

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

Jiro Nakamura^{1*}, Hideki Kamiya¹, Masakazu Haneda², Nobuya Inagaki³, Yukio Tanizawa⁴, Eiichi Araki⁵, Kohjiro Ueki⁶, Takeo Nakayama⁷

¹Division of Diabetes, Department of Internal Medicine, Aichi Medical University, Nagakute, ²Division of Metabolism and Biosystemic Science, Department of Medicine, Nobuya, ³Department of Diabetes, Endocrinology and Nutrition, Kyoto University Graduate School of Medicine, Kyoto, ⁴Division of Endocrinology, Metabolism, Hematological Science and Therapeutics, Yamaguchi University Graduate School of Medicine, Ube, ⁵Department of Metabolic Medicine, Faculty of Life Sciences, Kumamoto University, Kumamoto, ⁶Department of Molecular Sciences on Diabetes, The University of Tokyo, Graduate School of Medicine, Tokyo, and ⁷Department of Health Informatics, Kyoto University School of Public Health, Kyoto, Japan

Keywords

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*Correspondence

Jiro Nakamura
Tel: +81-561-63-1682
Fax: +81-561-63-1494
E-mail address:
jiro@aichi-med-u.ac.jp

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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 by, in order of descending frequency: infections (17.0%); and then vascular diseases (14.9%), including renal failure (3.5%), ischemic heart diseases (4.8%) and cerebrovascular diseases (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 the 97.0% of the total death due to vascular diseases was observed 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 the 80.7% of the total death due to pneumonia was observed in patients over the age of 70 years. 'Poorer' glycaemic control was associated with the reduced lifespan of patients with diabetes, especially of 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' glycaemic control than in those with 'better' glycaemic 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%, was on insulin therapy. The average age at death of the 45,708 patients with diabetes was 71.4 years in 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

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; produced to enhance the understanding for our non-Japanese colleagues and other interested parties.

This is the official published version of that report, and has been jointly published in *Diabetology International* (the official English journal of JDS: doi: 10.1007/s13340-017-0313-3) and *Journal of Diabetes Investigation* (the official journal of the Asian Association for the Study of Diabetes).

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women. Thus, the average lifespan of patients with diabetes still appears to be shorter than that of the general population in Japan. However, the differences in lifespan between patients with diabetes and the general population were shorter than those in the former surveys.

INTRODUCTION

The ultimate goal of treatment of diabetic patients is to maintain their quality of life (QOL) as much as possible, like in healthy people, and to prolong their lifespan. To assess the

contribution of recent advances in diabetes treatment, surveys of the causes of death and age at the time of death in diabetic patients are important. 'Study on the prevention and suppression of the development of vascular complications in diabetic

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

Sex and number	Male (%)	29,801 (n)	Female (%)	15,907 (n)	Total (%)	45,708 (n)
Causes of death						
Vascular diseases	13.8	4,126	17.0	2,698	14.9	6,824
Chronic renal failure	3.1	924	4.3	689	3.5	1,613
Diabetic nephropathy	2.5	746	3.5	557	2.9	1,303
Non-diabetic nephropathy	0.6	178	0.8	132	0.7	310
Ischemic heart diseases	4.5	1,342	5.3	841	4.8	2,183
Myocardial infarction	4.2	1,258	4.9	777	4.5	2,035
Angina pectoris	0.3	84	0.4	64	0.3	148
Cerebrovascular diseases	6.2	1,860	7.3	1,168	6.6	3,028
Hemorrhage	2.2	650	1.8	294	2.1	944
Infarction	3.1	929	4.1	652	3.5	1,581
Subarachnoidal 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	2,238	10.8	1,717	8.7	3,955
Arrhythmia	0.9	272	0.8	121	0.9	393
Heart failure	5.4	1,622	8.6	1,372	6.6	2,994
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	5,395	38.3	17,510
Esophagus	1.4	407	0.4	62	1.0	469
Stomach	4.0	1,189	2.4	389	3.5	1,578
Lung	8.9	2,658	3.5	555	7.0	3,213
Colon	2.7	799	2.6	418	2.7	1,217
Liver	6.7	2,007	4.7	741	6.0	2,748
Pancreas	5.5	1,628	6.1	972	5.7	2,600
Uterus	0.0	0	1.4	230	0.5	230
Breast	0.0	6	1.8	282	0.6	288
Leukemia/lymphoma	4.0	1,193	3.6	573	3.9	1,766
Others	7.5	2,228	7.4	1,173	7.4	3,401
Infectious diseases	17.6	5,255	15.8	2,516	17.0	7,771
Tuberculosis	0.3	86	0.2	37	0.3	123
Pneumonia	12.7	3,784	9.6	1,528	11.6	5,312
Others	4.6	1,385	6.0	951	5.1	2,336
Liver cirrhosis	3.3	971	3.4	544	3.3	1,515
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	3,977	14.9	2,375	13.9	6,352
Unknown	2.8	839	2.8	453	2.8	1,292

