Causes of death in Japanese patients with diabetes based on the results of a survey of 45,708 cases during 2001–2010: report of Committee on Causes of Death in Diabetes Mellitus

Jiro Nakamura¹ · Hideki Kamiya¹ · Masakazu Haneda² · Nobuya Inagaki³ · Yukio Tanizawa⁴ · Eiichi Araki⁵ · Kohjiro Ueki⁶ · Takeo Nakayama⁷

Received: 6 February 2017 / Published online: 28 March 2017
© The Japan Diabetes Society 2017

Abstract The principal causes of death among 45,708 patients with diabetes (29,801 men and 15,907 women) who died in 241 hospitals throughout Japan during 2001–2010 were determined based on a survey of the hospital records. Autopsy had been conducted in 978 of the 45,708 cases. The most frequent cause of death was malignant neoplasia (38.3%), followed, in order of descending frequency, by infection (17.0%) and then vascular disease (14.9%), including renal failure (3.5%), ischemic heart disease (4.8%) and cerebrovascular disease (6.6%). Diabetic coma associated with hyperglycemia with or without ketoacidosis accounted for only 0.6% of the deaths. In regard to the relationship between the age and

cause of death in patients with diabetes, the incidence of death due to vascular diseases was higher in patients over the age of 30 or 40 years, and 97.0% of the deaths due to vascular disease occurred in patients over the age of 50 years. The incidence of death due to infectious diseases, especially pneumonia, increased in an age-dependent fashion, and 80.7% of the deaths due to pneumonia occurred in patients over the age of 70 years. “Poorer” glycemic control was associated with the reduced lifespan of patients with diabetes, especially those with nephropathy. The average age at death in the survey population was 72.6 years. The lifespan was 1.6 years shorter in patients with “poorer” glycemic control than in those with “better” glycemic control. In patients with diabetes of less than 10 years’ duration, the incidence of death due to macroangiopathy was higher than that due to nephropathy. Of the 45,708 patients with diabetes, 33.9% were on oral medication, 41.9% received insulin therapy, and 18.8% were treated by diet alone. Among the patients in whom the cause of death was diabetic nephropathy, a high percentage, 53.7%, were on insulin therapy. The average age at death of the 45,708 patients with diabetes was 71.4 years in

In 2011, the Japan Diabetes Society established a Committee on Causes of Death in Diabetes Mellitus, which published its final committee report in 2016 [1]. This is the English version of that report with some revisions, which is published here to enhance our non-Japanese colleagues’ and other interested parties’ understanding of this topic. This is the official published version of that report, which is jointly published in *Diabetology International* (the official English journal of the Japan Diabetes Society) and the *Journal of Diabetes Investigation* (the official journal of the Asian Association for the Study of Diabetes: doi:10.1111/jdi.12645).

✉ Jiro Nakamura
jiro@aichi-med-u.ac.jp

¹ Division of Diabetes, Department of Internal Medicine, Aichi Medical University, 1-1 Yazako Karimata, Nagakute-Shi 480-1195, Japan

² Division of Metabolism and Biosystemic Science, Department of Medicine, Asahikawa Medical University, Asahikawa, Japan

³ Department of Diabetes, Endocrinology and Nutrition, Kyoto University Graduate School of Medicine, Kyoto, Japan

⁴ Division of Endocrinology, Metabolism, Hematological Science and Therapeutics, Yamaguchi University Graduate School of Medicine, Yamaguchi, Japan

⁵ Department of Metabolic Medicine, Faculty of Life Sciences, Kumamoto University, Kumamoto, Japan

⁶ Department of Molecular Sciences on Diabetes, The University of Tokyo, Graduate School of Medicine, Tokyo, Japan

⁷ Department of Health Informatics, Kyoto University School of Public Health, Kyoto, Japan

men and 75.1 years in women. However, the report of the Ministry of Health and Welfare of Japan in 2010 set the average lifespan of the Japanese at 79.6 years for men and 86.3 years for women. Thus, the average lifespan of patients with diabetes still appears to be shorter than that of the general population in Japan. However, the difference in lifespan between patients with diabetes and the general population is smaller than found in previous surveys.

Keywords Causes of death in Japanese diabetics · Average age at the time of death · Diabetic nephropathy · Ischemic heart diseases · Cerebrovascular diseases

Introduction

The ultimate goal of treating diabetic patients is to maintain their quality of life (QOL) as much as possible (just as in healthy people), and to prolong their lives. Surveys of the cause of death and the age at the time of death in diabetic patients are important for assessing the contributions made by recent advances in diabetes treatment. While a study on the prevention and suppression of the development of vascular complications in diabetic patients (the Japan Diabetes Complications (JDC) study) [2] and a large-scale observational study to investigate the current status of diabetic complications and their prevention in Japan (the Japan Diabetes Complication and its Prevention (JDCP) prospective study) [3, 4] clarified the clinical features of Japanese patients with diabetes, these studies had limitations in terms of sample size and did not include analyses of the causes of death in diabetic patients.

Previously, three questionnaire surveys were carried out to investigate the causes of death in Japanese diabetic patients [5–7]. The present questionnaire survey was conducted in a similar manner to the three previous surveys by the Committee of the Japan Diabetes Society on the Causes of Death in Diabetes Mellitus. In this study, we investigated the causes of death among Japanese diabetic patients between 2001 and 2010 and compared the data with the results of previous surveys.

Methods

The survey period comprised 10 years from January 1, 2001, to December 31, 2010. The survey contained the following items: (1) sex, (2) body height, (3) maximum body weight, (4) age at the time of death, (5) year and month of death, (6) estimated age of onset of diabetes, (7) duration of treatment for diabetes, (8) type of diabetes, (9) cause of death, (10) diabetic complications while alive, (11) details of treatment for diabetes, (12) source of

diagnosis of the cause of death, and (13) the most recent hemoglobin A1c (HbA1c) (JDS) level (converted to National Glycohemoglobin Standardization Program [NGSP] units for analyses). Five of the questions (1, 4, 8, 9, and 11) were mandatory. The contents of the questionnaire were slightly different from those of the three previous studies, but most of the contents remained the same to allow comparison with the results of those surveys.

As in the previous surveys, we sent survey forms to 1164 institutions that met the criterion of being an institution that had presented papers at an Annual Meeting of the Japan Diabetes Society during the previous 5 years (2006–2010). Although the subjects in the previous surveys were limited to patients who were being treated in the department of diabetes at the time of death, the subjects in the present study were those who were being treated in any of the departments in the institution at the time of death. We received responses from 241 institutions (20.7% response rate), covering 45,970 diabetic patients (22,182 collected by web-based questionnaire and 23,788 collected by paper-based questionnaire). Excluding survey forms with internal inconsistencies or missing important data left an analysis group of 45,708 subjects (29,801 men and 15,907 women). Because some data were missing in some of these forms, however, the number of subjects was not the same for all parameters. Results are for all subjects unless it is specified that they pertain to autopsy cases.

We analyzed in particular the relationship between vascular disease (chronic renal failure including diabetic nephropathy, ischemic heart disease, and cerebrovascular disease) as the cause of death and patient characteristics, including age, sex, glycemic control status, duration of diabetes, details of treatment for diabetes, and main complications.

Results

Causes of death in Japanese patients with diabetes

Comparison between all subjects and autopsy cases

The results of this survey of causes of death in Japanese diabetic patients are shown for all cases and for autopsy cases only in Tables 1 and 2, respectively.

The most frequent cause of death among all 45,708 cases was malignant neoplasia, accounting for 17,510 cases (38.3%), followed by infectious disease in 7771 (17.0%) and vascular diseases (chronic renal failure, ischemic heart diseases, and cerebrovascular diseases) in 6824 (14.9%). The most common malignancy was lung cancer in 3213 cases (7.0%), followed by liver cancer in 2748 (6.0%) and pancreatic cancer in 2600 (5.7%). Of the deaths from

Table 1 Causes of death in Japanese diabetic patients—study of a total of 45,708 cases during 2001–2010

Causes of death	Sex and number					
	Male (%)	29,801 (n)	Female (%)	15,907 (n)	Total (%)	45,708 (n)
Vascular diseases	13.8	4126	17.0	2698	14.9	6824
Chronic renal failure	3.1	924	4.3	689	3.5	1613
Diabetic nephropathy	2.5	746	3.5	557	2.9	1303
Nondiabetic nephropathy	0.6	178	0.8	132	0.7	310
Ischemic heart diseases	4.5	1342	5.3	841	4.8	2183
Myocardial infarction	4.2	1258	4.9	777	4.5	2035
Angina pectoris	0.3	84	0.4	64	0.3	148
Cerebrovascular diseases	6.2	1860	7.3	1168	6.6	3028
Hemorrhage	2.2	650	1.8	294	2.1	944
Infarction	3.1	929	4.1	652	3.5	1581
Subarachnoid hemorrhage	0.4	127	0.9	146	0.6	273
Others	0.5	154	0.5	76	0.5	230
Heart diseases (other than ischemic heart diseases)	7.5	2238	10.8	1717	8.7	3955
Arrhythmia	0.9	272	0.8	121	0.9	393
Heart failure	5.4	1622	8.6	1372	6.6	2994
Others	1.2	344	1.4	224	1.2	568
Diabetic coma	0.5	154	0.8	127	0.6	281
Hypoglycemic coma	0.2	49	0.2	30	0.2	79
Malignant neoplasia	40.7	12,115	33.9	5395	38.3	17,510
Esophagus	1.4	407	0.4	62	1.0	469
Stomach	4.0	1189	2.4	389	3.5	1578
Lung	8.9	2658	3.5	555	7.0	3213
Colon	2.7	799	2.6	418	2.7	1217
Liver	6.7	2007	4.7	741	6.0	2748
Pancreas	5.5	1628	6.1	972	5.7	2600
Uterus	0.0	0	1.4	230	0.5	230
Breast	0.0	6	1.8	282	0.6	288
Leukemia/lymphoma	4.0	1193	3.6	573	3.9	1766
Others	7.5	2228	7.4	1173	7.4	3401
Infectious diseases	17.6	5255	15.8	2516	17.0	7771
Tuberculosis	0.3	86	0.2	37	0.3	123
Pneumonia	12.7	3784	9.6	1528	11.6	5312
Others	4.6	1385	6.0	951	5.1	2336
Liver cirrhosis	3.3	971	3.4	544	3.3	1515
Type B	0.3	94	0.2	33	0.3	127
Type C	1.3	402	1.8	280	1.5	682
NAFLD	0.1	23	0.1	23	0.1	46
Others	1.5	452	1.3	208	1.4	660
Suicide	0.3	77	0.3	52	0.3	129
Others	13.3	3977	14.9	2375	13.9	6352
Unknown	2.8	839	2.8	453	2.8	1292

vascular diseases, ischemic heart diseases and cerebrovascular diseases accounted for 2183 (4.8%) and 3028 (6.6%), respectively, and deaths from chronic renal failure accounted for 1613 (3.5%). Regarding ischemic heart

diseases, angina pectoris was the cause of death in only 0.3% of cases, and almost all the deaths from ischemic heart diseases were due to myocardial infarction. A total of 3955 subjects (8.7%) died from heart diseases other than

