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Original Article

A Comparative analysis of type 2 diabetes management quality indicators in cancer survivors

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ABSTRACT

Objective: This study aimed to assess indicators of type 2 diabetes mellitus (DM) management, including adequate DM control, and treatment rates, in cancer survivors according to the time of DM diagnosis and to compare them with the DM management indicators of a non-cancer control group.

Methods: We used the 2013–2019 data of the Korea National Health and Nutrition Examination Survey for this study. To compare their adequate DM control, and treatment rates, we identified 4918 patients with type 2 DM aged ≥ 30 years and classified them into pre-existing diabetes, pre-existing cancer, and diabetes without cancer groups. Predictors of adequate glycemic control and diabetes treatment were analyzed using binary logistic regression.

Results: Diabetes without cancer group had higher fasting blood glucose and glycosylated hemoglobin A1c levels and lower adequate glycemic control than did the other two groups. The preexisting cancer group had low treatment rates. After adjusting for age, gender, employment status, and duration of diabetes, the preexisting cancer group had 0.51-fold lower odds of receiving treatment, such as insulin injection or oral diabetes medications, than the other two groups (adjusted odds ratio, 0.50; 95% confidence interval, 0.38–0.66)

Conclusions: Cancer survivors had lower fasting glucose and HbA1c than those with diabetes without cancer. However, as a result of the sub-analysis, the treatment rate of the pre-existing cancer group was significantly lower than that of diabetes without cancer. Based on these results, cancer survivors' care-related healthcare workers should be aware of the need for monitoring blood sugar even in cancer survivors without underlying diabetes mellitus and pay more attention to early detection and active treatment of diabetes.

Introduction

In Korea, the five-year survival rate for cancer was 70.3% as of 2018, 1.3 times higher than the survival rate (54.1%) from 2001 to 2005.[1] And the cancer survivor population is estimated to be approximately 2.01 million.[1] Aging is one of the important risk factors for cancer, and approximately 60% of the survivors are aged ≥ 65 years.[2] The prevalence of chronic diseases, such as diabetes mellitus (DM), hypertension, and osteoporosis, during the survival period, is increasing among cancer survivors.[3] Furthermore, the risk of exacerbating existing chronic conditions or the onset of a new chronic condition among cancer survivors is high due to interactions between the late effects of cancer treatment (e.g., surgery, hormone therapy, chemotherapy) and preexisting risk factors.[4] Early detection and management of chronic diseases have been highlighted in the health management of cancer survivors.[5]

DM, along with obesity, is a metabolic disorder with a burgeoning incidence worldwide,[6] which seriously impacts individuals' and families' health and quality of life.[7] The prevalence of DM among cancer survivors is approximately 22%–29%,[2,8] and this population has a 1.35–1.5 times higher risk for DM than the general population.[9,10] Moreover, DM is one of the major non-cancer causes of death among cancer survivors.[11,12] In addition, hyperinsulinemia and hyperglycemia affect cancer recurrence and prognosis[13] by stimulating the growth of cancer cells.[14] Recently, Erickson et al reported that breast cancer survivors with glycosylated hemoglobin A1c (HbA1c) levels ≥ 7% (≥ 53 mmol/mol) have shorter disease-free survival and an approximately two-fold higher mortality risk than those with an HbA1c level < 6.5% (< 48 mmol/mol).[15] This indicates that poor glycemic control may hurt the health outcomes and quality of life of cancer survivors. Owing to the continued improvement in cancer survival rates, comorbidities such as DM may have a greater impact on quality of life and life expectancy than early cancer.[16] In

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addition, diabetes increases all-cause mortality in survivors of some types of cancer[17]; thus, diabetes management in cancer survivors requires greater attention. However, clinical care for cancer survivors is primarily provided by oncologists who focus on treating primary cancer, recurrent cancer, and complications of cancer treatment. It is challenging for them to provide comprehensive health management, including screening for secondary cancer and management of comorbidities, for cancer survivors.[18]

