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• Commentary

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Increase of diesel car raises health risk in spite of recent development in engine technology

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Diesel exhaust particles (DEP) contain elemental carbon, organic compounds including Polyaromatic hydrocarbons (PAHs), metals, and other trace compounds. Diesel exhaust is complex mixture of thousands of chemicals. Over forty air contaminants are recognized as toxicants, such as carcinogens. Most diesel exhaust particles have aerodynamic diameters falling within a range of 0.1 to 0.25 μm. DEP was classified as a definite human carcinogen (group 1) by the International Agency for Research on Cancer at 2012 based on recently sufficient epidemiological evidence for lung cancer. Significant decreases in DEP and other diesel exhaust constituents will not be evident immediately, and outworn diesel car having longer mileage still threatens health of people in spite of recent remarkable development in diesel engine technology. Policy change in South Korea, such as introduction of diesel taxi, may raise health risk of air pollution in metropolitan area with these limitations of diesel engine. To protect people against DEP in South Korea, progressive strategies are needed, including disallowance of diesel taxi, more strict regulation of diesel engine emission, obligatory diesel particulate filter attachment in outworn diesel car, and close monitoring about health effects of DEP.

Keywords: Air pollution, Diesel engine technology, Diesel exhaust particles, Human carcinogen

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What Are Diesel Exhaust Particles?

Large populations are exposed to diesel exhaust in everyday life, whether through their occupation or through the ambient air. Especially near highways and high traffic areas, people are exposed to traffic-related air pollutants, including diesel exhaust particles (DEP). DEP, produced by the combustion of diesel fuel in a compression ignition engine, is a complex mixture of gases and particulates [1]. The composition of the exhaust depends on a number of factors including the type of engine (heavy or light duty), the type of fuel and oil, speed and load of operation, and emission control systems [1].

Gaseous compounds present in diesel exhaust can include oxygen, carbon dioxide, nitrogen, carbon monoxide, water vapor, nitrogen oxides (especially NO), sulfur compounds (especially sulfur oxides), volatile organic compounds (VOCs), low molecular weight hydrocarbons and their derivatives [1,2].

DEP can contain elemental carbon, organic compounds including polyaromatic hydrocarbons (PAHs), metals, and other trace compounds [3]. Diesel exhaust is complex mixture of thousands of chemicals. Over forty air contaminants are recognized as toxicants, such as carcinogens [4].

Most DEP have aerodynamic diameters falling within a range of 0.1 to 0.25 μm. Approximately 92% of the particulate emitted by diesel engines is respirable (particulate matter [PM] <10 μm), with the majority having diameters less than 1.0 micron [1].

Carcinogenicity and Other Health Effects

DEP was classified as a definite human carcinogen (group 1)

by the International Agency for Research on Cancer (IARC) at 2012 based on recently sufficient epidemiological evidence for lung cancer [5]. Diesel exhaust has yet limited evidence for bladder cancer in humans. The main studies that led to IARC conclusion were in highly exposed workers. However, we have learned from other carcinogens, such as radon, that initial studies showing a risk in heavily exposed occupational groups were followed by positive findings for the general population. Therefore actions to reduce exposures should encompass workers and the general population.

The one consistent observation that links the pulmonary and cardiovascular effects of inhaled PM is oxidative stress [6]. Ultrafine particles (UFPs) have emerged as a potentially important environmental health concern as they are produced in large numbers by vehicle emissions and may contribute to previously reported associations between traffic pollution and acute cardiovascular morbidity. Particular emphasis is placed on the vascular and atherosclerotic effects of urban air pollution and diesel exhaust emissions as rich sources of environmental UFPs [6].

DEP also induced apoptosis of airway epithelial cells *in vitro*. Patients with chronic airway diseases, such as asthma and chronic obstructive pulmonary disease (COPD), may be more vulnerable to the deleterious effects of DEP.

Diesel exhaust may initiate allergic reactions or increase immunological response to other allergens [3]. Increases in hospital admission, higher incidence of respiratory symptoms, and decreases in lung function are associated with exposures to airborne particulate, including DEP [3]. Increased mortality rates are also reported, particularly in the elderly and those with cardiopulmonary conditions [3]. In prospective mortality study, each 10 $\mu g/m^3$ elevation in fine particulate air pollution was associated with approximately a 4%, 6%, and 8% increased risk of all-cause, cardiopulmonary, and lung cancer mortality, respectively [7].