Table 2 Causes of death in Japanese diabetic patients—study of 978 autopsy cases during 2001–2010

Causes of death	Sex and number					
	Male (%)	665 (n)	Female (%)	313 (n)	Total (%)	978 (n)
Vascular diseases	13.4	89	18.5	58	15.0	147
Chronic renal failure	2.6	17	3.8	12	3.0	29
Diabetic nephropathy	2.0	13	2.9	9	2.2	22
Nondiabetic nephropathy	0.6	4	1.0	3	0.7	7
Ischemic heart diseases	6.8	45	10.2	32	7.9	77
Myocardial infarction	6.8	45	9.6	30	7.7	75
Angina pectoris	0.0	0	0.6	2	0.2	2
Cerebrovascular diseases	4.1	27	4.5	14	4.2	41
Hemorrhage	1.4	9	1.3	4	1.3	13
Infarction	1.7	11	1.9	6	1.7	17
Subarachnoid hemorrhage	0.5	3	0.6	2	0.5	5
Others	0.6	4	0.6	2	0.6	6
Heart diseases (other than ischemic heart diseases)	8.0	53	4.8	15	7.0	68
Arrhythmia	0.9	6	1.0	3	0.9	9
Heart failure	6.2	41	1.9	6	4.8	47
Others	0.9	6	1.9	6	1.2	12
Diabetic coma	0.9	6	0.6	2	0.8	8
Hypoglycemic coma	0.3	2	0.0	0	0.2	2
Malignant neoplasia	34.0	226	32.9	103	33.6	329
Esophagus	0.8	5	0.3	1	0.6	6
Stomach	2.1	14	1.0	3	1.7	17
Lung	6.9	46	3.2	10	5.7	56
Colon	0.8	5	1.3	4	0.9	9
Liver	5.7	38	5.1	16	5.5	54
Pancreas	2.6	17	3.5	11	2.9	28
Uterus	0.0	0	1.6	5	0.5	5
Breast	0.0	0	0.0	0	0.0	0
Leukemia/lymphoma	8.9	59	9.3	29	9.0	88
Others	6.3	42	7.7	24	6.7	66
Infectious diseases	20.6	137	21.7	68	21.0	205
Tuberculosis	0.6	4	0.6	2	0.6	6
Pneumonia	13.1	87	10.5	33	12.3	120
Others	6.9	46	10.5	33	8.1	79
Liver cirrhosis	2.7	18	1.9	6	2.5	24
Type B	0.2	1	0.0	0	0.1	1
Type C	0.6	4	1.3	4	0.8	8
NAFLD	0.0	0	0.0	0	0.0	0
Others	2.0	13	0.6	2	1.5	15
Suicide	0.5	3	0.0	0	0.3	3
Others	18.9	126	17.9	56	18.6	182
Unknown	0.8	5	1.6	5	1.0	10

ischemic heart diseases and most of those (2994, 6.6%) were due to heart failure. Of the deaths from cerebrovascular diseases, cerebral infarction—the cause of death in 1581 cases (3.5%)—was 1.7 times more common than

cerebral hemorrhage—the cause of death in 944 cases (2.1%). Of the deaths from infectious diseases, 5312 (11.6%) cases were from pneumonia, accounting for 68% of all the deaths from infectious diseases. Diabetic coma

was the cause of death in 281 cases (0.6%) and hypoglycemic coma in 79 cases (0.2%).

Analysis of differences between the sexes showed that malignant neoplasia was a more common cause of death in men (40.7%) than in women (33.9%). In particular, esophageal cancer, gastric cancer, lung cancer, and liver cancer were frequently observed. Deaths from vascular diseases were more common in women than in men, and deaths from chronic renal failure, ischemic heart diseases, or cerebrovascular diseases showed a similar trend. Deaths from heart diseases other than ischemic heart diseases were more common in women than in men. Deaths from infectious diseases were more common in men than in women, and deaths from diabetic coma were slightly more common in women than in men.

An autopsy was performed in 978 cases, accounting for only 2.1% of all cases. The most common cause of death in all the subjects who underwent autopsy was malignant neoplasia, accounting for 329 cases (33.6%), followed by infectious diseases in 205 (21.0%) and vascular diseases in 147 (15.0%). These results, including sex differences, were similar to those for all the surveyed subjects, with deaths from ischemic heart diseases more common and those from cerebrovascular diseases less common.

Causes of death according to age groups

The causes of death for all subjects according to age group are shown in Table 3. The male to female ratio was 1.9:1 for all subjects, 2.6:1 for those aged 40–69, and 1.6:1 for those aged ≥ 70 .

The mortality rate as a result of vascular diseases was 13–16% for subjects aged ≥ 30 , with no significant difference among the age groups, and it was higher in men than in women for subjects aged 40–59. The mortality rate as a result of chronic renal failure due to diabetic nephropathy was not reported in subjects aged ≤ 29 , and it was approximately 2–3% for subjects aged ≥ 30 . The mortality rate as a result of myocardial infarction increased to approximately 4–5% for subjects aged ≥ 40 . The mortality rate as a result of cerebrovascular diseases was 6–8% for subjects aged ≥ 30 , with deaths from cerebral hemorrhage being more common in subjects aged ≤ 49 and those from cerebral infarction more prevalent in subjects aged ≥ 60 .

The mortality rate as a result of malignant neoplasia was as high as 46.3% for subjects aged 50–59 and 47.7% for those aged 60–69, while those aged ≥ 51 accounted for 97.4% of the deaths from malignant neoplasia. In addition, the proportion of deaths from leukemia and lymphoma was high in subjects aged ≤ 29 .

The mortality rate as a result of pneumonia increased with age, reaching 20.0% in the subjects aged ≥ 70 , and

80.7% of the deaths from pneumonia occurred in the subjects aged ≥ 70 .

The mortality rate as a result of diabetic coma was as high as 14.6% in the subjects aged 10–19 and 10.4% in those aged 20–29, and it was the second most frequent cause of death following malignant neoplasia in these age groups.

Glycemic control, duration of diabetes, cause of death, and age at death

Glycemic control, cause of death, and age at death

Table 4 shows the cause of death, level of glycemic control, and average age at the time of death in 20,348 subjects in whom HbA1c levels were measured (the subjects were divided into two groups based on the level of glycemic control: better, with NGSP $< 8.4\%$; and poorer, with NGSP $\geq 8.4\%$).

The average age at time of death for all subjects was 72.6 years, and was 1.6 years shorter in subjects with poorer glycemic control than in those with better glycemic control. Lifespans were longer for those with better control almost regardless of the cause of death, and this difference was smaller for deaths as a result of malignant neoplasms (0.8 years) and greater for deaths as a result of vascular disease (2.4 years), particularly renal failure due to diabetic nephropathy (4.7 years). On the other hand, for subjects who died from renal failures other than diabetic nephropathy, lifespans were 2.6 years longer in subjects with poorer glycemic control. In addition, for subjects who died from diabetic coma or hypoglycemic coma, lifespans were shorter in those with poorer glycemic control (6.9 and 10.7 years, respectively). For subjects who died from arrhythmia as a heart disease other than ischemic heart diseases, lifespans were 5 years shorter in those with poorer glycemic control.

Glycemic control, duration of diabetes, and deaths caused by vascular diseases

Data on HbA1c levels and estimated duration of diabetes were available for 1503 of the 6824 subjects who died from vascular diseases (Table 5). As approximately 90% of the patients had better glycemic control, it was difficult to compare those with better and poorer control, and analysis was performed only on the relationship between cause of death and duration of diabetes.

The duration of diabetes was 10 years or more in 73.4% of the deaths from diabetic nephropathy, 62.7% of the deaths from ischemic heart diseases, and 50% of the deaths from cerebrovascular diseases.

