Chapter 8

Diabetes Mellitus

Hideyo Tsutsui, Go Tanaka, and Katsunori Kondo

1 Introduction

In 2017, diabetes mellitus (DM) was estimated to affect 452 million patients worldwide, a number that is predicted to grow to 693 million by 2045 [1]. DM has become one the most pressing and prevalent issues in the past few decades, hand- in- hand with the rising obesity crisis. It is now the seventh leading cause of death worldwide [2]. The number of deaths caused by DM increased from less than 1 million in 2000 to 1.6 million in 2016 [2]. DM is a major risk factor for the development of microvascular complications including nephropathy, retinopathy, and neuropathy as well as macrovascular complications including coronary artery disease, peripheral vascular disease, and carotid artery disease [3]. With the rapid and alarming growth of DM, both the prevalence and major complications associated with DM need to be addressed.

In Japan, the number of patients with DM reached ten million in 2017 [4]. Moreover, 16,492 patients had diabetic nephropathy (DMN), which is the most common cause of the need for dialysis [5]. Therefore, the Ministry of Health, Labour and Welfare (MHLW) created a program to prevent progression of DMN for

H. Tsutsui (✉)

Department of Human Culture, Faculty of Modern Life, Teikyo Heisei University,
Tokyo, Japan

e-mail: h.tsutsui@thu.ac.jp

G. Tanaka

Human Development Department, Japan International Cooperation Agency, Tokyo, Japan

K. Kondo

Professor of Social Epidemiology and Health Policy, Department of Social Preventive
Medical Sciences, Center for Preventive Medical Sciences, Chiba University, Chiba, Japan

Head of Department of Gerontological Evaluation, Center for Gerontology and
Social Science, National Center for Geriatrics and Gerontology, Obu City, Aichi, Japan

those who have not been assessed or for those with high risk of severe DM who do not adhere to treatment regimens. This program aims to prevent the transition to kidney failure and the need for dialysis.

According to the International Diabetes Federation, diagnostic criteria for DM, include one or more of the following criteria: (1) fasting plasma glucose ≥ 7.0 ; or (2) 2-h plasma glucose ≥ 11.1 mmol/L (200 mg/dL) following a 75-g oral glucose load; or (3) a random glucose > 11.1 mmol/L (200 mg/dL) or hemoglobin A1c (HbA1c) ≥ 48 mmol/mol (equivalent to 6.5%) [1]. The onset of DM and its relation to socioeconomic status (SES) have been reported. Individuals with lower SES may suffer from unrecognized and untreated DM [6–10]. Furthermore, the association of DM with SES has been shown to be related to a higher number of socioeconomically disadvantaged individuals living in an area as well as the characteristics of the area itself.

Agardh et al. [6] performed a meta-analysis to explore the association between SES and DM. They reported that compared with high educational level, occupation, and income, low levels of these determinants were associated with an overall increased risk of type 2 DM (T2DM); [relative risk (RR), 1.41; 95% confidence interval (CI), 1.28–1.51], (RR, 1.31; 95% CI, 1.09–1.57), and (RR, 1.40; 95% CI, 1.04–1.88), respectively]. Wu et al. [7] demonstrated the relationship between low education and prevalence of DM in a meta-analysis and Suwannaphant et al. [8] showed this same relationship in a cross-sectional study. Nagata et al. [9] reported the association between occupation and prevalence of DM in a follow-up study in Japan, and Nagamine et al. [10] showed the relationship between low-income status and the prevalence of DM in a cross-sectional study. Moreover, Lamy et al. [11] and Green et al. [12] demonstrated that a high prevalence of DM was strongly correlated with indicators of low SES, poor environmental quality, and poor lifestyles in an ecological study.

In this chapter, we introduce findings on the relationship between SES and DM in Japan and other countries, and discuss the future direction of preventive measures.

2 Methods

2.1 Countries Other than Japan

Suitable studies that measured the association between SES and DM were systematically identified from PubMed. Studies published from the inception date of the database to June 2018 were retrieved. Studies were restricted to those published in English and within the past 5 years. Keywords included “socioeconomic status,” “income,” “education level,” “occupation,” “diabetes mellitus,” “type 1 diabetes mellitus,” and “type 2 diabetes mellitus.” Abstracts without full articles were excluded. The search yielded 172 articles.