Environmental Exposures

The primary source of exposure to the general population is from ambient air. The three major sources of diesel exhaust are mobile sources; stationary area sources; and stationary point sources. Non-road sources can double the exposure to diesel exhaust in metropolitan area such as Seoul.

New technology diesel engines, operating on ultra-low sulfur diesel fuel and oxidation catalysts and wall-flow particulate filters, have fundamentally different exhaust characteristics than traditional diesel engines. Euro 5 and Euro 6 standards changed common European Union rules on the construction of motor vehicles, and reduced the emission of atmospheric pollutants (both particulates and NOx) from light duty vehicles. The main effect of Euro 5 is to decrease the emission of PM from diesel cars from 25 mg/km to 5 mg/km. Euro 6 limits will mainly decrease the emissions of nitrogen oxide from diesel cars further, from 180 mg/km to 80 mg/km. Emission standards will be met through technological changes including catalytic converters and particle traps.

Recent regulations regarding fuel composition and emission standards in South Korea should result in lower diesel exhaust emissions across South Korea [8]. Although the change to ultra-low sulphur fuels will decrease sulphur emissions, significant decreases in DEP and other diesel exhaust constituents will not be evident immediately, as older technology engines will remain in use until replacement is required [9].

Data from PM_{10} emission in South Korea estimated that over 53% of PM_{10} emitted from the transportation sector was attributable to diesel engines [10]. Although regulation of engine performance and fuel formulation has decreased exhaust emissions, the increased numbers of vehicles and increased use of sports utility vehicles are continued issues of concern [9].

It is estimated that portion of diesel car in 2025 will exceed gasoline car in Seoul metropolitan area [11]. Diesel engine exhaust also contributes to the formation of smog, composed primarily of ground level ozone (formed by the reaction of nitrous oxides and VOCs, or VOCs, in sunlight) and PM [12].

Taxi has more than 4-5 times longer mileage than privately owned car. Taxi has also unique characteristics such as, slowly driving and sudden stopping [13]. In this circumstances, diesel car with high technology, such satisfaction of Euro 5 and Euro 6 standards, may emit more exhaust particles, compared to other type engine car such as LPG engine [13]. At testing by Korea Automotive Technology Institute (KATECH), diesel taxi cars have 0.605 g/km NOx emissions, compared to 0.012 NOx emissions in LPG. Total running distance by taxi is 5,174,962,493 km/yr in Seoul. If LPG taxis in Seoul are all converted into diesel cars, NOx emissions are estimated 50 times from 62 ton/yr to 3,131 ton/yr by emission factors investigated by KATECH [13]. Also, PM emissions from diesel taxis are estimated as 19.7 ton/yr.

Primary PM directly emitted can increase the ambient PM concentration. PM can also be formed in the atmosphere from the reaction of various gases; SOx, NOx, and NH_3. So increased NOx emission by diesel taxis can contribute secondary $PM_{2.5}$ concentration.

Exposure Reduction in the Public Health

Increasing environmental concerns over the past two decades have resulted in remarkable development in diesel engine technology. Due to strong interplay between standards and technol-

ogy, new technology enables more stringent standards. For diesel engines, this required changes in the fuel such as marked decreases in sulfur content, changes in engine design to burn diesel fuel more efficiently and reductions in emissions through exhaust control technology.

However, while the amount of particulates and chemicals are reduced with these changes, it is not yet clear how the quantitative and qualitative changes may translate into altered health effects; further research to give an answer to this question is needed. In addition, existing fuels and vehicles without these modifications will take many years to be replaced, in South Korea, where regulatory measures are currently also less stringent. Especially data on the occurrence and health impact of diesel exhaust are very limited.

According to Organization for Economic Cooperation and Development (OECD) health data, avoidable asthma hospital admission rates in population age 15 and over, at 2009, are 101.5/100,000 persons, while OECD averages are 51.8/100,000 persons. Avoidable COPD hospital admission rates in population age 15 and over, at 2009, are 222/100,000 persons, while OECD averages are 198/100,000 persons [14]. The incidence rate for all cancers combined in South Korea showed an annual increase of 3.3% from 1999 to 2009 [15]. Korean people have high chronic disease incidences of cancer and chronic respiratory diseases, such as asthma and COPD. Increases of diesel car will threaten the health of people, especially vulnerable group, in spite of recent high technology advancement. To protect people against DEP, progressive strategies are needed, including disallowance of diesel taxi, more strict regulation of diesel engine emission, obligatory diesel particulate filter attachment in outworn diesel car, and close monitoring about health effects of DEP.

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Conflict of Interest

The authors have no conflicts of interest with the material presented in this paper.

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