NAFLD, non-alcoholic fatty liver disease.

patients' (Japan Diabetes Complications study: JDC study)² and 'A large-scale observational study to investigate the current status of diabetic complications and their prevention in Japan' (Japan Diabetes Complication and its Prevention prospective study: JDCP study)^{3,4} have clarified the clinical features of Japanese patients with diabetes; however, these studies had limitations with respect to 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 patients⁵⁻⁷. The present questionnaire survey was conducted in a similar manner to that of the three previous surveys by the Committee of 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.

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

Sex and number	Male (%)	665 (n)	Female (%)	313 (n)	Total (%)	978 (n)
Causes of death						
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
Non-diabetic 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
Subarachnoidal 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

NAFLD, non-alcoholic fatty liver disease.

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

Age at death (years)	0–9			10–19			20–29			30–39			40–49	
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Causes of death	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%)	177 (100.0%)	92 (100.0%)	269 (100.0%)	682 (100.0%)	289 (100.0%)
<i>Vascular diseases</i>	2 (28.6)	1 (20.0)	3 (25.0)	3 (13.0)	1 (5.6)	4 (9.8)	6 (13.6)	1 (3.0)	7 (9.1)	24 (13.6)	14 (15.2)	38 (14.1)	109 (16.0)	39 (13.5)
Chronic renal failure	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.6)	1 (2.4)	1 (2.3)	0 (0.0)	1 (1.3)	4 (2.3)	5 (5.4)	9 (3.3)	10 (1.5)	9 (3.1)
Diabetic nephropathy	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)	2 (1.1)	5 (5.4)	7 (2.6)	6 (0.9)	6 (2.1)
Non-diabetic nephropathy	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.6)	1 (2.4)	1 (2.3)	0 (0.0)	1 (1.3)	2 (1.1)	0 (0.0)	2 (0.7)	4 (0.6)	3 (1.0)
<i>Ischemic heart diseases</i>	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.3)	0 (0.0)	1 (2.4)	1 (2.3)	0 (0.0)	1 (1.3)	5 (2.8)	2 (2.2)	7 (2.6)	39 (5.7)	8 (2.8)
Myocardial infarction	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.3)	0 (0.0)	1 (2.4)	1 (2.3)	0 (0.0)	1 (1.3)	5 (2.8)	2 (2.2)	7 (2.6)	38 (5.6)	8 (2.8)
Angina pectoris	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)	1 (0.1)	0 (0.0)
<i>Cerebrovascular diseases</i>	2 (28.6)	1 (20.0)	3 (25.0)	2 (8.7)	0 (0.0)	2 (4.9)	4 (9.1)	1 (3.0)	5 (6.5)	15 (8.5)	7 (7.6)	22 (8.2)	60 (8.8)	22 (7.6)
Hemorrhage	1 (14.3)	0 (0.0)	1 (8.3)	1 (4.3)	0 (0.0)	1 (2.4)	1 (2.3)	0 (0.0)	1 (1.3)	6 (3.4)	4 (4.3)	10 (3.7)	34 (5.0)	11 (3.8)
Infarction	1 (14.3)	0 (0.0)	1 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.3)	1 (3.0)	2 (2.6)	4 (2.3)	0 (0.0)	4 (1.5)	12 (1.8)	5 (1.7)
Subarachnoidal hemorrhage	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.3)	0 (0.0)	1 (2.4)	1 (2.3)	0 (0.0)	1 (1.3)	2 (1.1)	3 (3.3)	5 (1.9)	10 (1.5)	6 (2.1)
Others	0 (0.0)	1 (20.0)	1 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.3)	0 (0.0)	1 (1.3)	3 (1.7)	0 (0.0)	3 (1.1)	4 (0.6)	0 (0.0)
<i>Heart diseases (other than ischemic heart diseases)</i>	0 (0.0)	0 (0.0)	0 (0.0)	3 (13.0)	3 (16.7)	6 (14.6)	2 (4.5)	4 (12.1)	6 (7.8)	10 (5.6)	4 (4.3)	14 (5.2)	51 (7.5)	9 (3.1)