In recent years, there has been increased research interest in cancer survivors with DM. Previous studies on the effects of a cancer diagnosis on the quality of diabetic care have indicated that cancer survivors have poorer HbA1c levels and total cholesterol control,[19] and a higher risk for preventable complications[16] than those without cancer group. On the other hand, some studies have demonstrated that cancer survivors show a higher HbA1c testing or control rate than controls[20] and that the quality indicators for DM management before and after cancer diagnosis do not differ.[21] However, these findings were obtained from a specific cancer population, including patients with colorectal cancer, breast cancer, and prostate cancer.[16,19] In addition, the duration of DM, a major predictor of glycemic control, was not considered in these studies.[22] Poor glycemic control during the survivorship period also has been associated with an increased risk for recurrent cancer.[23] In addition, cancer patients with uncontrolled glycemic levels are at risk for a shorter overall survival than are cancer patients with well-controlled diabetes[24]; therefore, DM management should be included in the survivorship care plan. From this perspective, it is necessary to examine the current state of DM management, including DM control, and treatment rates, among cancer survivors and identify high-risk groups with poor glycemic control. Therefore, this study aimed to assess indicators of DM management, including DM control, and treatment rates, in cancer survivors according to the time of DM diagnosis and compare them with the DM management indicators of a non-cancer control group using the nationally representative Korea National Health and Nutrition Examination Survey (KNHANES) data.

Methods

Study design and participants

This cross-sectional descriptive survey was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Institutional Review Board of Hallym University (IRB No. HIRB-2021-EX003). Informed consent was not required for this study given the use of secondary data that contained no patient identifiers. Data from the KNHANES VI (2013–2015), VII (2016–2018), and VIII (2019), conducted by the Korea Disease Control and Prevention Agency, were used. The KNHANES is conducted using two-stage stratified cluster sampling to extract a nationally representative sample of individuals aged $\geq$ 1 year. At the time of sampling, the latest census data were used to extract sample enumeration districts and households after stratification according to the region (city, province, and town), age, sex, residential space, and the education level of the head of the household. All eligible members of each sample household aged $\geq$ 1 year were selected for analysis. The KNHANES VI to VIII included 192 sampling units each year, with 3840 households in KNHANES VI (2013–2015), and 4416 households in KNHANES VII (2016–2018), and 4800 households in KNHANES VIII. The survey was conducted from January to December each year and consisted of household surveys, health interviews, and examinations. The household surveys and health interviews were conducted as interviews

