale of ECIG along with regulations,^[4-5] other countries, including Malaysia,^[6] are in the midst intensive discussion and debate among stakeholders to establish the most appropriate legislation regarding EICGs.^[3]

Past research has revealed that heavy metals including lead (Pb), nickel (Ni), chromium (Cr), cadmium (Cd), iron (Fe), tin (Sn), zirconium (Zr), strontium (Sr), manganese (Mn), titanium (Ti), copper (Cu), aluminium (Al) and barium (Ba) are detectable in aerosols emitted from ECIG (Table 1).^[7-9]

These heavy metals are potentially hazardous to human body, especially when they are inhaled at levels that exceed permissible daily exposure (PDE) from inhalational medications as defined in the United States Pharmacopeia (U.S.P.) Chapter 232.^[10] Among the heavy metals detected in the aerosols emitted from EICGs, Cd, Cr, Pb and Ni have the

lowest PDE limits, which are 2.0 µg, 3.0 µg, 5.0 µg and 5.0 µg, respectively.^[10] In terms of their toxicities, Cd and Pb are known as metalloestrogens, because they can disrupt the endocrine functionality in human body.^[11] Inhalation of excessive Cr can cause respiratory irritation and Cr (VI) is found to be carcinogenic at cellular level while Cr (III) is potentially genotoxic.^[12,13] Ni is classified as Group 1 carcinogen and was found to be associated with both chronic bronchitis and pulmonary cancer.^[14,15]

Notwithstanding evidence demonstrating the hazardous effects of the aforementioned heavy metals, the actual health risk from the inhalation of heavy metals from ECIG requires further evaluation to elucidate effects of specific dosages and durations of exposure.^[2] This will allow researchers to translate laboratory findings into potential health risks. To this end, this study has adopted the assessment method used by Farsalinos and colleagues.^[2] Nevertheless, the ability to make generalizations based on past research is limited, since heavy metal content in aerosols emitted from ECIG vary among products.^[7-9] Notably, Hess and colleagues have urged more researchers to investigate heavy metals in aerosols emitted from ECIG from a wider variety of products.^[16] To bridge gaps in the literature, this study aimed to investigate the type and level of heavy metals in aerosols emitted