Table 3 Causes of death at specified ages in Japanese diabetic patients—study of a total number of 45,708 cases during 2001–2010

Sex and number: Causes of death	Age at death (years):			10–19			20–29		
	0–9			Total			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
	7 (100.0%)	5 (100.0%)	12 (100.0%)	23 (100.0%)	18 (100.0%)	41 (100.0%)	44 (100.0%)	33 (100.0%)	77 (100.0%)
Vascular diseases	2 (28.6)	1 (20.0)	3	3 (13.0)	1 (5.6)	4	6 (13.6)	1 (3.0)	7
Chronic renal failure	0 (0.0)	0 (0.0)	0	0 (0.0)	1 (5.6)	1	1 (2.3)	0 (0.0)	1
Diabetic nephropathy	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Non-diabetic nephropathy	0 (0.0)	0 (0.0)	0	0 (0.0)	1 (5.6)	1	1 (2.3)	0 (0.0)	1
Ischemic heart diseases	0 (0.0)	0 (0.0)	0	1 (4.3)	0 (0.0)	1	1 (2.3)	0 (0.0)	1
Myocardial infarction	0 (0.0)	0 (0.0)	0	1 (4.3)	0 (0.0)	1	1 (2.3)	0 (0.0)	1
Angina pectoris	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Cerebrovascular diseases	2 (28.6)	1 (20.0)	3	2 (8.7)	0 (0.0)	2	4 (9.1)	1 (3.0)	5
Hemorrhage	1 (14.3)	0 (0.0)	1	1 (4.3)	0 (0.0)	1	1 (2.3)	0 (0.0)	1
Infarction	1 (14.3)	0 (0.0)	1	8.3	0 (0.0)	0	1 (2.3)	1 (3.0)	2
Subarachnoidal hemorrhage	0 (0.0)	0 (0.0)	0	1 (4.3)	0 (0.0)	1	1 (2.3)	0 (0.0)	1
Others	0 (0.0)	1 (20.0)	1	8.3	0 (0.0)	0	1 (2.3)	0 (0.0)	1
Heart diseases (other than ischemic heart diseases)	0 (0.0)	0 (0.0)	0	3 (13.0)	3 (16.7)	6	2 (4.5)	4 (12.1)	6
Arrhythmia	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	1 (3.0)	1
Heart failure	0 (0.0)	0 (0.0)	0	1 (4.3)	3 (16.7)	4	1 (2.3)	2 (6.1)	3
Others	0 (0.0)	0 (0.0)	0	2 (8.7)	0 (0.0)	2	1 (2.3)	1 (3.0)	2
Diabetic coma	0 (0.0)	0 (0.0)	0	3 (13.0)	3 (16.7)	6	4 (9.1)	4 (12.1)	8
Hypoglycemic coma	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	1 (3.0)	1
Malignant neoplasia	3 (42.9)	4 (80.0)	7	9 (39.1)	6 (33.3)	15	20 (45.5)	9 (27.3)	29
Esophagus	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Stomach	1 (14.3)	0 (0.0)	1	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Lung	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	1 (2.3)	0 (0.0)	1
Colon	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Liver	0 (0.0)	2 (40.0)	2	0 (0.0)	0 (0.0)	0	1 (2.3)	0 (0.0)	1
Pancreas	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Uterus	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Breast	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Leucemia/lymphoma	2 (28.6)	2 (40.0)	4	33.3	6 (33.3)	13	15 (34.1)	4 (12.1)	19
Others	0 (0.0)	0 (0.0)	0	0.0	0 (0.0)	2	3 (6.8)	5 (15.2)	8
Infectious diseases	1 (14.3)	0 (0.0)	1	8.3	1 (5.6)	3	1 (2.3)	3 (9.1)	4
Tuberculosis	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Pneumonia	1 (14.3)	0 (0.0)	1	8.3	2 (8.7)	2	1 (2.3)	0 (0.0)	1
Others	0 (0.0)	0 (0.0)	0	0.0	1 (5.6)	1	0 (0.0)	3 (9.1)	3
Liver cirrhosis	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Type B	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Type C	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
NAFLD	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Others	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Suicide	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0	0 (0.0)	0 (0.0)	0
Others	1 (14.3)	0 (0.0)	1	8.3	3 (16.7)	6	9 (20.5)	2 (6.1)	12
Unknown	0 (0.0)	0 (0.0)	0	0.0	1 (5.6)	1	2 (4.5)	6 (18.2)	8

Table 3 continued

Age at death (years): Sex and number:	30–39			40–49			50–59		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Causes of death	177 (100.0%)	92 (100.0%)	269 (100.0%)	682 (100.0%)	289 (100.0%)	971 (100.0%)	3010 (100.0%)	1104 (100.0%)	4114 (100.0%)
Vascular diseases	24 (13.6)	14 (15.2)	38	109 (16.0)	39 (13.5)	148	434 (14.4)	132 (12.0)	566
Chronic renal failure	4 (2.3)	5 (5.4)	9	10 (1.5)	9 (3.1)	19	68 (2.3)	39 (3.5)	107
Diabetic nephropathy	2 (1.1)	5 (5.4)	7	6 (0.9)	6 (2.1)	12	58 (1.9)	33 (3.0)	91
Non-diabetic nephropathy	2 (1.1)	0 (0.0)	2	4 (0.6)	3 (1.0)	7	10 (0.3)	6 (0.5)	16
Ischemic heart diseases	5 (2.8)	2 (2.2)	7	39 (5.7)	8 (2.8)	47	158 (5.2)	37 (3.4)	195
Myocardial infarction	5 (2.8)	2 (2.2)	7	38 (5.6)	8 (2.8)	46	152 (5.0)	34 (3.1)	186
Angina pectoris	0 (0.0)	0 (0.0)	0	1 (0.1)	0 (0.0)	1	6 (0.2)	3 (0.3)	9
Cerebrovascular diseases	15 (8.5)	7 (7.6)	22	60 (8.8)	22 (7.6)	82	208 (6.9)	56 (5.1)	264
Hemorrhage	6 (3.4)	4 (4.3)	10	34 (5.0)	11 (3.8)	45	116 (3.9)	24 (2.2)	140
Infarction	4 (2.3)	0 (0.0)	4	12 (1.8)	5 (1.7)	17	59 (2.0)	16 (1.4)	75
Subarachnoid hemorrhage	2 (1.1)	3 (3.3)	5	10 (1.5)	6 (2.1)	16	20 (0.7)	10 (0.9)	30
Others	3 (1.7)	0 (0.0)	3	4 (0.6)	0 (0.0)	4	13 (0.4)	6 (0.5)	19
Heart diseases (other than ischemic heart diseases)	10 (5.6)	4 (4.3)	14	51 (7.5)	9 (3.1)	60	155 (5.1)	71 (6.4)	226
Arrhythmia	1 (0.6)	1 (1.1)	2	15 (2.2)	1 (0.3)	16	25 (0.8)	10 (0.9)	35
Heart failure	6 (3.4)	3 (3.3)	9	26 (3.8)	4 (1.4)	30	87 (2.9)	46 (4.2)	133
Others	3 (1.7)	0 (0.0)	3	10 (1.5)	4 (1.4)	14	43 (1.4)	15 (1.4)	58
Diabetic coma	13 (7.3)	2 (2.2)	15	14 (2.1)	7 (2.4)	21	12 (0.4)	14 (1.3)	26
Hypoglycemic coma	2 (1.1)	1 (1.1)	3	1 (0.1)	2 (0.7)	3	9 (0.3)	3 (0.3)	12
Malignant neoplasia	46 (26.0)	27 (29.3)	73	227 (33.3)	108 (37.4)	335	1382 (45.9)	522 (47.3)	1904
Esophagus	0 (0.0)	0 (0.0)	0	3 (0.4)	2 (0.7)	5	44 (1.5)	10 (0.9)	54
Stomach	2 (1.1)	1 (1.1)	3	10 (1.5)	5 (1.7)	15	115 (3.8)	27 (2.4)	142
Lung	4 (2.3)	0 (0.0)	4	22 (3.2)	3 (1.0)	25	258 (8.6)	35 (3.2)	293
Colon	3 (1.7)	3 (3.3)	6	15 (2.2)	4 (1.4)	19	89 (3.0)	30 (2.7)	119
Liver	4 (2.3)	0 (0.0)	4	32 (4.7)	4 (1.4)	36	260 (8.6)	38 (3.4)	298
Pancreas	3 (1.7)	0 (0.0)	3	33 (4.8)	9 (3.1)	42	224 (7.4)	89 (8.1)	313
Uterus	0 (0.0)	2 (2.2)	2	0 (0.0)	14 (4.8)	14	0 (0.0)	45 (4.1)	45
Breast	0 (0.0)	2 (2.2)	2	0 (0.0)	18 (6.2)	18	1 (0.0)	59 (5.3)	60
Leucemia/lymphoma	23 (13.0)	11 (12.0)	34	71 (10.4)	28 (9.7)	99	156 (5.2)	74 (6.7)	230
Others	7 (4.0)	8 (8.7)	15	41 (6.0)	21 (7.3)	62	235 (7.8)	115 (10.4)	350
Infectious diseases	25 (14.1)	13 (14.1)	38	67 (9.8)	28 (9.7)	95	311 (10.3)	119 (10.8)	430
Tuberculosis	1 (0.6)	0 (0.0)	1	4 (0.6)	0 (0.0)	4	4 (0.1)	2 (0.2)	6
Pneumonia	7 (4.0)	6 (6.5)	13	20 (2.9)	14 (4.8)	34	174 (5.8)	48 (4.3)	222
Others	17 (9.6)	7 (7.6)	24	43 (6.3)	14 (4.8)	57	133 (4.4)	69 (6.3)	202
Liver cirrhosis	7 (4.0)	1 (1.1)	8	65 (9.5)	24 (8.3)	89	201 (6.7)	53 (4.8)	254
Type B	0 (0.0)	0 (0.0)	0	8 (1.2)	2 (0.7)	10	28 (0.9)	6 (0.5)	34
Type C	2 (1.1)	1 (1.1)	3	23 (3.4)	5 (1.7)	28	61 (2.0)	22 (2.0)	83
NAFLD	0 (0.0)	0 (0.0)	0	1 (0.1)	0 (0.0)	1	8 (0.3)	2 (0.2)	10
Others	5 (2.8)	0 (0.0)	5	33 (4.8)	17 (5.9)	50	104 (3.5)	23 (2.1)	127
Suicide	2 (1.1)	6 (6.5)	8	5 (0.7)	3 (1.0)	8	13 (0.4)	5 (0.5)	18
Others	35 (19.8)	19 (20.7)	54	106 (15.5)	55 (19.0)	161	382 (12.7)	150 (13.6)	532
Unknown	13 (7.3)	5 (5.4)	18	37 (5.4)	14 (4.8)	51	111 (3.7)	35 (3.2)	146