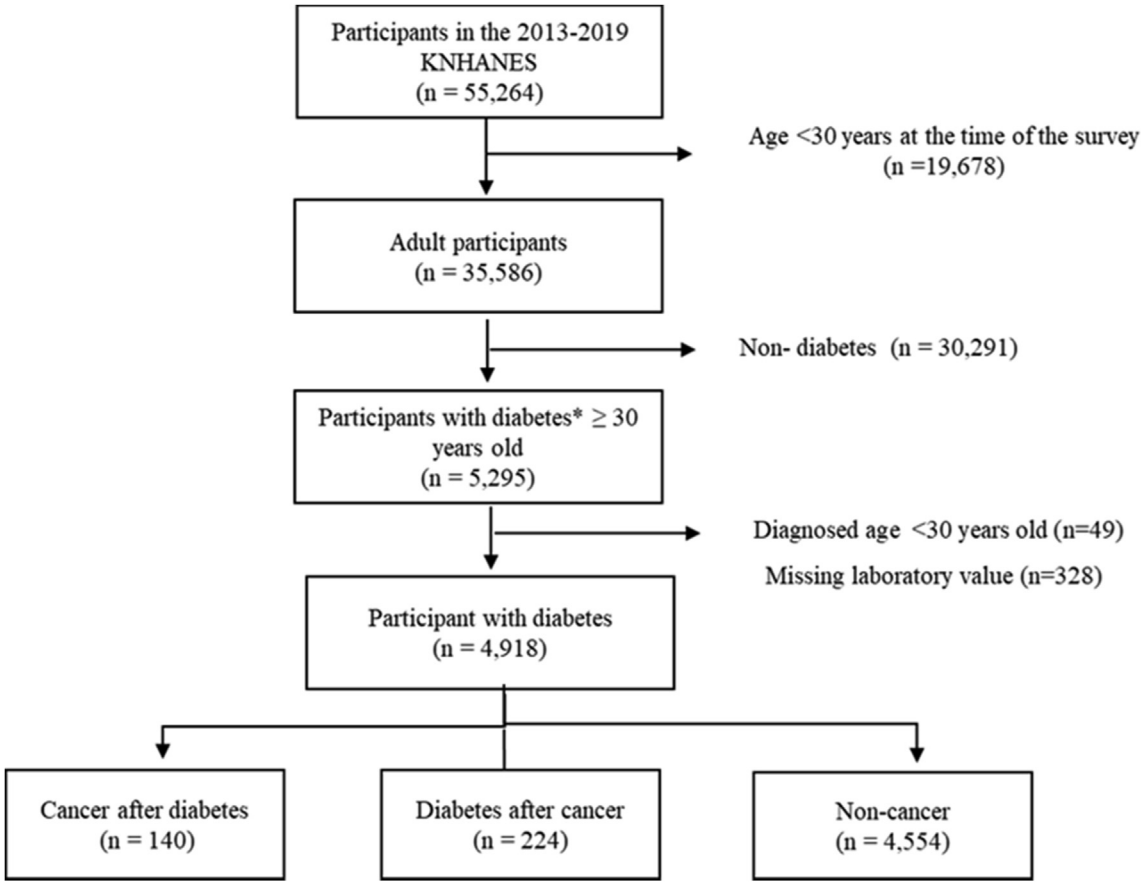

Fig. 1. Flowchart for the selection of study participants, KNHANES, Korea National Health, and Nutrition Examination Survey, *Participants with a previous clinical diagnosis of diabetes made by a physician, those who are currently taking insulin or oral antidiabetic medication, or those with fasting plasma glucose level $\geq$ 126 mg/dL or HbA1c level $\geq$ 6.5%.

Table 1
General characteristics of the participants ($n = 4918$).

Characteristics	Group 1 ($n = 140$)	Group 2 ($n = 224$)	Group 3 ($n = 4554$)	*P*
Age (years)	68.8 ± 7.5	65.7 ± 9.4	63.5 ± 11.5	< 0.001
Gender				
Male	88 (62.9%)	101 (45.1%)	2264 (49.7%)	0.003
Female	52 (37.1%)	123 (54.9%)	2290 (50.3%)	
Marital status				0.012
Married	139 (99.3%)	220 (98.2%)	4407 (96.8%)	
Single (divorced, separated, widowed)	1 (0.7%)	4 (1.8%)	147 (3.2%)	
Household income				0.932
Lowest	51 (36.4%)	83 (37.1%)	1544 (34.1%)	
Lower middle	38 (27.1%)	60 (26.8%)	1245 (27.5%)	
Upper middle	28 (20.0%)	47 (21.0%)	926 (20.5%)	
Highest	23 (16.4%)	34 (15.2%)	811 (17.9%)	
Educational (year)				0.533
0–6	56 (40.0%)	91 (40.8%)	1765 (41.0%)	
7–9	26 (18.6%)	34 (15.2%)	681 (15.8%)	
10–12	31 (22.1%)	53 (23.8%)	1153 (26.8%)	
13 or more	27 (19.3%)	45 (20.2%)	701 (16.3%)	
Employment status				< 0.001
Yes	45 (32.1%)	92 (41.1%)	2142 (47.0%)	
No	95 (67.9%)	131 (58.5%)	2162 (47.5%)	
Comorbidity				
Hypertension	88 (62.9%)	130 (58.0%)	2559 (56.2%)	0.098
Dyslipidemia	76 (54.3%)	96 (42.9%)	1871 (41.1%)	0.005
Stroke	15 (10.7%)	14 (6.2%)	276 (6.1%)	< 0.001
Cardiovascular disease	10 (7.1%)	20 (8.9%)	328 (7.6%)	0.739
Arthritis	34 (24.3%)	62 (27.7%)	1010 (23.3%)	0.316

Group 1, pre-existing diabetes group; Group 2, pre-existing cancer group; Group 3, diabetes without cancer group Data are presented as means (± standard deviations) and proportions (percentages).

