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Men's Health in Industries: Plastic Plant Pollution and Prevalence of Pre-diabetes and Type 2 Diabetes Mellitus

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Abstract

Plastic production is prominently increasing and its pollution is an emerging environmental global health concern. This study aimed to investigate the occurrence of pre-diabetes and type 2 diabetes mellitus (T2DM) among nonsmoking plastic industry workers. Three hundred and forty volunteers male plastic industry workers were interviewed after medical history and examination; finally, 278 nonsmoking plastic industry workers were selected. The mean age for the participants was 38.03 ± 10.86 years and body mass index was 25.52 ± 3.15 $(kg/m)^2$. The plastic industry workers had been exposed to plastic plant pollution for 8 hr daily, 6 days in a week. Subjects with glycated hemoglobin (HbA1c) less than 5.7% were considered non-diabetics; HbA1c 5.7%–6.4% were pre-diabetics; and subjects with HbA1c greater than 6.4% were considered diabetics. In plastic industry workers, the prevalence of pre-diabetes was 176 (63.30%) and T2DM was 66 (23.74%); however, 36 (12.95%) plastic plant workers were normal. The prevalence of pre-diabetes and T2DM among plastic industry workers was significantly increased with duration of working exposure in plastic industry ($p = .0001$). Exposure to plastic plant pollution is associated with the prevalence of pre-diabetes and T2DM among plastic industry workers. The prevalence was associated with the duration of working exposure in plastic industry. The occupational and environmental health executives must take priority steps to minimize the plastic plant pollution from plastic industries to reduce the occurrence of pre-diabetes and T2DM among the plastic industrial workers and save the men's health in industries.

Diabetes mellitus is an evolving global community health apprehension with rising occurrence and numerous unbearable complications. In spite of remarkable improvements in medical sciences, diabetes mellitus is still an incurable lifelong disease and is rapidly aggregating in all age and gender clusters (Meo, 2009). Diabetes mellitus involves physiological functions, organs, and body systems (Meo, Memon et al., 2015) accompanying with wide-ranging devastating complications (Oudin, Segersson, Adolfsson, & Forsberg, 2018). It is rapidly growing in developing as well as the developed countries and has involved both urban and rural regions of the world. The current global prevalence of diabetes mellitus is 425 million people; 212 million people are unaware that they are suffering from diabetes mellitus. Two hundred and seventy-nine million people with diabetes are living in urban areas and 146 million people are from rural areas, and three-quarters 327 millions of people with diabetes are in working age (International Diabetic Federation, 2018). Diabetes mellitus ranks high on the international health agenda as a global

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pandemic and as a threat to human health and global economies (Wang et al., 2018).

Worldwide, millions of people are working daily in a dusty environment in various occupational allied industries such as oil, wood, flour, welding, cement (Meo, Memon et al., 2015) and the plastic industries. Plastic production is rapidly rising globally with a doubling of production since its commercial production began in year 1950s (Wilcox, Van Sebille, & Hardesty, 2015). Plastic pollution has been documented in environments including the rivers, ocean, and air. Occupational and environmental exposure to plastic pollutants and its allied dust is an emerging environmental risk factor that contributes to the development of acute and chronic pulmonary and chromosomal diseases (Helal & Elshafy, 2013).

The current literature indicates that air pollutants may contribute to "insulin resistance, impaired glucose metabolism and type-2 diabetes mellitus" (Dendup, Feng, Clingan, & Astell-Burt, 2018; Meo, Memon et al., 2015). However, the available literature is mainly on animal model-based studies on various types of pollutants. But, none of the human model studies have been conducted on plastic pollutants and occurrence of type 2 diabetes mellitus (T2DM). This novel study aimed to investigate the prevalence of pre-diabetes and type 2 diabetic mellitus among nonsmoking plastic industry workers and to understand the mechanism that provides linkage between exposure to plastic pollutants and pre-diabetes and T2DM.