Table 3 continued

Age at death (years): Sex and number: Causes of death	60–69			70–79			All age		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
	7599 (100.0%)	2899 (100.0%)	10498 (100.0%)	18192 (100.0%)	11424 (100.0%)	29616 (100.0%)	29734 (100.0%)	15864 (100.0%)	45598 (100.0%)
Vascular diseases	969 (12.8)	391 (13.5)	1360	2571 (14.1)	2114 (18.5)	4685	4118 (13.8)	2693 (17.0)	6811 (14.9)
Chronic renal failure	202 (2.7)	97 (3.3)	299	638 (3.5)	537 (4.7)	1175	923 (3.1)	688 (4.3)	1611 (3.5)
Diabetic nephropathy	158 (2.1)	79 (2.7)	237	521 (2.9)	433 (3.8)	954	745 (2.5)	556 (3.5)	1301 (2.9)
Non-diabetic nephropathy	44 (0.6)	18 (0.6)	62	117 (0.6)	104 (0.9)	221	178 (0.6)	132 (0.8)	310 (0.7)
Ischemic heart diseases	301 (4.0)	103 (3.6)	404	835 (4.6)	689 (6.0)	1524	1340 (4.5)	839 (5.3)	2179 (4.8)
Myocardial infarction	285 (3.8)	91 (3.1)	376	774 (4.3)	640 (5.6)	1414	1256 (4.2)	775 (4.9)	2031 (4.5)
Angina pectoris	16 (0.2)	12 (0.4)	28	61 (0.3)	49 (0.4)	110	84 (0.3)	64 (0.4)	148 (0.3)
Cerebrovascular diseases	466 (6.1)	191 (6.6)	657	1098 (6.0)	888 (7.8)	1986	1855 (6.2)	1166 (7.3)	3021 (6.6)
Hemorrhage	178 (2.3)	68 (2.3)	246	312 (1.7)	187 (1.6)	499	649 (2.2)	294 (1.9)	943 (2.1)
Infarction	213 (2.8)	81 (2.8)	294	636 (3.5)	547 (4.8)	1183	926 (3.1)	650 (4.1)	1576 (3.5)
Subarachnoidal hemorrhage	38 (0.5)	26 (0.9)	64	55 (0.3)	101 (0.9)	156	127 (0.4)	146 (0.9)	273 (0.6)
Others	37 (0.5)	16 (0.6)	53	95 (0.5)	53 (0.5)	148	153 (0.5)	76 (0.5)	229 (0.5)
Heart diseases (other than ischemic heart diseases)	456 (6.0)	206 (7.1)	662	1553 (8.5)	1418 (12.4)	2971	2230 (7.5)	1715 (10.8)	3945 (8.7)
Arrhythmia	78 (1.0)	22 (0.8)	100	152 (0.8)	86 (0.8)	238	271 (0.9)	121 (0.8)	392 (0.9)
Heart failure	300 (3.9)	145 (5.0)	445	1194 (6.6)	1167 (10.2)	2361	1615 (5.4)	1370 (8.6)	2985 (6.5)
Others	78 (1.0)	39 (1.3)	117	207 (1.1)	165 (1.4)	372	344 (1.2)	224 (1.4)	568 (1.2)
Diabetic coma	29 (0.4)	20 (0.7)	49	79 (0.4)	77 (0.7)	156	154 (0.5)	127 (0.8)	281 (0.6)
Hypoglycemic coma	11 (0.1)	4 (0.1)	15	26 (0.1)	19 (0.2)	45	49 (0.2)	30 (0.2)	79 (0.2)
Malignant neoplasia	3712 (48.8)	1298 (44.8)	5010	6692 (36.8)	3401 (29.8)	10093	12091 (40.7)	5375 (33.9)	17466 (38.3)
Esophagus	163 (2.1)	11 (0.4)	174	197 (1.1)	39 (0.3)	236	407 (1.4)	62 (0.4)	469 (1.0)
Stomach	366 (4.8)	95 (3.3)	461	695 (3.8)	259 (2.3)	954	1189 (4.0)	387 (2.4)	1576 (3.5)
Lung	745 (9.8)	116 (4.0)	861	1624 (8.9)	398 (3.5)	2022	2654 (8.9)	552 (3.5)	3206 (7.0)
Colon	256 (3.4)	96 (3.3)	352	434 (2.4)	282 (2.5)	716	797 (2.7)	415 (2.6)	1212 (2.7)
Liver	676 (8.9)	171 (5.9)	847	1027 (5.6)	519 (4.5)	1546	2000 (6.7)	734 (4.6)	2734 (6.0)
Pancreas	545 (7.2)	243 (8.4)	788	818 (4.5)	628 (5.5)	1446	1623 (5.5)	969 (6.1)	2592 (5.7)
Uterus	0 (0.0)	67 (2.3)	67	0 (0.0)	102 (0.9)	102	0 (0.0)	230 (1.4)	230 (0.5)
Breast	4 (0.1)	97 (3.3)	101	1 (0.0)	105 (0.9)	106	6 (0.0)	281 (1.8)	287 (0.6)
Leucemia/lymphoma	326 (4.3)	130 (4.5)	456	592 (3.3)	318 (2.8)	910	1192 (4.0)	573 (3.6)	1765 (3.9)
Others	631 (8.3)	272 (9.4)	903	1304 (7.2)	751 (6.6)	2055	2223 (7.5)	1172 (7.4)	3395 (7.4)
Infectious diseases	934 (12.3)	330 (11.4)	1264	3904 (21.5)	2016 (17.6)	5920	5245 (17.6)	2510 (15.8)	7755 (17.0)
Tuberculosis	22 (0.3)	0 (0.0)	22	54 (0.3)	35 (0.3)	89	85 (0.3)	37 (0.2)	122 (0.3)
Pneumonia	599 (7.9)	154 (5.3)	753	2975 (16.4)	1305 (11.4)	4280	3779 (12.7)	1527 (9.6)	5306 (11.6)
Others	313 (4.1)	176 (6.1)	489	875 (4.8)	676 (5.9)	1551	1381 (4.6)	946 (6.0)	2327 (5.1)
Liver cirrhosis	324 (4.3)	158 (5.5)	482	370 (2.0)	305 (2.7)	675	967 (3.3)	541 (3.4)	1508 (3.3)
Type B	30 (0.4)	10 (0.3)	40	28 (0.2)	15 (0.1)	43	94 (0.3)	33 (0.2)	127 (0.3)
Type C	132 (1.7)	89 (3.1)	221	181 (1.0)	160 (1.4)	341	399 (1.3)	277 (1.7)	676 (1.5)
NAFLD	7 (0.1)	5 (0.2)	12	7 (0.0)	16 (0.1)	23	23 (0.1)	23 (0.1)	46 (0.1)
Others	155 (2.0)	54 (1.9)	209	154 (0.8)	114 (1.0)	268	451 (1.5)	208 (1.3)	659 (1.4)

Table 3 continued

Age at death (years): Sex and number:	60–69			70–79			All age		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Causes of death	7599 (100.0%)	2899 (100.0%)	10498 (100.0%)	18192 (100.0%)	11424 (100.0%)	29616 (100.0%)	29734 (100.0%)	15864 (100.0%)	45598 (100.0%)
Suicide	24 (0.3)	16 (0.6)	40	33 (0.2)	20 (0.2)	53	77 (0.3)	52 (0.3)	129 (0.3)
Others	908 (11.9)	390 (13.5)	1298	2522 (13.9)	1749 (15.3)	4271	3966 (13.3)	2369 (14.9)	6335 (13.9)
Unknown	232 (3.1)	86 (3.0)	318	442 (2.4)	305 (2.7)	747	837 (2.8)	452 (2.8)	1289 (2.8)

Relationships between deaths caused by vascular disease, treatment for diabetes, and complications and concomitant diseases

Treatment for diabetes and deaths caused by vascular diseases

As shown in Table 6, treatments for diabetes in all the subjects comprised diet alone in 18.8%, oral hypoglycemic agents in 33.9%, and insulin in 41.9%, with insulin therapy the most common. In particular, 53.7% of diabetic patients who died from diabetic nephropathy were on insulin therapy, a higher proportion than those who died from ischemic heart diseases (38.9%) or those who died from cerebrovascular diseases (39%). Oral hypoglycemic agent therapy was more common in diabetic patients who died from ischemic heart diseases (34.6%) and cerebrovascular diseases (33.6%) compared with those who died from diabetic nephropathy (28.6%). Diet therapy alone was slightly less common in diabetic patients who died from diabetic nephropathy (13.9%) than in those who died from ischemic heart diseases (16.2%) or cerebrovascular diseases (17.8%). The sum of the percentages exceeds 100 because there were subjects who used both oral hypoglycemic agents and insulin.

Complications, concomitant diseases, and deaths from vascular diseases

The relationship between complications and concomitant diseases and deaths from vascular diseases is shown in Table 7 (all subjects) and Table 8 (autopsy subjects). The incidence rates of almost all the complications and concomitant diseases were much lower than those in the previous surveys, probably because it was not mandatory to answer the question about complications and concomitant diseases in the present survey. On the other hand, the incidence rates of complications and concomitant diseases in the autopsy subjects were higher than those in all the subjects, probably because complications and concomitant diseases were evaluated based on the autopsy records for which detailed data were available; however, it should be noted that the data may be insufficient for analysis because the number of autopsy subjects who died from vascular diseases was as low as 140 subjects and only 68% of those who died from diabetic nephropathy were reported to have diabetic nephropathy as a concomitant disease.