and self-report questionnaires, whereas the examinations were performed through observation, direct measurements, and specimen testing. The participation rate was 78.3% in KNHANES VI, 76.6% in KNHANES VII, and 71.1% in KNHANES VIII. A total of 55,264 participants completed the survey. Of these, 35,586 were adults aged ≥ 30 years. DM diagnosis was identified using one or more of the following criteria or responses to one or more of the following questions: (1) "Have you ever been told by a doctor that you have diabetes?"; (2) "Are you taking insulin?"; (3) "Are you currently taking an oral anti-hyperglycemic agent?"; (4) HbA1c level ≥ 6.5%; or (5) fasting blood glucose measured after fasting for at least 8 h was ≥ 126 mg/dL. A total of 5295 participants were diagnosed with DM. Despite abundant information from KNAHES, there was no information on the type of diabetes KNHANES. We hypothesized that respondents diagnosed with diabetes before the age of 30 had type 1 diabetes, based on the results of a study on the characteristics of Korean diabetes patients[25] and the diabetes trends using data from the Korea Insurance Corporation.[26] Therefore, to limit the sample to those with type 2 DM,[26] we excluded 49 patients diagnosed with DM before the age of 30 and 328 participants with missing data. Thus, 4918 participants were included in the final analysis. Those who answered yes to the question "Have you been diagnosed with cancer by a physician?" were considered cancer survivors. Those who were diagnosed with DM before cancer were assigned to the pre-existing diabetes group (group 1), whereas those who were diagnosed with DM after cancer were assigned to the pre-existing cancer group (group 2). Patients with DM without a history of cancer were assigned to diabetes without cancer group (Fig. 1).

Measures

Demographic and disease characteristics

The demographic characteristics recorded included age, gender, marital status, household income, educational level, employment status, and comorbidities. Marital status was divided into married and single (never married, divorced, separated, or widowed). Household income is defined as the monthly household income divided by the number of household members. It was categorized into 4 levels: highest, upper-middle, lower-middle, and lowest, as presented in the KNHANES data. Education level was divided into ≤ 6 years, 7–9 years, 10–12 years, and ≥ 13 years. Participants who answered yes to the question "Have you worked for an hour or longer in the past week for income?" were defined as those with a job. Comorbidities were categorized into hypertension, dyslipidemia, stroke, cardiovascular disease, and arthritis.

Biochemical measurements and quality of diabetes care

The examination portion of the KNHANES was performed via observation, direct measurements, and sample testing. For this study, we used anthropometric data (height, weight, and waist circumference), blood pressure data (systolic and diastolic), and blood test results. The blood test results included fasting blood glucose, HbA1c, total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and triglyceride levels. Trained examiners performed the anthropometric and blood pressure measurements. Waist circumference was measured (to the nearest decimal point) around the midpoint between the lowest rib and iliac crest, with both arms hanging down naturally at the end of a normal expiration. Blood pressure was measured three times with the participant seated after 5 min of rest, and the average value was used. Blood samples were taken after at least 8 h of fasting since dinner on the day before the test, and the sample was analyzed within 24 h. Fasting blood glucose, TC, and HDL-C levels were measured using a Hitachi automatic analyzer (Hitachi, Japan). HbA1c level was measured using high-performance liquid chromatography. Indicators of the quality of diabetes care included DM treatment and control rates. DM treatment modalities were categorized into oral medication monotherapy, combined oral medication, and insulin injection. The duration of DM was calculated by subtracting the age at the time of DM diagnosis from the current age (as of the date of survey completion). DM treatment rate was defined as the percentage of participants with DM who were receiving insulin injections or oral anti-hyperglycemic medications. Additionally, the proportion of subjects receiving diabetes treatment in the poor glycemic control group was also analyzed. DM control rate was defined as the percentage of participants with DM who had an HbA1c level < 6.5%.

Table 2
Diabetes management and quality indicators of participants with or without cancer ($n = 4918$).