2.2 *Japan*

Suitable studies that measured the association between SES and DM were systematically identified from PubMed. Studies published from the inception date of the database to June 2018 were retrieved. Studies were restricted to those published in English and within the past 5 years. Keywords included “socioeconomic status,” “income,” “education level,” “occupation,” “diabetes mellitus,” “type 1 diabetes mellitus,” and “type 2 diabetes mellitus,” “Japan,” and “Japanese.” Abstracts without full articles were excluded. The search yielded three articles. Moreover, Japanese studies that measured the association between SES and DM were identified from the Japan Medical Abstracts Society. As a result of the search, two original articles and two abstracts were retrieved.

3 Results

3.1 *Countries Other than Japan*

3.1.1 Living Area

A high incidence and poor control of DM were reported in areas with residents of low SES [11–15]. For instance, a study conducted in Winnipeg, Manitoba, Canada (DM prevalence rate of 47.3 cases/1000 population) [12] found a high DM prevalence clustered in the City of Winnipeg which has a high percentage of Aboriginal population, as well as people with low educational levels, low family income, a high percentage of single parent families, high levels of unemployment, high numbers of vacant and placarded houses, high levels of crime, and high rates of smoking. In a survey [13] in the United States, individuals with incident DM were shown to reside in neighborhoods of people with lower education levels, lower median household incomes, and greater proportions of people living below the poverty line. Lindner et al. [14] indicated that a low-SES area was associated with an increased risk for diabetic ketoacidosis at all ages. A cross-sectional study from 2012 to 2013 conducted using the Korean National Health Insurance Research Database [15] reported those living in rural areas were less likely to undergo HbA1c testing.

3.1.2 Individual Levels

Income

The Korea National Health and Nutrition Examination Survey (KNHANES) analyzed data from 2008 to 2014 in South Korea [16] and showed an increasing trend in the prevalence of DM in the low-income group. In assessing data from KNHANES

V, which was conducted from 2010 to 2012, Kim et al. [17] demonstrated that the odds ratio (OR) and 95% CI for the prevalence of DM among the lower income group was OR 2.87 (95% CI, 2.35–3.50) relative to higher income groups. Dinca-Panaiteanu et al. [18] showed that the prevalence of T2DM in the lowest income group was 4.14 times higher than that in the highest income group. In addition, they reported that prevalence of DM decreased steadily as income went up [18].

Education

In a cross-sectional study, Suwannaphant et al. [8] demonstrated that the OR for the prevalence of DM among individuals with a lower education was 5.87 (95% CI, 4.70–7.33) relative to individuals with a higher education. A cross-sectional study of 664,969 adults [19] reported the rate of increase in prevalence of DM was higher for adults who had a high school education or less compared with those who had more than a high school education (for interaction, $P = 0.006$ for <high school and $P < 0.001$ for high school). In a population-based nationwide cross-sectional study of 19,303 individuals in Korea [20], educational status showed a significant association with DM; furthermore, the OR for DM increased with less education. The ORs were 1.41 (95% CI, 1.13–1.77) for elementary school or less, 1.33 (95% CI, 1.08–1.65) for middle school, and 1.30 (95% CI, 1.09–1.54) for high school.

Occupation

Reviriego et al. [21] performed a cross-sectional study and showed that the prevalence rates of impaired fasting glucose levels, type 1 DM, and T2DM by occupational categories in a nationwide sample of a Spanish working population were greater among blue-collar workers than among white-collar workers. Cleal et al. [22] showed that DM and low occupational status have a clear compound effect, showing that workers with DM with low-level occupations have a 1173% greater risk for early retirement than professionals without DM. Moreover, Shamshirgaran et al. [23] demonstrated that compared with people who were in paid employment, the age and sex-adjusted OR for prevalence of DM was higher in people who were retired (OR, 1.22; 95% CI, 1.16–1.29), or who were unemployed or involved in other types of work (OR, 1.17; 95% CI, 1.12–1.23).

3.2 Japan

3.2.1 Living Area

We could not find original articles from Japan reporting the relationship between SES and DM by living area.