Amythmia	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.0)	1 (1.3)	1 (0.6)	1 (1.1)	2 (0.7)	15 (2.2)	1 (0.3)
Heart failure	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.3)	3 (16.7)	4 (9.8)	1 (2.3)	2 (6.1)	3 (3.9)	6 (3.4)	3 (3.3)	9 (3.3)	26 (3.8)	4 (1.4)
Others	0 (0.0)	0 (0.0)	0 (0.0)	2 (8.7)	0 (0.0)	2 (4.9)	1 (2.3)	1 (3.0)	2 (2.6)	3 (1.7)	0 (0.0)	3 (1.1)	10 (1.5)	4 (1.4)
<i>Diabetic coma</i>	0 (0.0)	0 (0.0)	0 (0.0)	3 (13.0)	3 (16.7)	6 (14.6)	4 (9.1)	4 (12.1)	8 (10.4)	13 (7.3)	2 (2.2)	15 (5.6)	14 (2.1)	7 (2.4)
<i>Hypoglycemic coma</i>	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.0)	1 (1.3)	2 (1.1)	1 (1.1)	3 (1.1)	1 (0.1)	2 (0.7)
<i>Malignant neoplasia</i>	3 (42.9)	4 (80.0)	7 (58.3)	9 (39.1)	6 (33.3)	15 (36.6)	20 (45.5)	9 (27.3)	29 (37.7)	46 (26.0)	27 (29.3)	73 (27.1)	227 (33.3)	108 (37.4)
Esophagus	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)	3 (0.4)	2 (0.7)
Stomach	1 (14.3)	0 (0.0)	1 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.1)	1 (1.1)	3 (1.1)	10 (1.5)	5 (1.7)
Lung	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.3)	0 (0.0)	1 (1.3)	4 (2.3)	0 (0.0)	4 (1.5)	22 (3.2)	3 (1.0)
Colon	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)	3 (1.7)	3 (3.3)	6 (2.2)	15 (2.2)	4 (1.4)
Liver	0 (0.0)	2 (40.0)	2 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.3)	0 (0.0)	1 (1.3)	4 (2.3)	0 (0.0)	4 (1.5)	32 (4.7)	4 (1.4)
Pancreas	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)	3 (1.7)	0 (0.0)	3 (1.1)	33 (4.8)	9 (3.1)
Uterus	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)	2 (2.2)	2 (0.7)	0 (0.0)	14 (4.8)
Breast	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)	2 (2.2)	2 (0.7)	0 (0.0)	18 (6.2)
Leukemia/lymphoma	2 (28.6)	2 (40.0)	4 (33.3)	7 (30.4)	6 (33.3)	13 (31.7)	15 (34.1)	4 (12.1)	19 (24.7)	23 (13.0)	11 (12.0)	34 (12.6)	71 (10.4)	28 (9.7)
Others	0 (0.0)	0 (0.0)	0 (0.0)	2 (8.7)	0 (0.0)	2 (4.9)	3 (6.8)	5 (15.2)	8 (10.4)	7 (4.0)	8 (8.7)	15 (5.6)	41 (6.0)	21 (7.3)
<i>Infectious diseases</i>	1 (14.3)	0 (0.0)	1 (8.3)	2 (8.7)	1 (5.6)	3 (7.3)	1 (2.3)	3 (9.1)	4 (5.2)	25 (14.1)	13 (14.1)	38 (14.1)	67 (9.8)	28 (9.7)
Tuberculosis	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)	1 (0.6)	0 (0.0)	1 (0.4)	4 (0.6)	0 (0.0)
Pneumonia	1 (14.3)	0 (0.0)	1 (8.3)	2 (8.7)	0 (0.0)	2 (4.9)	1 (2.3)	0 (0.0)	1 (1.3)	7 (4.0)	6 (6.5)	13 (4.8)	20 (2.9)	14 (4.8)
Others	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (6.1)	1 (2.4)	0 (0.0)	3 (9.1)	3 (3.9)	17 (9.6)	7 (7.6)	24 (8.9)	43 (6.3)	14 (4.8)
<i>Liver cirrhosis</i>	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)	7 (4.0)	1 (1.1)	8 (3.0)	65 (9.5)	24 (8.3)
Type B	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)	8 (1.2)	2 (0.7)
Type C	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)	2 (1.1)	1 (1.1)	3 (1.1)	23 (3.4)	5 (1.7)
NAFLD	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)	1 (0.1)	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)	0 (0.0)	0 (0.0)	5 (2.8)	0 (0.0)	5 (1.9)	33 (4.8)	17 (5.9)
<i>Suicide</i>	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (6.1)	2 (2.6)	2 (1.1)	6 (6.5)	8 (3.0)	5 (0.7)	3 (1.0)
Others	1 (14.3)	0 (0.0)	1 (8.3)	3 (13.0)	3 (16.7)	6 (14.6)	9 (20.5)	3 (9.1)	12 (15.6)	35 (19.8)	19 (20.7)	54 (20.1)	106 (15.5)	55 (19.0)
Unknown	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.6)	1 (2.4)	2 (4.5)	6 (18.2)	8 (10.4)	13 (7.3)	5 (5.4)	18 (6.7)	37 (5.4)	14 (4.8)