	Group 1 ($n = 140$)	Group 2 ($n = 224$)	Group 3 ($n = 4554$)	*P*
BMI (kg/m^2)	23.7 ± 3.1	24.9 ± 3.4	25.5 ± 3.6	< 0.001
Waist circumference, cm	86.4 ± 9.3	86.7 ± 9.7	88.7 ± 9.4	< 0.001
Blood pressure (mmHg)				
Systolic	125.2 ± 17.2	125.0 ± 16.7	126.2 ± 16.9	0.263
Diastolic	70.6 ± 9.6	74.0 ± 9.3	74.4 ± 10.8	< 0.001
Fasting blood glucose (mg/dL)	138.6 ± 49.2	127.2 ± 32.3	140.6 ± 44.2	0.006
HbA1c	7.2 ± 1.2	6.9 ± 0.9	7.3 ± 1.3	< 0.001
Total cholesterol	163.1 ± 32.5	180.9 ± 36.8	179.8 ± 43.0	< 0.001
High-density lipoprotein	44.9 ± 13.2	47.5 ± 11.2	45.8 ± 11.1	0.735
Triglyceride	145.4 ± 129.7	159.3 ± 110.8	173.1 ± 140.1	0.007
Diabetes treatment				
Insulin	17 (12.1%)	6 (2.7%)	254 (5.6%)	< 0.001
Oral hypoglycemic agent	127 (90.7%)	117 (52.2%)	2955 (64.9%)	< 0.001
Duration of diabetes (year)	13.7 ± 7.6	3.4 ± 4.9	6.8 ± 8.5	< 0.001
Diabetes management index				
Treatment[a]	130 (92.9%)	119 (53.1%)	2998 (65.8%)	< 0.001
Adequate glycemic control[b]	44 (31.4%)	58 (25.9%)	870 (19.1%)	< 0.001
Treatment in patients with poor glycemic control[c]	90 (93.8%)	70 (42.2%)	2237 (60.7%)	<0.001

Group 1, pre-existing diabetes group; Group 2, pre-existing cancer group; Group 3, diabetes without cancer group Data are presented as means (± standard deviations) and proportions (percentages).
BMI, body mass index, HbA1c, glycated hemoglobin.
[a] Treatment: percentage of people with diabetes treated with oral hypoglycemic agents or insulin therapy.
[b] Adequate glycemic control: percentage of people with diabetes who have HbA1c level <6.5%.
[c] Treatment in patients with poor glycemic control: proportion of treatment in patients with poor glycemic control (HbA1c ≥ 6.5).

Data analysis

Descriptive statistics are presented as proportions for categorical variables and as mean ± standard deviation, as appropriate. We confirmed the normality of the distribution of continuous variables using the Kolmogorov–Smirnov test. Comparisons between the three groups (preexisting diabetes group, preexisting cancer group, and diabetes without cancer group) were performed using analysis of variance for continuous variables and Pearson's chi-square test. We performed binary logistic regression analyses to evaluate the association between-group differences and outcomes (adequate glycemic control and the use of anti-diabetic treatment). In these analyses, the reference group was diabetes without cancer group. In the multivariate analysis, we adjusted for age, sex, employment status, and duration of diabetes in the final model. All statistical analyses were performed using the R software [R Foundation for Statistical Computing, version 4.1.2)]. A two-sided *P*-value < 0.05 in the univariate and multivariate models was considered significant.

Results

General characteristics of the participants

Of the 4918 participants included, 140 were in the preexisting diabetes group (group 1), 224 in the preexisting cancer group (group 2), and 4554 in the diabetes without cancer group (group 3). The preexisting diabetes group had the highest mean age (group 1, 68.8 ± 7.5; group 2, 65.7 ± 9.4; group 3, 63.5 ± 11.5, $P < 0.001$) and the highest proportions of male participants ($P = 0.003$), unemployed individuals ($P < 0.001$), those with hyperlipidemia ($P = 0.005$), and those with stroke ($P < 0.001$) (Table 1).

Quality indicators of diabetes management

Table 2 shows the results pertaining to DM management and quality indicators. The mean body mass index (BMI) for groups 1, 2, and 3 was 23.7 ± 3.1, 24.9 ± 3.4, and 25.5 ± 3.6, respectively, whereas the mean

Table 3
Binary logistic regression analysis of predictors of adequate glycemic control and diabetes treatment according to group ($n = 4918$).