Subjects and Methods

Participants

In this study, the plastic industry was selected from Riyadh, Saudi Arabia, a total of 340 volunteer male plastic industry workers were interviewed. After clinical history and examination, finally 278 nonsmoking, Indian subcontinent plastic industry workers were selected. The plastic industry workers had been exposed to plastic plant pollution for 8 hr daily, 6 days in a week. It was confirmed that these workers are only working in the plastic factory and there were no previous working exposure of other industries such as cement, welding, wood, oil, cotton, and flour factories. From all the participants, a written consent was obtained who voluntarily registered to join the research project, where they have the opportunity to read the research objectives and join or withdraw from the research at any time, without any profits or penalties.

Exclusion Criteria

Plastic industry workers with history of known blood diseases, anemia, blood transfusion, diabetes mellitus,

asthma, and malignancy were not included in the study. Subjects with body mass index (BMI) more than 30 were excluded to minimize the impact of obesity on prevalence of pre-diabetes and T2DM. Plastic industry workers who smoke cigarette and shisha were excluded (Kim, Noh, ChoiM, & Park, 2017), and subjects with a history of an employment in any other industrial plant which produces dust or fumes such as cement, welding, wood, oil, cotton, and flour were also not included in the study (Meo et al., 2013).

Clinical History and Sociodemographic Characteristics

Two co-investigators interviewed 340 volunteer male plastic industry workers and a detailed clinical history was obtained. Age, weight, BMI, and duration of exposure in plastic industry were recorded. After clinical history and examination, finally 278 nonsmoking plastic industry workers were selected.

Measurements of Glycated Hemoglobin

Plastic industry workers were assigned an identification number; paramedical staff obtained a 2–3 ml of blood with a vein-puncture technique; blood was collected in a container having "ethylene diamine tetra-acetic acid (EDTA)," with specific code number of workers on the bottle. The blood samples were immediately transferred to the biochemistry laboratory. Glycated hemoglobin (HbA1c) was analyzed by Dimension Xpand plus Integrated Chemistry System, Henkestr, Erlangen, Germany (Meo, Alsubaie et al., 2015).

American Diabetes Association (ADA) classification approach was employed (ADA, 2018) based on HbA1c levels participants were divided into three groups. Subjects with HbA1c less than 5.7% were considered non-diabetics; HbA1c 5.7%–6.4% were pre-diabetics; and subjects with HbA1c greater than 6.4% were considered diabetics (ADA, 2018). The "American Diabetes Association" has advocated glycated hemoglobin (HbA1c) as a standard of care and an imperative indicator of long-term glycemic control with the capability to reproduce the glycemic history of previous 3–4 months. HbA1c is a trustworthy measure of long-lasting hyperglycemia and rendered as a reliable test for the diagnosis of diabetes mellitus (ADA, 2018; Sherwani, Khan, Ekhzaimy, Masood, & Sakharkar, 2016).

Ethics Statement

This study was executed in harmony with the "Declaration of Helsinki," and the protocol was approved by the

Table 1. Sociodemographic Characteristics of Plastic Industry Workers (*n* = 278).

Variable	Mean (*SD*)
Age (years)	38.03 ± 10.96
BMI (m/kg)^2	25.52 ± 3.15
Exposure: Months	120.06 ± 105.08

Note. Values are expressed in mean ± *SD*. BMI = body mass index; *SD* = standard deviation.

Table 2. Prevalence of Pre-diabetes and T2DM in Plastic Industry Workers (*n* = 278).

Parameters	Prevalence of T2DM
Non diabetic: HbA1c less than 5.7%	36 (12.95%)
Pre-diabetic: HbA1c 5.7–6.4 %	176 (63.30%)
Diabetic: HbA1c > 6.4%	66 (23.74%)

Note. HbA1c values are presented as per American Diabetic Association Guidelines.
T2DM = type 2 diabetes mellitus; HbA1c = glycated hemoglobin.