In all the subjects as well as in the autopsy subjects only, diabetic retinopathy and neuropathy were both common in diabetic patients who eventually died from diabetic nephropathy, and the incidence of coronary artery diseases was high in diabetic patients who died from ischemic heart diseases. Hypertension was present in

Table 4 Causes of death, average age at death, and glycemic control in Japanese diabetic patients—study of a total of 45,708 cases during 2001–2010

Causes of death	Glycemic control								
	Better (<i>n</i> = 16,911)			Poorer (<i>n</i> = 3437)			Total (<i>n</i> = 20,348)		
	Male	Female	Mean	Male	Female	Mean	Male	Female	Mean
Vascular diseases	72.3	77.6	74.4	68.8	77.2	72.0	71.7	77.5	74.0
Chronic renal failure	73.7	77.9	75.5	72.1	73.3	72.6	73.5	77.5	75.2
Diabetic nephropathy	74.3	78.0	75.8	71.2	71.0	71.1	74.0	77.3	75.4
Nondiabetic nephropathy	71.6	77.8	74.5	74.2	82.0	77.1	71.9	78.2	74.7
Ischemic heart diseases	71.6	77.7	74.2	66.7	79.4	71.2	70.5	78.0	73.5
Myocardial infarction	71.4	77.8	74.0	66.2	79.5	70.9	70.2	78.1	73.3
Angina pectoris	75.1	76.9	76.0	79.6	77.0	78.6	75.7	76.9	76.3
Cerebrovascular diseases	72.1	77.3	74.0	70.1	76.6	72.7	71.8	77.1	73.8
Hemorrhage	68.6	72.0	69.6	68.5	75.1	69.9	68.6	72.4	69.6
Infarction	75.1	80.7	77.3	71.0	77.4	74.1	74.4	80.0	76.6
Subarachnoid hemorrhage	68.2	74.2	71.5	71.4	75.0	73.3	68.7	74.3	71.8
Others	72.2	75.4	73.2	69.8	70.0	69.8	71.8	74.8	72.8
Heart diseases (other than ischemic heart diseases)	74.4	79.3	76.4	72.2	76.1	74.0	74.1	78.7	76.1
Arrhythmia	72.0	73.5	72.5	65.5	72.4	67.5	71.2	73.4	71.8
Heart failure	75.6	80.5	77.8	73.5	77.4	75.5	75.3	79.9	77.4
Others	70.0	73.9	71.4	70.7	68.7	69.9	70.1	72.9	71.1
Diabetic coma	68.8	76.4	72.1	63.5	66.7	65.2	65.8	69.9	67.8
Hypoglycemic coma	71.7	76.9	73.8	57.3	66.0	63.1	69.3	72.8	70.9
Malignant neoplasia	70.1	71.7	70.6	69.3	70.9	69.8	69.9	71.6	70.4
Esophagus	69.9	76.0	70.7	68.9	69.4	69.0	69.8	74.9	70.5
Stomach	71.8	73.8	72.3	70.2	73.2	71.0	71.7	73.7	72.2
Lung	71.5	74.5	72.0	70.8	74.3	71.4	71.3	74.4	71.9
Colon	70.4	74.3	71.7	69.2	73.2	70.3	70.2	74.2	71.5
Liver	69.6	73.5	70.6	68.1	71.2	69.0	69.5	73.2	70.5
Pancreas	68.6	71.7	69.7	68.8	73.4	70.3	68.6	72.1	69.9
Uterus	0.0	67.2	67.2	0.0	65.9	65.9	0.0	67.0	67.0
Breast	62.7	67.2	67.1	0.0	62.0	62.0	62.7	66.0	65.9
Leukemia/lymphoma	66.4	68.0	66.9	67.7	69.1	68.1	66.5	68.2	67.0
Others	70.7	71.4	70.9	68.8	70.0	69.1	70.4	71.2	70.7
Infectious diseases	75.0	77.7	75.9	73.3	75.5	74.1	74.7	77.3	75.6
Tuberculosis	72.0	80.5	74.9	64.0	80.7	72.3	71.4	80.5	74.7
Pneumonia	76.4	79.5	77.3	74.7	78.0	75.6	76.1	79.3	77.0
Others	71.4	74.6	72.7	69.9	72.9	71.3	71.1	74.2	72.4
Liver cirrhosis	65.4	69.8	67.0	61.5	71.9	66.1	64.9	70.2	66.9
Type B	64.6	63.7	64.4	61.6	74.5	63.9	63.9	65.5	64.3
Type C	67.3	71.1	68.9	63.9	71.1	67.8	67.0	71.1	68.8
NAFLD	66.9	75.6	71.9	0.0	79.0	79.0	66.9	76.2	72.6
Others	63.5	67.4	64.6	60.2	71.5	65.1	63.0	68.4	64.7
Suicide	64.2	63.1	63.8	69.3	63.1	65.4	64.7	63.1	64.1
Others	71.5	76.1	73.2	70.6	73.8	71.8	71.4	75.6	73.0
Unknown	71.0	74.3	72.1	66.0	68.3	66.9	69.8	72.6	70.8
All causes	71.6	75.1	72.8	70.0	73.5	71.2	71.4	74.9	72.6

Values are years

Table 5 Glycemic control, duration of diabetes, and vascular diseases as causes of death in Japanese diabetic patients during 2001–2010

Glycemic control	Duration of diabetes (years)	Vascular diseases													
		Diabetic nephropathy						Ischemic heart diseases							

Table 6 Treatment of diabetes and vascular diseases as causes of death in Japanese diabetic patients during 2001–2010

Treatment	Causes of death																	
	Diabetic nephropathy						Ischemic heart diseases											
	Myocardial infarction			Angina pectoris			Total			Cerebrovascular diseases								
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total						
Diet alone	90	91	13.89% 181	210	122	16.31% 332	14	8	14.86% 22	224	130	16.22% 354	104	51	16.42% 155	172	117	18.28% 289
Oral hypoglycemic agents	218	155	28.63% 373	440	276	35.18% 716	19	21	27.03% 40	459	297	34.63% 756	216	74	30.72% 290	357	229	37.07% 586
Insulin	433	267	53.72% 700	490	293	38.48% 783	36	31	45.27% 67	526	324	38.94% 850	260	122	40.47% 382	357	235	37.44% 592
GLP-1 receptor agonist	2	2	0.31% 4	3	0	0.15% 3	0	0	0.00% 0	3	0	0.14% 3	1	0	0.11% 1	4	2	0.38% 6
Others	62	56	9.06% 118	140	94	11.50% 234	12	3	10.14% 15	152	97	11.41% 249	65	31	10.17% 96	75	70	9.17% 145
Total	746	557	1303 (105.60%)	1258	777	2035 (101.62%)	84	64	148 (97.30%)	1342	841	2183 (101.33%)	650	294	944 (97.88%)	929	652	1581 (102.34%)

Treatment	Causes of death														
	Cerebrovascular diseases						Others								
	Subarachnoid hemorrhage			Others			Total			All					
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total			
Diet alone	20	40	21.98% 60	28	8	15.65% 36	324	216	17.83% 540	4934	2568	19.14% 7502	5572	3005	18.76% 8577
Oral hypoglycemic agents	32	42	27.11% 74	44	23	29.13% 67	649	368	33.59% 1017	8965	4381	34.05% 13,346	10,291	5201	33.89% 15,492
Insulin	46	52	35.90% 98	70	38	46.96% 108	733	447	38.97% 1180	10,714	5713	41.91% 16,427	12,406	6751	41.91% 19,157
GLP-1 receptor agonist	0	0	0.00% 0	0	1	0.43% 1	5	3	0.26% 8	49	26	0.19% 75	59	31	0.20% 90
Others	21	17	13.92% 38	16	9	10.87% 25	177	127	10.04% 304	1887	962	7.27% 2849	2278	1242	7.70% 3520
Total	127	146	273 (98.90%)	154	76	230 (103.04%)	1860	1168	3028 (100.69%)	25,853	13,341	39,194 (102.56%)	29,801	15,907	45,708 (102.47%)

Table 7 Complications in Japanese diabetic patients with vascular diseases as causes of death—study of a total of 6514 cases during 2001–2010