DM Treatment[a]				
	Univariable OR (95% CI)	Model 1 aOR (95% CI)	Model 2 aOR (95% CI)	Model 3 aOR (95% CI)
Non- cancer	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Group 1	6.75 (3.54–12.87)	5.41 (2.82–10.35)	5.19 (2.71–9.95)	4.99 (2.60–8.35)
Group 2	0.59 (0.45–0.77)	0.52 (0.39–0.68)	0.50 (0.38–0.66)	0.51 (0.39–0.68)
Adequate glycemic control[b]				
	Univariable OR (95% CI)	Model 1 aOR (95% CI)	Model 2 aOR (95% CI)	Model 3 aOR (95% CI)
Non- cancer	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Group 1	1.94 (1.35–2.79)	1.67 (1.16–2.42)	1.67 (1.15–2.41)	1.67 (1.15–2.42)
Group 2	1.48 (1.09–2.01)	1.41 (1.03–1.92)	1.40 (1.03–1.91)	1.40 (1.02–1.91)

Model 1: adjusted for age and sex.
Model 2: adjusted for covariates included in Model 1 plus employment status.
Model 3: adjusted for covariates included in Model 2 plus duration of diabetes.
Group 1, cancer after diabetes development; Group 2, diabetes after cancer development; Group 3, non-cancer aOR, adjusted odds ratio; CI, confidence interval.
[a] DM Treatment: people with diabetes are treated with oral hypoglycemic agents or insulin therapy.
[b] Adequate glycemic control: HbA1c < 6.5%.

waist circumference was 86.4 ± 9.3, 86.7 ± 9.7, and 88.7 ± 9.4, respectively, indicating that group 3 had the highest BMI and waist circumference ($P < 0.001$). Group 3 also had the highest diastolic blood pressure (group 1, 70.6 ± 9.6; group 2, 74.0 ± 9.3; group 3, 74.4 ± 10.8, respectively, $P < 0.001$), fasting blood glucose level (group 1, 138.6 ± 49.2; group 2, 127.2 ± 32.3; group 3, 140.6 ± 44.2, respectively, $P = 0.006$), HbA1c level (group 1, 7.2 ± 1.2; group 2, 6.9 ± 0.9; group 3, 7.3 ± 1.3, respectively, $P < 0.001$), and triglyceride level (group 1, 145.4 ± 129.7; group 2, 159.3 ± 110.8; group 3, 173.1 ± 140.1, respectively, $P = 0.007$). However, TC was highest in group 2 (group 1, 163.1 ± 32.5; group 2, 180.9 ± 36.8; group 3, 179.8 ± 43.0, respectively, $P < 0.001$), whereas the duration of DM was the longest in group 1 (group 1, 13.7 ± 7.6; group 2, 3.4 ± 4.9, and group 3, 6.8 ± 8.5, respectively; $P < 0.001$). The use of insulin injection (group 1, 12.1%; group 2, 2.7%; group 3, 5.6%, respectively, $P < 0.001$) and oral hypoglycemic agents (group 1, 90.7%; group 2, 52.2%; group 3, 64.9%, respectively, $P < 0.001$) was more common in group 1 than in groups 2 and 3. Regarding the quality indicators for diabetes care, group 2 had the lowest treatment rate (53.1%, $P < 0.001$), whereas group 3 had the lowest DM control rate (19.1%, $P < 0.001$). Among subjects with HbAq1 level of 6.5 or higher, the proportion of subjects receiving diabetes treatment was the lowest in group 2 (group 1, 93.8%; group 2 42.2%; group 3 60.7%, respectively, $P < 0.001$).

Predictors of adequate glycemic control and diabetes treatment according to group

The pre-existing diabetes group (group 1) had 1.67 times higher odds (adjusted odds ratio [aOR], 1.67; 95% confidence interval [CI], 1.15–2.42), and the preexisting cancer group (group 2) had 1.40 times higher odds (aOR 1.40; 95% CI, 0.02–1.91) for having well-controlled blood sugar level than diabetes without cancer group (group 3), even after adjusting for age, sex, employment status, and duration of diabetes.