3.2.2 Income

Nagamine et al. [10] showed that compared with people in the highest income category, prevalence ratios of women with DM for the lowest income category and the second-lowest category were 1.42 and 1.33 after adjusting for each SES factor. In a case-control study in 1993 [24], patients with DM had lower incomes than control participants, after adjusting for disability. Moreover, patients with low income were reported to have higher levels of complications of DM than those with higher income. For example, Funakoshi et al. [25] found that the ORs of having DMN were higher among patients with middle-income (OR, 3.61; 95% CI, 1.69–8.27) or low-income levels (OR, 2.53; 95% CI, 1.11–6.07), even after adjustment for covariates.

3.2.3 Education

Nishi et al. [26] found that Japanese men with a low level of education were more likely to have DM than those with a high level of education (OR, 2.55; 95% CI, 1.21–5.39). Moreover, patients who had only graduated from junior high school were shown to have more complications of DM than patients with a higher level of education. For example, Funakoshi et al. [25] found that the ORs of having diabetic retinopathy were greater among patients who had graduated from junior high school (OR, 1.91; 95% CI, 1.09–3.34) than for patients who had graduated from college. In addition, they reported that the ORs of having DMN were greater among patients who had graduated from junior high school (OR, 2.38; 95% CI, 1.06–5.31) than for patients who had graduated from college.

3.2.4 Occupation

Hayashino et al. [27] demonstrated that compared with white-collar workers, the age-adjusted OR for prevalent DM was 1.91 (95% CI, 1.37–2.64) in blue-collar workers. Another study [28] showed that among those aged 40–49 years, the incidence of DM in sales workers, which is considered a lower-level job, was significantly increased compared with clerical, with a multivariate-adjusted hazard ratio (HR) of 1.55 (95% CI, 1.02–2.35). In contrast, the incidence of DM in technical/professional workers and in managerial/administrative workers did not have a significant HR in any model.

4 Discussion

Common determinants of DM include excess body fat and high blood pressure and lifestyle factors such as inadequate diet, physical inactivity, and stress. Therefore, lifestyle interventions are appropriate strategies to help prevent DM. However, as

mentioned in Chap. 7, unhealthy lifestyle habits are more common in low-SES groups [29, 30]. Moreover, in DM treatment, various self-care behaviors, such as diet, medication, and exercise, are required, and appropriate training is needed to help patients with DM to complete these self-management tasks. In addition, people of low SES have more difficulties with self-monitoring of blood glucose levels, because they cannot afford the test strips. The low-SES group may have worse self-care behavior than the high-SES group. Walker et al. [31] found that social determinants of health were significantly associated with diabetic knowledge, self-care, and outcomes. Uchmanowicz et al. [32] suggested that higher education was associated with higher cognitive function and better self-care.

4.1 Diet

Consumption of whole grains, coffee or tea, low-fat milk and dairy products, moderate alcohol consumption, fruit and vegetables, pulses, and nuts (in women only) are associated with a decreased risk for T2DM [33]. Conversely, consumption of foods high in fat and low in dietary fiber is associated with an increased risk for DM. High consumption of junk food, bread, and butter is associated with substantial increases in the risk for DM. Gittelsohn et al. [34] reported that high junk food consumption was associated with a 2.4 times greater risk for DM. As introduced in Chap. 7, the daily consumption of fruit, vegetables, milk, meat, rice, and dairy products was lower in those with a low SES than those with a high SES, whereas the daily consumption was higher for cakes, salty/fatty snacks, sweet drinks, fast foods, and potatoes [30]. In terms of the relationship between childhood SES and adult eating habits, Hardy et al. [35] indicated that compared with children from high-SES neighborhoods, children from low-SES neighborhoods were generally more than twice as likely to have a high junk food intake, not eat breakfast daily, and eat fast food once a week or more. Junk foods are high-calorie foods, with high sugar contents. Obesity, which is mostly caused by high-calorie food intake, often leads to insulin resistance [36]. An unfavorable impact on body composition caused by poor eating habits could be one mechanism linking early childhood growth with a later increased risk for T2DM. Yanagi et al. [37] found that those with low childhood SES in Japan were 1.36 times less likely to consume fruit and vegetables than those with a high childhood SES. Li et al. [38] found a 6% lower risk for T2DM per 1 serving/day increment of fruit intake and a 13% lower risk for T2DM per 0.2 servings/day increment of green leafy vegetable intake.