Complications	Vascular diseases																	
	Diabetic nephropathy						Ischemic heart diseases											
				Myocardial infarction			Angina pectoris			Total								
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total			
746	557	1303	1258	777	2035	84	64	148	1342	841	2183	650	294	944	929	652	1581	
Kidney diseases other than diabetic nephropathy	42.1%	41.5%	41.8%	18.0%	18.0%	18.0%	10.7%	12.5%	11.5%	17.6%	17.6%	17.6%	18.9%	8.5%	15.7%	12.6%	10.9%	11.9%
	(314)	(231)	(545)	(227)	(140)	(367)	(9)	(8)	(17)	(236)	(148)	(384)	(123)	(25)	(148)	(117)	(71)	(188)
	1.5	1.4	1.5	2.9	3.0	2.9	6.0	1.6	4.1	3.1	2.9	3.0	1.8	4.1	2.5	3.4	2.8	3.2
	(11)	(8)	(19)	(37)	(23)	(60)	(5)	(1)	(6)	(42)	(24)	(66)	(12)	(12)	(24)	(32)	(18)	(50)
Retinopathy	17.4	16.2	16.9	11.8	13.0	12.2	8.3	14.1	10.8	11.5	13.1	12.1	12.0	5.4	10.0	7.9	5.7	7.0
Neuropathy	(130)	(90)	(220)	(148)	(101)	(249)	(7)	(9)	(16)	(155)	(110)	(265)	(78)	(16)	(94)	(73)	(37)	(110)
	13.1	12.0	12.7	7.5	8.2	7.8	6.0	6.3	6.1	7.4	8.1	7.7	7.8	2.4	6.1	4.5	4.6	4.6
Gangrene	(98)	(67)	(165)	(94)	(64)	(158)	(5)	(4)	(9)	(99)	(68)	(167)	(51)	(7)	(58)	(42)	(30)	(72)
	4.8	4.8	4.8	3.4	2.3	3.0	2.4	0.0	1.4	3.4	2.1	2.9	1.5	1.0	1.4	2.6	1.4	2.1
Cerebrovascular diseases	(36)	(27)	(63)	(43)	(18)	(61)	(2)	(0)	(2)	(45)	(18)	(63)	(10)	(3)	(13)	(24)	(9)	(33)
	16.4	10.2	13.7	12.0	13.8	12.7	10.7	12.5	11.5	11.9	13.7	12.6	16.3	15.3	16.0	18.5	16.3	17.6
	(122)	(57)	(179)	(151)	(107)	(258)	(9)	(8)	(17)	(160)	(115)	(275)	(106)	(45)	(151)	(172)	(106)	(278)
	1.2	0.7	1.0	0.9	0.5	0.7	2.4	1.6	2.0	1.0	0.6	0.8	6.2	6.5	6.3	1.5	0.6	1.1
Hemorrhage	(9)	(4)	(13)	(11)	(4)	(15)	(2)	(1)	(3)	(13)	(5)	(18)	(40)	(19)	(59)	(14)	(4)	(18)
Infarction	14.1	9.5	12.1	10.7	12.7	11.4	7.1	10.9	8.8	10.4	12.6	11.3	8.6	7.8	8.4	16.0	15.2	15.7
Subarachnoidal hemorrhage	(105)	(53)	(158)	(134)	(99)	(233)	(6)	(7)	(13)	(140)	(106)	(246)	(56)	(23)	(79)	(149)	(99)	(248)
	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.9	0.3	0.7	0.3	0.0	0.2
Others	(0)	(0)	(0)	(1)	(1)	(2)	(0)	(0)	(0)	(1)	(1)	(2)	(6)	(1)	(7)	(3)	(0)	(3)
	1.1	0.0	0.6	0.4	0.4	0.4	1.2	0.0	0.7	0.4	0.4	0.4	0.6	0.7	0.6	0.6	0.5	0.6
Ischemic heart diseases	(8)	(0)	(8)	(5)	(3)	(8)	(1)	(0)	(1)	(6)	(3)	(9)	(4)	(2)	(6)	(6)	(3)	(9)
	13.0	11.3	12.3	23.6	22.7	23.2	11.9	28.1	18.9	22.9	23.1	23.0	10.0	4.8	8.4	11.1	10.7	10.9
	(97)	(63)	(160)	(297)	(176)	(473)	(10)	(18)	(28)	(307)	(194)	(501)	(65)	(14)	(79)	(103)	(70)	(173)
	7.0	3.9	5.7	14.0	12.4	13.4	7.1	10.9	8.8	13.6	12.2	13.1	4.2	0.3	3.0	5.4	4.1	4.9
Myocardial infarction	(52)	(22)	(74)	(176)	(96)	(272)	(6)	(7)	(13)	(182)	(103)	(285)	(27)	(1)	(28)	(50)	(27)	(77)
Angina pectoris	6.0	7.4	6.6	9.6	10.3	9.9	4.8	17.2	10.1	9.3	10.8	9.9	5.8	4.4	5.4	5.7	6.6	6.1
Heart diseases other than ischemic heart diseases	(45)	(41)	(86)	(121)	(80)	(201)	(4)	(11)	(15)	(125)	(91)	(216)	(38)	(13)	(51)	(53)	(43)	(96)
	8.2	12.2	9.9	8.4	9.4	8.8	11.9	7.8	10.1	8.6	9.3	8.9	4.5	6.5	5.1	8.8	14.4	11.1
	(61)	(68)	(129)	(106)	(73)	(179)	(10)	(5)	(15)	(116)	(78)	(194)	(29)	(19)	(48)	(82)	(94)	(176)
	9.0	6.5	7.9	6.1	6.3	6.2	8.3	7.8	8.1	6.3	6.4	6.3	2.0	2.4	2.1	4.4	3.4	4.0
Peripheral artery diseases	(67)	(36)	(103)	(77)	(49)	(126)	(7)	(5)	(12)	(84)	(54)	(138)	(13)	(7)	(20)	(41)	(22)	(63)
Hypertension	26.1	34.3	29.6	27.2	32.9	29.4	25.0	28.1	26.4	27.0	32.6	29.2	32.5	25.2	30.2	28.1	27.1	27.7
Dyslipidemia	(195)	(191)	(386)	(342)	(256)	(598)	(21)	(18)	(39)	(363)	(274)	(637)	(211)	(74)	(285)	(261)	(177)	(438)
	7.0	10.4	8.4	13.8	14.9	14.2	9.5	15.6	12.2	13.5	15.0	14.1	7.2	7.1	7.2	10.0	8.3	9.3
	(52)	(58)	(110)	(173)	(116)	(289)	(8)	(10)	(18)	(181)	(126)	(307)	(47)	(21)	(68)	(93)	(54)	(147)

Table 7 continued

Complications						
Vascular diseases						
Cerebrovascular diseases						
Subarachnoid hemorrhage						
	Male 127	Female 146	Total 273	Others		Total
	Male 1860	Female 1168	Total 3028			
Diabetic nephropathy	7.9% (10)	5.5% (8)	6.6% (18)	12.3% (19)	10.5% (8)	11.7% (27)
Kidney diseases other than diabetic nephropathy	2.4 (3)	4.1 (6)	3.3 (9)	3.2 (5)	5.3 (4)	3.9 (9)
Retinopathy	6.3 (8)	6.2 (9)	6.2 (17)	5.2 (8)	3.9 (3)	4.8 (11)
Neuropathy	2.4 (3)	5.5 (8)	4.0 (11)	2.6 (4)	5.3 (4)	3.5 (8)
Gangrene	0.8 (1)	0.7 (1)	0.7 (2)	0.6 (1)	1.3 (1)	0.9 (2)
Cerebrovascular diseases	11.0 (14)	15.1 (22)	13.2 (36)	11.7 (18)	17.1 (13)	13.5 (31)
Hemorrhage	3.1 (4)	2.1 (3)	2.6 (7)	0.6 (1)	2.6 (2)	1.3 (3)
Infarction	5.5 (7)	6.8 (10)	6.2 (17)	7.1 (11)	9.2 (7)	7.8 (18)
Subarachnoidal hemorrhage	2.4 (3)	4.1 (6)	3.3 (9)	0.0 (0)	0.0 (0)	0.0 (0)
Others	0.0 (0)	2.1 (3)	1.1 (3)	3.9 (6)	5.3 (4)	4.3 (10)
Ischemic heart diseases	6.3 (8)	8.9 (13)	7.7 (21)	11.7 (18)	11.8 (9)	11.7 (27)
Myocardial infarction	2.4 (3)	4.1 (6)	3.3 (9)	3.2 (5)	2.6 (2)	3.0 (7)
Angina pectoris	3.9 (5)	4.8 (7)	4.4 (12)	8.4 (13)	9.2 (7)	8.7 (20)
Heart diseases other than ischemic heart diseases	3.9 (5)	5.5 (8)	4.8 (13)	9.7 (15)	11.8 (9)	10.4 (24)
Peripheral artery diseases	1.6 (2)	2.1 (3)	1.8 (5)	5.8 (9)	1.3 (1)	4.3 (10)
Hypertension	24.4 (31)	25.3 (37)	24.9 (68)	25.3 (39)	23.7 (18)	24.8 (57)
Dyslipidemia	7.1 (9)	11.0 (16)	9.2 (25)	7.8 (12)	13.2 (10)	9.6 (22)

Table 8 Complications in Japanese diabetic patients with vascular diseases as causes of death—study of 140 autopsy cases during 2001–2010

Complications	Vascular diseases											
	Diabetic nephropathy						Ischemic heart diseases					
	Male	Female	Total	Male	Female	Total	Myocardial infarction	Angina pectoris	Total	Male	Female	Total
	13	9	22	45	30	75	Male	Female	2	2	0	75
Diabetic nephropathy	69.2%	66.7%	68.2%	35.6%	23.3%	30.7%	0.0%	0.0%	0.0%	0.0%	0.0%	29.9%
	(9)	(6)	(15)	(16)	(7)	(23)	(0)	(0)	(0)	(0)	(0)	(23)
Kidney diseases other than diabetic nephropathy	7.7	11.1	9.1	6.7	6.7	6.7	0.0	0.0	0.0	0.0	0.0	6.5
	(1)	(1)	(2)	(3)	(2)	(5)	(0)	(0)	(0)	(0)	(0)	(5)
Retinopathy	23.1	33.3	27.3	17.8	26.7	21.3	0.0	0.0	0.0	0.0	0.0	20.8
	(3)	(3)	(6)	(8)	(8)	(16)	(0)	(0)	(0)	(0)	(0)	(16)
Neuropathy	23.1	33.3	27.3	13.3	26.7	18.7	0.0	0.0	0.0	0.0	0.0	18.2
	(3)	(3)	(6)	(6)	(8)	(14)	(0)	(0)	(0)	(0)	(0)	(14)
Gangrene	7.7	0.0	4.5	6.7	6.7	6.7	0.0	0.0	0.0	0.0	0.0	6.5
	(1)	(0)	(1)	(3)	(2)	(5)	(0)	(0)	(0)	(0)	(0)	(5)
Cerebrovascular diseases	53.8	22.2	40.9	13.3	30.0	20.0	0.0	0.0	0.0	0.0	0.0	19.5
	(7)	(2)	(9)	(6)	(9)	(15)	(0)	(0)	(0)	(0)	(0)	(15)
Hemorrhage	7.7	0.0	4.5	2.2	0.0	1.3	0.0	0.0	0.0	0.0	0.0	1.3
	(1)	(0)	(1)	(1)	(0)	(1)	(0)	(0)	(0)	(0)	(0)	(1)
Infarction	46.2	22.2	36.4	11.1	26.7	17.3	0.0	0.0	0.0	0.0	0.0	16.9
	(6)	(2)	(8)	(5)	(8)	(13)	(0)	(0)	(0)	(0)	(0)	(13)
Subarachnoidal hemorrhage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Others	0.0	0.0	0.0	0.0	3.3	1.3	0.0	0.0	0.0	0.0	0.0	1.3
	(0)	(0)	(0)	(0)	(1)	(1)	(0)	(0)	(0)	(0)	(0)	(1)
Ischemic heart diseases	46.2	22.2	36.4	35.6	40.0	37.3	0.0	0.0	0.0	0.0	0.0	36.4
	(6)	(2)	(8)	(16)	(12)	(28)	(0)	(0)	(0)	(0)	(0)	(28)
Myocardial infarction	23.1	11.1	18.2	22.2	26.7	24.0	0.0	0.0	0.0	0.0	0.0	23.4
	(3)	(1)	(4)	(10)	(8)	(18)	(0)	(0)	(0)	(0)	(0)	(18)
Angina pectoris	23.1	11.1	18.2	13.3	13.3	13.3	0.0	0.0	0.0	0.0	0.0	13.0
	(3)	(1)	(4)	(6)	(4)	(10)	(0)	(0)	(0)	(0)	(0)	(10)
Heart diseases other than ischemic heart diseases	0.0	11.1	4.5	8.9	20.0	13.3	0.0	0.0	0.0	0.0	0.0	18.8
	(0)	(1)	(1)	(4)	(6)	(10)	(0)	(0)	(0)	(0)	(0)	(10)
Peripheral artery diseases	0.0	11.1	4.5	15.6	20.0	17.3	0.0	0.0	0.0	0.0	0.0	16.9
	(0)	(1)	(1)	(7)	(6)	(13)	(0)	(0)	(0)	(0)	(0)	(13)
Hypertension	38.5	66.7	50.0	48.9	56.7	52.0	0.0	0.0	0.0	0.0	0.0	50.6
	(5)	(6)	(11)	(22)	(17)	(39)	(0)	(0)	(0)	(0)	(0)	(39)
Dyslipidemia	15.4	33.3	22.7	24.4	26.7	25.3	0.0	0.0	0.0	0.0	0.0	24.7
	(2)	(3)	(5)	(11)	(8)	(19)	(0)	(0)	(0)	(0)	(0)	(19)