The pre-existing diabetes group had 4.99 times higher odds (aOR, 4.99; 95% CI, 2.60–8.35), and the pre-existing cancer group had 0.51 times lower odds (aOR, 0.51; 95% CI, 0.39–0.68) for receiving DM care, such as insulin injection or oral anti-hyperglycemic medications than diabetes without cancer group after adjusting age, sex, employment status, and duration of diabetes (Table 3).

Discussion

This study investigated the DM management indicators of cancer survivors according to the time of DM diagnosis and compared them with those of a non-cancer control group. The results showed that DM treatment rates (53.1%) were significantly lower in the pre-existing cancer group than in the pre-existing diabetes group (92.9%, respectively) and diabetes without cancer group (65.8%, respectively).

DM is closely linked to metabolic syndrome, a late complication of anticancer treatment. In addition, various cancer treatment modalities affect glucose metabolism. Growth hormone deficiency following cranial and abdominal radiotherapy elevates the risk of metabolic syndrome.[25] Lipscombe et al[26] reported that the incidence of DM increases from 2 years after the breast cancer diagnosis, particularly in patients who underwent adjuvant chemotherapy. Zhang et al[27] reported that the incidence of DM is higher in patients with ovarian cancer treated with paclitaxel than in those that did not undergo treatment. L-asparaginase and diazoxide interfere with insulin production and secretion, whereas glucocorticoids, megestrol acetate, and targeted therapy lower insulin sensitivity, thereby elevating the risk for DM.[28] However, it was recently reported that active treatment with metformin after cancer diagnosis in cancer survivors with diabetes improves their survival rate.[29]

Cancer is a critical disease.[30] Cancer survivors and healthcare providers tend to primarily focus on treating cancer and preventing recurrence. Therefore, metabolic disorders, such as DM, that may occur during the process of cancer treatment are likely to receive less attention than cancer.[31,32] Pinheiro et al reported that these factors lead to lower rates of HbA1c testing, LDL testing, and eye examination after a cancer diagnosis.[33] In this study, the use of insulin injections and oral anti-hyperglycemic agents was lower in the pre-existing cancer group (2.7% and 52.2%, respectively) than in the pre-existing diabetes group (12.1% and 90.7%, respectively) and diabetes without cancer group (5.6% and 64.9%, respectively). As a result of analyzing the treatment rate of subjects with HbA1c of 6.5 or higher in each group, the treatment rate (42.2%) in the pre-existing cancer group was the lowest compared to the other two groups (group 1, 93.8%; group 3, 60.7%, respectively). Based on these results, it is necessary to analyze the cause of the low treatment rate in the pre-existing cancer group and to observe the progress of blood sugar management in this group.

In this study, adequate glycemic control was lowest in diabetes without cancer group. Health behaviors related to diet, smoking, drinking, and physical activities practiced by cancer survivors to prevent recurrence may positively impact glycemic control. A study of the health behaviors of cancer survivors, which was conducted using the KNHANES data, showed that the rates of smoking and problematic drinking were lower, whereas the rate of physical activity was higher among cancer survivors than among the non-cancer group.[34] In this study, the cancer survivor group showed significantly lower BMI and waist circumference than diabetes without cancer group. Meanwhile, Mourouti et al suggested that cancer survivors often increase their consumption of healthy foods, such as vitamins and mineral supplements, after the cancer diagnosis, without the knowledge of their physician.[35] Therefore, additional studies are needed to examine the factors that potentially influence DM care, such as DM care-related knowledge, attitude, and self-care behaviors, and physiological indices, such as fasting blood glucose and HbA1c levels, in cancer survivors with DM.