"Institutional Review Board, Ethics Committee," College of Medicine Research Centre, King Saud University (CMED 305- 14/01/1439).

Statistical Analysis

The data were entered into the computer, SPSS V. 22 and Microsoft Windows was used. Continuous variables were expressed as the mean ± standard deviation and descriptive data were expressed as frequency (%). The frequencies and percentages for prevalence of pre-diabetes and T2DM, their association with social-demographics data and duration of exposure in plastic industry were calculated by using χ^2 tests of independence. The level of significance was presumed at $p < .05$.

Results

The anthropometric characteristics of the plastic factory workers are presented in Table 1. The mean age for all the participants was 38.03 ± 10.86 years; BMI 25.52 ± 3.15 (kg/m)^2; and duration of working exposure in plastic factory was 120.06 ± 105.08 months.

The prevalence of pre-diabetes and T2DM among workers involved in plastic industry is demonstrated in Table 2. Based on HbA1c, all the participants were divided into three groups, non-diabetics HbA1c less than 5.7%; pre-diabetics HbA1c 5.7%–6.4%; and diabetics HbA1c >6.4%. In plastic industry workers, 36 (12.95%) were with normal HBA1c, 176 (63.30%) were pre-diabetics, and 66 (23.74%) workers were diabetics.

The mean duration of exposure for non-diabetics was 60.97 ± 55.79 months, pre-diabetics 109.78 ± 101.07 months, and among diabetics was 179.71 ± 109.73 months. The prevalence of pre-diabetes and T2DM among plastic industry workers significantly increased with duration of exposure in plastic industry ($p = .0001$). However, no association was identified between the BMI and prevalence of pre-diabetes and type 2 diabetes among plastic industry workers ($p = .07$) (Table 3).

Discussion

Great advancement in material sciences has led to the extensive and assorted use of plastics in daily lives to provide multipurpose products and consumer goods. However, public apprehension exists over the possible adverse human health risks related to plastic items, chemicals used while its manufacturing, and exposures to plastic plant pollutants generated in the plastic industries. This is the first study added in the medical literature on the occurrence of pre-diabetes and T2DM in plastic industry workers. In this study, it was identified that the prevalence of pre-diabetes and T2DM was increased in the plastic factory workers. At the end of 20th century, the general concept about the occurrence of T2DM was documented due to the unhealthy food and sedentary lifestyles; however, in the recent years, environmental pollution is becoming an emerging causative mechanism in the development of T2DM (Ezzati & Riboli, 2013; Meo, Memon et al., 2015).

In animal model-based studies, Balti, Echouffo-Tcheugui, Yako, and Kengne (2014), Bellou, Belbasis, Tzoulaki, and Evangelou (2018), Eze et al. (2015), Park and Wang (2014), Wang et al. (2014) established that prolonged exposure to higher concentrations of environmental air pollutants is significantly associated with increased risk of T2DM. Meo, Memon et al. (2015) reported that air pollution is a major cause of insulin resistance and incidence of T2DM. Similarly, in the present study, the occurrence of pre-diabetes and diabetes mellitus has been identified in the plastic industry workers and associated with the duration of working exposure in plastic industry. However, no association was established between the BMI and prevalence of pre-diabetes and type 2 diabetes among plastic industry workers. It indicates the impact of exposure to plastic plant pollution rather than BMI (Table 2–3).

In agreement to the present study findings, Kelsall, Fernando, Gwini, and Sim (2017) identified the similar results. They investigated the occurrence of T2DM and the risk in various occupational and industrial working population. High diabetes risk was testified in various occupational groups who worked in industries compared to the office workers. They concluded that the blue collar

Table 3. Age, BMI, and Duration of Working Exposure in Plastic Industry Among Normal, Pre-diabetes and T2DM (*n* = 278).