Table 8 continued

Complications	Vascular diseases									
	Cerebrovascular diseases					Others				
	Subarachnoidal hemorrhage									
	Male 3	Female 2	Total 5	Male 4	Female 2	Total 6	Male 27	Female 14	Total 41	
Diabetic nephropathy	0.0% (0)	50.0% (1)	20.0% (1)	50.0% (2)	50.0% (1)	50.0% (3)	33.3% (9)	50.0% (7)	39.0% (16)	
Kidney diseases other than diabetic nephropathy	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	3.7 (1)	0.0 (0)	2.4 (1)	
Retinopathy	0.0 (0)	50.0 (1)	20.0 (1)	25.0 (1)	0.0 (0)	16.7 (1)	11.1 (3)	21.4 (3)	14.6 (6)	
Neuropathy	0.0 (0)	0.0 (0)	0.0 (0)	25.0 (1)	0.0 (0)	16.7 (1)	14.8 (4)	21.4 (3)	17.1 (7)	
Gangrene	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	50.0 (1)	16.7 (1)	0.0 (0)	14.3 (2)	4.9 (2)	
Cerebrovascular diseases	33.3 (1)	0.0 (0)	20.0 (1)	25.0 (1)	0.0 (0)	16.7 (1)	18.5 (5)	14.3 (2)	17.1 (7)	
Hemorrhage	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	7.1 (1)	2.4 (1)	
Infarction	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	11.1 (3)	7.1 (1)	9.8 (4)	
Subarachnoidal hemorrhage	33.3 (1)	0.0 (0)	20.0 (1)	0.0 (0)	0.0 (0)	0.0 (0)	3.7 (1)	0.0 (0)	2.4 (1)	
Others	0.0 (0)	0.0 (0)	0.0 (0)	25.0 (1)	0.0 (0)	16.7 (1)	3.7 (1)	0.0 (0)	2.4 (1)	
Ischemic heart diseases	0.0 (0)	0.0 (0)	0.0 (0)	50.0 (2)	0.0 (0)	33.3 (2)	18.5 (5)	7.1 (1)	14.6 (6)	
Myocardial infarction	0.0 (0)	0.0 (0)	0.0 (0)	25.0 (1)	0.0 (0)	16.7 (1)	11.1 (3)	7.1 (1)	9.8 (4)	
Angina pectoris	0.0 (0)	0.0 (0)	0.0 (0)	25.0 (1)	0.0 (0)	16.7 (1)	7.4 (2)	0.0 (0)	4.9 (2)	
Heart diseases other than ischemic heart diseases	0.0 (0)	0.0 (0)	0.0 (0)	25.0 (1)	0.0 (0)	16.7 (1)	14.8 (4)	14.3 (2)	14.6 (6)	
Peripheral artery diseases	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	3.7 (1)	7.1 (1)	4.9 (2)	
Hypertension	33.3 (1)	0.0 (0)	20.0 (1)	25.0 (1)	50.0 (1)	33.3 (2)	37.0 (10)	50.0 (7)	41.5 (17)	
Dyslipidemia	0.0 (0)	0.0 (0)	0.0 (0)	50.0 (2)	0.0 (0)	33.3 (2)	18.5 (5)	14.3 (2)	17.1 (7)	

approximately half of the autopsy subjects who died from vascular diseases, but the presence of dyslipidemia was as low as approximately 20% in those who died from ischemic heart diseases or cerebrovascular diseases. Renal dysfunction was present in 30–40% of subjects who died from ischemic heart diseases or cerebrovascular diseases. Diabetic gangrene was more common in diabetic patients who died from diabetic nephropathy than in those who died from ischemic heart diseases or cerebrovascular diseases.

Discussion

Although the questions used in the questionnaire were almost the same as those used in the three previous surveys, several changes were made in the present survey, including the availability of the web option, making five of the 13 questions mandatory to answer, and including patients who were followed up by any of the departments in the institution. As a result, the number of subjects exceeded 45,000, which was approximately 2.5 times larger than the number included in the last survey even though the number of participating institutions decreased from 282 to 241 in the present survey. Although the number of subjects significantly increased, the response rates for non-mandatory questions were low—an issue that must be addressed in future surveys.

The number of deaths in men was approximately two-fold greater than that in women in the present study. According to the National Health and Nutrition Survey in 2010, the number of male diabetic patients was 1.8-fold greater than the number of female diabetic patients [8]. According to the Outline of the Report of Vital Statistics in 2010 (Tables 2, 3, 4, 5, and 6), the number of deaths in men was 1.2-fold greater than that in women in a Japanese general population [9]. Thus, our data on differences between the sexes are in accord with the above data.

Comparisons of the results of the surveys of the causes of death of Japanese diabetic patients that are periodically conducted in the same manner, as well as the results of other Japanese surveys on causes of death, are of great interest when attempting to understand changes in the clinical features of diabetic patients in Japan, and should also be useful when formulating future strategies. Table 9 shows a comparison of the causes of death found in the four surveys, including the present survey, with the causes of death in the Japanese general population over the same period in the Annual Statistical Report of the National Health Condition published by the Health and Welfare Statistics Association in 2010 [10–12] and the Outline of the Report of Vital Statistics in 2010 [9]. In the present study, the most frequent cause of death was malignant neoplasia, followed by infectious diseases and then

Table 9 Causes of death in the Japanese general population and Japanese diabetic patients—comparisons between 1971–1980, 1981–1990, 1991–2000, and 2001–2010

Causes of death	1971–1980		1981–1990		1991–2000		2001–2010	
	General population ^[10] (n = 695,821)	Diabetic patients ^[5] (n = 9737)	General population ^[11] (n = 793,014)	Diabetic patients ^[6] (n = 11,648)	General population ^[12] (n = 970,331)	Diabetic patients ^[7] (n = 18,385)	General population ^[9] (n = 1,197,066)	Diabetic patients ^[1] (n = 45,708)
Vascular diseases	31.7	41.5	24.6	39.3	22.7	26.8	18.8	14.9
Chronic renal failure	1.0	12.8	2.0	11.2	1.8	6.8	2.0	3.5
Ischemic heart diseases	6.6	12.3	6.4	14.6	7.3	10.2	6.5	4.8
Cerebrovascular diseases	24.1	16.4	16.2	13.5	13.6	9.8	10.3	6.6
Malignant neoplasia	21.6	25.3	25.9	29.2	31.0	34.1	29.5	38.3
Lung	—	—	—	—	5.6	5.3	5.8	7.0
Liver	—	—	—	—	3.5	8.6	2.7	6.0
Pancreas	—	—	—	—	2.0	4.8	2.3	5.7
Infectious diseases	6.2	9.2	8.4	10.2	9.2	14.3	12.1	17.0
Others	40.5	24.1	41.3	21.3	37.1	24.8	39.6	29.8

vascular diseases. In the first and second surveys, the most frequent cause of death was vascular disease; malignant neoplasia was second, followed by infectious diseases. The top two causes exchanged positions in the third survey. It is noteworthy that the percentage of deaths from vascular diseases has since declined further so that it is now the third most frequent cause of death. It should also be noted that diabetic coma was the cause of death in 281 cases and hypoglycemic coma in 79 cases. Although these numbers are relatively low compared to the overall population, clinicians should be aware that such deaths are possible.

The proportion of deaths from malignant neoplasia in diabetic patients has increased from 25.3 to 29.2 to 34.1% in the previous three surveys and to 38.3% in the present survey. On the other hand, the proportion of deaths from malignant neoplasia in the Japanese general population increased from 21.6 to 25.9 to 31.0% every 10 years from 1970 to 2000, but decreased slightly to 29.5% in 2010. This may support recent findings on the association between diabetes mellitus and cancer. Comparison of the proportions of deaths from malignant neoplasia in the present study with those in the previous surveys highlighted an increase in deaths from lung cancer and pancreatic cancer and a decrease in deaths from liver cancer, similar to the trends observed in the study of the Japanese general population; however, the proportion of deaths from liver cancer was 2.2-fold higher and that of deaths from pancreatic cancer was 2.5-fold higher in diabetic patients than in the Japanese general population. The proportion of deaths from malignant neoplasia was slightly higher than that in the pooled analyses by the Committee on Diabetes Mellitus and Cancer [13], although those results were not directly comparable to ours.