The pre-existing diabetes group showed significantly higher rates of DM treatment and control than the pre-existing cancer group. However, fasting blood glucose and HbA1c levels were lower in the pre-existing cancer group than in the pre-existing diabetes group, which may be attributable to the duration of DM. The mean duration of DM in the pre-existing diabetes group was 13.7 ± 7.6 years, which is markedly longer than that in the pre-existing cancer group (3.4 ± 4.9 years). According to a previous study, blood sugar control is worse among those who have had DM for ≥ 10 years than among those who have had DM for ≤ 5 years.[36–38] Furthermore, the risks for hyperglycemia and complications increase with the increasing duration of DM. In particular, the fact that the pre-existing diabetes group in this study had higher average treatment rates, and control rates but lower fasting blood glucose and HbA1c levels than the pre-existing cancer group also appears to be related to the duration of DM. As a result of analyzing the treatment rate of subjects with HbA1c of 6.5 or higher in each group, 93.8% of the pre-existing diabetes group with a longer duration of diabetes than the diabetic without cancer group (60.7%) were using insulin or oral hypoglycemic agents. These results of this study support the results of previous studies that the longer the duration of diabetes mellitus.

We performed a bivariate logistic regression analysis to analyze DM treatment and control rates according to the time of DM diagnosis. As a result, it was predicted that the pre-existing diabetes group would have more adequate blood sugar control than the pre-existing cancer group. It was found that the pre-existing diabetes group was more likely to take insulin injections or oral hypoglycemic agents than the pre-existing cancer group, suggesting that there is a significant relationship between proper blood sugar control and treatment rate. These results were significant even after adjusting for significant confounding factors including the duration of diabetes. As a result, considering that HbA1c and fasting glucose in the pre-existing diabetes group are higher than in the pre-existing cancer group, the results of this study reconfirmed that diabetes treatment using insulin or oral hypoglycemic agents is important for adequate glycemic control management.[39,40]

Most aggressive cancer treatments, such as chemotherapy and radiotherapy, are concluded within 1–2 years after diagnosis.[41] In the

Republic of Korea, most cancer survivors continue to receive care from the oncologist that treated their primary cancer until 5 years after diagnosis.[42,43] However, management after this period varies depending on the cancer type or healthcare provider. In addition, research on post-treatment management in cancer survivors is scarce. Considering the strong correlation between DM and cancer mortality, long-term follow-up studies are required to explore the changes in the DM management factors and develop DM care measures accordingly.

This study has a few limitations. First, this was a cross-sectional study using the KNHANES data; thus, factors that may potentially influence blood sugar level, including treatment modalities (eg., chemotherapy, radiotherapy, and hormone therapy) and adverse events (e.g., nausea and vomiting), were not examined. Second, patients hospitalized in a healthcare facility were excluded from the KNHANES; therefore, the data are likely to be biased toward cancer survivors with DM who have relatively mild conditions. Hence, considering the high rate of mortality among cancer survivors with DM, it is possible that the high-risk group of patients that died was excluded from the data. Nevertheless, this study is significant in that it involved the investigation of the current state of DM management, including DM treatment, and control, among cancer survivors with DM using nationally representative KNHANES data. In addition, the results showed that the pre-existing cancer group in this study had the lowest DM treatment rates and higher odds of adequate glycemic control than the other two groups.

Conclusions

This study analyzed type 2 diabetes mellitus management quality indicators of cancer survivors with diabetes compared to those without cancer. Cancer survivors had lower fasting glucose and HbA1c than those with diabetes without cancer. However, as a result of the sub-analysis, the treatment rate of the pre-existing cancer group was significantly lower than that of diabetes without cancer. Based on these results, cancer survivors' care-related health care workers should be aware of the need for monitoring blood sugar even in cancer survivors without underlying diabetes mellitus and pay more attention to early detection and active treatment of diabetes.

Author contributions

Conceptualization: Su Jung Lee, Eun Jeong Ko. First draft of manuscript: Su Jung Lee, Writing-review & editing: Su Jung Lee, Eun Jeong Ko, Supervision: Su Jung Lee, Data analysis: Su Jung Lee.

Declaration of competing interest

None declared.

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Ethics statements

This study was approved by the Institutional Review Board of Hallym University (IRB No. HIRB-2021-EX003).

Data availability

The datasets generated and analyzed during the current study are available in the [Korea National Health and Nutrition Examination Survey] repository [https://knhanes.kdca.go.kr/knhanes/main.do],

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