In addition, those who had been exposed to maternal malnutrition during pregnancy may have increased morbidity associated with metabolic diseases, including T2DM in adult life [39]. Similarly, Portrait et al. [40] showed significant associations between exposure to undernutrition during adolescence and the presence of DM at ages 60–76 years for women. These findings indicate that pregnancy and childhood diets are linked to the risk for developing DM in the future. The fetal origins of disease hypothesis suggests that the weight and nutritional status of a

woman before and during pregnancy can affect the long-term health of her children through programming of the adrenal-pituitary-hypothalamic axis during gestation [41]. These effects also increase the risk for T2DM, obesity, and hypertension [41]. Obesity may increase the risk for hypertensive disorders among pregnant women [42]. Hypertension during pregnancy has been associated with increased insulin resistance during pregnancy [43]. Gestational hypertension has been shown to double the risk for development of T2DM in the mother within 17 years postpartum [43]. It has been reported that pregnant women and children with a low SES have poor eating habits. In a prospective cohort study in the United Kingdom [44], poorer nutrient intakes associated with deprivation were consistent with food choices: diets of the more deprived women were characterized by low intakes of fruit and vegetables and higher intakes of fried potatoes, crisps, snacks, and processed meat.

The reasons for poor eating habits in pregnant women with a low SES in childhood can be attributed to low income and less education, as discussed in Chap. 7. In Japan, recently pregnant women tend to lack energy intake, and gain insufficient weight during pregnancy [45]. Essentially, they are in a state of malnutrition. A preliminary prospective study [46] showed that a dietary pattern with a high intake of bread, confectioneries, and soft drinks, and a low intake of fish and vegetables during pregnancy might be associated with small birth weight and increased risk for having a small-for-gestational-age infant. Low birth weight is also associated with the onset of DM as well as chronic kidney disease [46].

4.2 *Smoking*

The World Health Organization recognizes smoking as a preventable risk factor for T2DM and endorses smoking avoidance/cessation as part of their lifestyle recommendations [47]. Cigarettes and other smoking products contain a mix of chemical additives with the potential to impact metabolic health. In particular, the effect of nicotine is great. Nicotine has been shown to directly alter glucose homeostasis [48]. Thus nicotine plays an important role in the incidence of T2DM. As mentioned in Chap. 7, people with low-SES status are more likely to smoke [49, 50]. In the Japan epidemiology collaboration on occupational health (J-ECOH) study, Akter et al. [51] indicated that DM risk increased with increasing numbers of cigarettes among current smokers. In addition, Fukuda et al. [52] reported that a low SES measured according to income and occupation in Japan was generally associated with higher likelihood of risky health behaviors, such as current smoking and excessive alcohol consumption. Furthermore, a Japanese study of a national integrated project for prospective observation of non-communicable disease and its trends in the aged in 2010 (NIPPON DATA 2010) [53] indicated that women with ≤ 9 years of education had a higher risk for passive smoking at home than women with ≥ 13 years of education (OR, 2.06; 95% CI, 1.31–3.25). The high proportion of smokers among people with a low-SES status is believed to be a result of inadequate

stress-coping behaviors and a lack of knowledge about the harmful effects of smoking, as discussed in Chap. 7.

4.3 Exercise

Physical activity and exercise have a beneficial effect on a variety of factors relevant to DM. Exercise is recommended for both the prevention of DM and the treatment of people with DM [54]. However, many people of low- SES do not exercise [55, 56]. Lin et al. [55] found women with sub-high- school education had significantly lower average levels of physical activity than women with education of high school or above. In Japan, Murakami et al. [56] indicated that respondents with a higher education showed a higher prevalence of habitual exercise than those with a lower level of education in all stratified groups. Koohsari et al. [57] found that low-SES areas were disadvantaged in environmental attributes related to walking, such as lack of footpaths, high crime areas, and low street lighting. They suggested that improving environmental factors related to walking in lower-SES areas may enhance walking, and thus reduce the gap between low- and high-SES areas. Because a lower SES is associated with more work-related physical activity, and less travel-related, recreational, and total physical activity [58], providing an environment that makes access to exercise easier may lead to increased exercise habits among the low-SES group.