Variables	Non-diabetics (*n* = 36)	Pre-diabetics (*n* = 176)	Diabetics (*n* = 66)		
Parameters	HbA1c < 5.7%	HbA1c 5.7–6.4 %	HbA1c > 6.4%	*F*-value	*p*-value
Age (years)	30.83 ± 7.69	36.83 ± 10.14	45.12 ± 10.96	26.798	.0001
BMI (m/kg)^2	24.72 ± 2.67	25.42 ± 3.35	26.17 ± 2.68	2.684	.07
Exposure: Months	60.97 ± 55.79	109.78 ± 01.07	179.71± 09.73	19.457	.0001

Note. Values are expressed in mean ± *SD*. HbA1c values are presented as per American Diabetic Association Guidelines. BMI = body mass index; *SD* = standard deviation; HbA1c = glycated hemoglobin.

industry workers had a high diabetes risk. Similarly, Yang et al. (2015) reported high relationship between metal workers and risk of pre-diabetes and diabetes mellitus.

Stahlhut, Van Wijngaarden, Dye, Cook, and Swan (2007) reported the potential contributing role for phthalates (chemicals used in plastics), the authors identified that exposure to phthalate increased the insulin resistance, obesity and related clinical conditions. It was also noted that phthalates have anti-androgenic effect, decreased testosterone levels in adult males, and associated with an increased prevalence of T2DM (Selvin et al., 2007). Mazumdar and Goswami (2014) reported that plastic industry emit lead to its surrounding areas and their workers being generally exposed to high concentration of chronic exposure to lead as fume, dust, and additive. The acute health risk faced by plastic industry workers is an increase absorption and accumulation of lead. This increases the oxidative stress causing metabolic damage and organic injuries with space occupying lesions.

The epidemiologic and experimental studies suggest that environmental air pollutants raise the risk of insulin resistance and ultimately leads to T2DM. Inflammation is a potential mechanism in the pathogenesis underlying the association between air pollution and T2DM (Rajagopalan & Brook, 2012). Insulin resistance evidently has been a major hallmark for the etio-pathogenesis of T2DM. Development of insulin resistance is mainly allied with inflammatory response induced by various pro-inflammatory or oxidative stress mediators. Air pollutants may contribute oxidative stress, low-grade inflammation (Krämer et al., 2010; Pearson, Bachiredd, Shyamprasad, Goldfine, & Brownstein, 2010; Rajagopalan & Brook, 2012) endocrine-disrupting (Meeker, Sathyanarayana, & Swan, 2009), decrease insulin signaling, glucose metabolism impairment, insulin resistance and T2DM (Krämer et al., 2010; Pearson et al., 2010). All these possible mechanism for the adverse effect of air pollution on the incidence of T2DM is mainly insulin resistance.

Study Strengths and Limitations

The strengths of this study are as follows: This is the first novel study to investigate the occurrence of pre-diabetes and type 2 diabetic mellitus among plastic industry workers. The study exclusion criteria were highly standardized and cigarette smokers were excluded. American Diabetes Association Classification and Diagnosis approach was employed, and based on HbA1c levels all the participants were divided into normal, pre-diabetics, and diabetics. This work could be therefore a good reference on the environment pollution due to plastic pollutants and pre-diabetes and T2DM. However, the limitations of the present study are as follows: despite trying to recruit large number of workers from plastic industry, the majority of employees were cigarette smokers therefore, study sample size is small, and did not measure the metal levels in the plastic industry workers. Further studies with better sample size are essential to validate the current evidence to understand the role of plastic plant pollutants and occurrence of pre-diabetes and T2DM among plastic industries workers.

Conclusions

Exposure to plastic plant pollution provides an association with the incidence of pre-diabetes and T2DM among plastic industry workers. The prevalence was associated with the duration of exposure in plastic industry. The plastic industry workers should wear respiratory protective equipment to minimize the risk of plastic dust, fumes, and pollutants exposure. The occupational and environmental protection health executives could take priority steps to minimize the plastic plant pollution from the plastic industries to reduce the occurrence of pre-diabetes and T2DM among the plastic industrial workers.

Declaration of Conflicting Interests

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