The proportion of deaths from vascular diseases has declined in the Japanese general population over the past four decades, and a similar trend was observed in diabetic patients. Indeed, the proportion of deaths from vascular diseases in diabetic patients decreased from 26.8 to 14.9% (i.e., approximately halved). For diabetic patients who died from vascular diseases, the proportion of deaths from ischemic heart diseases decreased from 14.6 to 10.2% (i.e., decreased by approximately one-third) in the last survey, and then decreased sharply again to 4.8% in the present study. This should be contrasted with the slight decrease in deaths from ischemic heart diseases (from 7.3 to 6.5%) in the Japanese general population over the same timeframe. In addition, it was interesting that the proportion of deaths from ischemic heart diseases in diabetic patients was lower than that in the Japanese general population even though the former was consistently higher than the latter in previous surveys. In Japan, an increase in the ratio of deaths from ischemic heart diseases to deaths from all vascular diseases in diabetic patients was reported in 1967 by Goto

et al. [14], in 1968–1970 by Hirata et al. [15], and in 1960–1984 by Sasaki et al. [16]. The recent decrease in the proportion of deaths from ischemic heart diseases in the previous and present surveys may be attributable to stricter control of blood lipids through the use of statins and of blood pressure through the use of antihypertensive agents, increased awareness of the importance of intensive diabetes management including glycemic control due to a wide range of clinical studies, and advances in screening and intervention methods such as coronary artery computed tomography for ischemic heart diseases. On the other hand, the proportion of deaths from cerebrovascular diseases decreased from 16.4 to 13.5 to 9.8% in previous surveys and to 6.6% in the present survey. This may be a reflection of improvements in the control of blood pressure and blood lipids in general, because a similar trend was observed in the Japanese general population. The proportion of deaths from renal failure in diabetic patients tended to decrease in previous surveys, and it decreased from 6.8 to 3.5% in the present study. On the other hand, the proportion of deaths from renal failure in the Japanese general population showed only a slight increase from 1.8 to 2.0%, which was not a significant change. Although renal failure in the Japanese general population and that in diabetic patients may not be directly comparable, the proportion of deaths from renal failure in diabetic patients is still high compared with that in the Japanese general population, although the ratio has significantly decreased from 12.8-fold to 5.6-fold to 3.8-fold in previous surveys and to 1.8-fold in the present survey. The reason for this decreasing trend may be improved treatment for a variety of conditions associated with diabetes mellitus that allow more diabetic patients to receive dialysis therapy and prevent death from renal failure, leading to an increase in deaths due to malignant neoplasia or pneumonia.

The proportion of deaths from infectious diseases, the third highest cause of death, has risen slightly in both the Japanese general population and diabetic patients, and is consistently approximately 1.5-fold higher in diabetic patients than in the Japanese general population. This reinforces the importance of considering the susceptibility of diabetic patients to infectious diseases in the course of clinical practice.

Table 10 shows a comparison of the mean ages at death of Japanese diabetic patients in the four surveys, including the present study, and life expectancy at birth of the Japanese general population over the same time periods [17]. Although life expectancy at birth is not directly comparable to mean age at death, we used the data for comparison because there are no data on the mean age at death in the Japanese general population. In the present study, the mean age at death in diabetic patients was 71.4 years in men and 75.1 years in women. In contrast,

Table 10 Mean ages at death of Japanese diabetic patients and life expectancy at birth of the Japanese general population—comparisons between 1971–1980, 1981–1990, 1991–2000, 1991–2000, and 2001–2010

	(1) 1971–1980		(2) 1981–1990		(3) 1991–2000		(4) 2001–2010		Difference between (2) and (1)		Difference between (3) and (2)		Difference between (4) and (3)	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
A. General population (life expectancy in years)	73.4 ^[17]	78.8 ^[17]	75.9 ^[17]	81.9 ^[17]	77.6 ^[17]	84.6 ^[17]	79.6 ^[17]	86.3 ^[17]	+2.5	+3.1	+1.7	+2.7	+2.0	+1.7
B. Diabetic patients (mean age at death)	63.1 ^[5]	64.9 ^[5]	66.5 ^[6]	68.4 ^[6]	68.0 ^[7]	71.6 ^[7]	71.4 ^[11]	75.1 ^[11]	+3.4	+3.5	+1.5	+3.2	+3.4	+3.5
Difference between A and B (B – A)	–10.3	–13.9	–9.4	–13.5	–9.6	–13.0	–8.2	–11.2						

the mean life expectancy at birth in the Japanese general population in 2010 was 79.6 years in men and 86.3 years in women. As in the previous three surveys, the mean age at death in diabetic patients was lower than the life expectancy at birth in the Japanese general population. However, the difference between age at death in diabetic patients and life expectancy at birth in the Japanese general population became significantly smaller in the present study, reducing from 9.5 to 10 years to 8.2 years in men and from 13 to 14 years to 11.2 years in women. Given that 30 years have passed since the first survey was conducted, we believe that the significant advances in the treatment and control of diabetes that have occurred during that time have led to the improved prognosis of diabetic patients. We hope that future studies will demonstrate that the life expectancy of diabetic patients is comparable to that of the Japanese general population.

There are limitations on the interpretation of results obtained through questionnaire surveys, such as difficulties in standardizing diagnostic criteria and assessment criteria for causes of death. However, we can state that the results collated from 45,708 subjects received from 241 institutions throughout the country greatly clarify the clinical features of Japanese diabetic patients in the decade 2001–2010. In the present study, we tabulated the results of the present questionnaire survey, setting them out in the same manner as the previous surveys to facilitate comparison. We sincerely hope that the results presented here will be of use in the treatment of diabetes. We believe that this kind of survey is very important and should be continued in the future because it can clarify the current clinical features of Japanese diabetic patients by comparing current results with previous data.

Acknowledgements We would like to thank all the survey participants for their great cooperation in collecting information and completing the questionnaires. We would like to apologize for any trouble this project may have caused to the participants, and we greatly appreciate their valuable contributions. It is entirely due to the assistance of the members of the Japan Diabetes Society, and many non-members as well, that we were able to complete this survey with some degree of success.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

References

1. Nakamura J, Kamiya H, Haneda M, Inagaki N, Tanizawa Y, Araki E, Ueki K, Nakayama T. Causes of death in Japanese patients with diabetes based on the results of survey of 45,708 cases during 2001–2010. *J Japan Diabet Soc.* 2016;59:667–84 (Japanese).

2. Sone H, Mizuno S, Ohashi Y, Saito O, Ito H, Yamashita H, Yamasaki Y, Katayama S, Akanuma Y, Yamada N. Study on the prevention and suppression of the development of vascular complications in diabetics (Japan Diabetes Complications Study: JDC Study). In: Diabetes S, editor. *Advances of Diabetology 2004*. Tokyo: Shindan To Chiryō Sha; 2004. p. 161–5 (**Japanese**).
3. Tajima N, Nishimura N, Izumi K, Hayashino Y, Origasa H, Noda M, Ueki K. A large-scale observational study to investigate the current status of diabetes complications and their prevention in Japan: research outline and baseline data for type 2 diabetes: JDCP study 1. *J Japan Diabet Soc*. 2015;58:346–57 (**Japanese**).
4. Nishimura R, Izumi K, Hayashino Y, Origasa H, Noda M, Ueki K, Tajima N. A large-scale observational study to investigate the current status of diabetes complications and their prevention in Japan: research outline and baseline data for type 1 diabetes: JDCP study 2. *J Japan Diabet Soc*. 2015;58:426–36 (**Japanese**).
5. Sakamoto N, Hotta N, Kakuta H, Kamei I, Kimura M, Fukasawa H, Koh N, Kosaka K. The features of causes of death in Japanese diabetics during the period 1971–1980. *Tohoku J Exp Med*. 1983;141(Suppl):631–8.
6. Sakamoto N, Hotta N, Toyota T, Ikeda Y, Matsuoka K, Kasuga M, Kikkawa R. The causes of death in Japanese diabetics based on questionnaire survey results among 11,648 diabetics during 1981–1990. *J Japan Diabet Soc*. 1996;39:221–36 (**Japanese**).
7. Hotta N, Nakamura J, Iwamoto Y, Ono Y, Kasuga M, Kikkawa R, Toyota T. Causes of death in Japanese diabetics: a questionnaire survey of 18,385 diabetics over a 10-year period. *J Diabetes Investig*. 2007;1:66–76.
8. Ministry of Health, Labour, and Welfare. The National Health and Nutrition Survey in 2010. <http://www.mhlw.go.jp/bunya/kenkou/eiyou/dl/h22-houkoku-01.pdf> (**Japanese**).
9. Ministry of Health, Labour, and Welfare. Outline of vital statistics in 2010. <http://www.mhlw.go.jp/toukei/saikin/hw/jinkou/geppo/nengai10/index.html> (**Japanese**).
10. The Health and Welfare Statistics Association. *Annual Statistical Report of National Health Condition* vol. 28. Tokyo: The Health and Welfare Statistics Association; 1981 (**Japanese**).
11. The Health and Welfare Statistics Association. *Annual Statistical Report of National Health Condition* vol. 38. Tokyo: The Health and Welfare Statistics Association; 1991 (**Japanese**).
12. The Health and Welfare Statistics Association. *Annual Statistical Report of National Health Condition* vol. 48. Tokyo: The Health and Welfare Statistics Association; 2001 (**Japanese**).
13. Kasuga M, Ueki K, Tajima N, Noda M, Ohashi K, Noto H, Goto A, Ogawa W, Sakai R, Tsugane S, Hamajima N, Nakagama H, Tajima K, Miyazono K, Imai K. Report of the Japan Diabetes Society/Japanese Cancer Association Joint Committee on Diabetes and Cancer. *J Japan Diabet Soc*. 2013;56:374–90 (**Japanese**).
14. Goto Y, Toyota T, Matsuda M, Utsumi N, Katsuse T. Vascular complications of diabetic patients in Japan. In: Baba S, Goto Y, Fukui I, editors. *Diabetes mellitus in Asia. Ecological aspects of epidemiology, complications and treatment*. Amsterdam: Excerpta Medica; 1976. p. 82–90.
15. Hirata Y, Mihara T. Principal causes of death among diabetic patients in Japan from 1968 to 1970. In: Baba S, Goto Y, Fukui I, editors. *Diabetes mellitus in Asia. Ecological aspects of epidemiology, complications and treatment*. Amsterdam: Excerpta Medica; 1976. p. 91–7.
16. Sasaki A, Kamado K, Uehara M. Changes in causes of death in diabetic patients based on death certificates during a 30-year period in Osaka district, Japan, with special reference to cancer mortality. *Diabetes Res Clin Pract*. 1994;24:103–12.
17. Ministry of Health, Labour, and Welfare. Abridged life tables for Japan 2013. Reference data 2: trends of life expectancies. <http://www.mhlw.go.jp/toukei/saikin/hw/life/life13/dl/life13-09.pdf> (**Japanese**).