In addition, an experience of childhood poverty is associated with lack of exercise [59]. Low SES in childhood has a long-lasting adverse impact on numerous physical and mental health outcomes in adulthood [60]. Thus, low SES in childhood is linked to low SES in adulthood. Therefore, improving SES in childhood may promote better health behaviors in adulthood. Currently, childhood poverty is a major policy concern in Japan. The relative poverty rate of children in Japan was ranked 11th out of 41 developed countries [61], with a current relative poverty rate of children in Japan of 13.9% [62]. Therefore, providing health education for low-SES children may be important. DM often occurs in patients with low health literacy [63–65]. There are many patients with low health literacy in the low-SES group in Japan [65–67]. Therefore, strengthening health education for those with low-SES may help reduce the incidence of DM among patients with a low SES.

4.4 Stress

Excessive stress is a risk factor for the onset of DM. Exposure to long-term stress affects the entire neuroendocrine system, activating the hypothalamo-pituitary-adrenal axis and/or the central sympathetic nervous system, which results in an increase in cortisol levels [68]. Insulin resistance and increased hepatic glucose production induced by glucocorticoids result in increased plasma insulin levels [69].

Moreover, stress stimulates the release of various hormones, which can result in elevated blood glucose levels [70]. Thus, psychological distress can be a cause of insulin resistance [71].

People in low-SES groups have more psychological distress than people in high-SES groups [72, 73]. As mentioned earlier, the living environment can increase stress levels in people in low-SES groups. Baum et al. [72] suggested that lower SES is likely to be correlated with settings with higher population density, noise, crime, pollution, discrimination, poor access to resources, and with hazards or deprivations. In addition, they proposed that limited income, education, and/or lower social class may cause people to live in poorer, stressful settings or may perpetuate their living in such areas. Low household income and education level may also contribute to psychological stress. Markwick et al. [74] indicated that low household income results in less disposable income to purchase healthy foods, engage in leisure time activities that may be an important source of physical activity, and afford safe and adequate housing and healthcare. A low level of educational attainment puts people at higher risk for unemployment, limits their likelihood of obtaining a job that pays a living wage, and is associated with lower levels of health literacy. Furthermore, the heavy workload associated with the need to work to financially support their lives may limit time for healthy food preparation and cooking.

Moreover, people of low SES have been shown to have poor stress-coping abilities [75]. Low SES has been indirectly associated with poor mental health outcomes through the inability to adopt a suitable coping style [72]. Inadequate health behaviors such as smoking, poor diet, and lack of exercise are risk factors for developing DM. Psychological stress also decreases the motivation to take part in healthy lifestyle behaviors both before and after the onset of T2DM [76, 77]. Stress leads to unhealthy behaviors such as poor food intake [78]. Deasy et al. [79] reported that high psychological stress scores were correlated with poor diet (OR, 1.03) and increased consumption of convenience foods (OR, 1.04). Emami et al. [80] also reported that lower distress tolerance scores were related to higher levels of unhealthy eating. Cockerham et al. [81] indicated that psychological distress is associated with frequent drinking in men, and hypothesized that once drinking practices are established for an individual, they continue, as habitual drinking is perceived as suppressing distress. Furthermore, it has also been reported that distress is significantly associated with smoking in women who are distressed (OR, 1.064) [81]. Lipscombe et al. [82] indicated that smoking was associated with an increased probability of severe distress. The need for adequate stress-coping instructions for people of low SES is suggested.

5 Summary

We demonstrated that low SES is related to the onset of DM. In addition, we reported that there are many inappropriate health behaviors that increase the risk for developing DM in the low-SES group. In Japan, the MHLW, in as part of “Healthy Japan

21,” is designed to implement “A basic direction for comprehensive implementation of national health promotion.” [83] This initiative aims to improve lifestyle habits for people with DM and to reduce the number of patients with lifestyle-related diseases. The policy points out that it is important to classify target groups based on life stage, gender, and SES to improve lifestyle habits. Moreover, the policy points out the need to improve lifestyle factors, such as eating appropriate foods, taking part in moderate exercise, stopping smoking, etc., and to provide a social environment that is conducive to these activities. In addition, the policy aims to implement specific health checkups and health guidance for subjects with a low SES. However, many people who have medical examinations are in the high-SES group [50]. Therefore, to improve lifestyle-related diseases such as DM, it may be necessary to proceed with measures such as low-cost sale of low-calorie foods, maintenance of parks where exercise can be carried out, and cessation of smoking in all public places.

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