NAFLD, non-alcoholic fatty liver disease.

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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) 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 previous surveys.

As in the previous surveys, we sent survey forms to 1,164 institutions that met the criterion of an institution that 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

Total	50~59		60~69			70~			All age			
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
971 (100.0%)	3,010 (100.0%)	1,104 (100.0%)	4,114 (100.0%)	7,599 (100.0%)	2,899 (100.0%)	10,498 (100.0%)	18,192 (100.0%)	11,424 (100.0%)	29,616 (100.0%)	29,734 (100.0%)	15,864 (100%)	45,598 (100%)
148 (15.2)	434 (14.4)	132 (12.0)	566 (13.8)	969 (12.8)	391 (13.5)	1,360 (13.0)	2,571 (14.1)	2,114 (18.5)	4,685 (15.8)	4,118 (13.8)	2,693 (17.0)	6,811 (14.9)
19 (2.0)	68 (2.3)	39 (3.5)	107 (2.6)	202 (2.7)	97 (3.3)	299 (2.8)	638 (3.5)	537 (4.7)	1,175 (4.0)	923 (3.1)	688 (4.3)	1,611 (3.5)
12 (1.2)	58 (1.9)	33 (3.0)	91 (2.2)	158 (2.1)	79 (2.7)	237 (2.3)	521 (2.9)	433 (3.8)	954 (3.2)	745 (2.5)	556 (3.5)	1,301 (2.9)
7 (0.7)	10 (0.3)	6 (0.5)	16 (0.4)	44 (0.6)	18 (0.6)	62 (0.6)	117 (0.6)	104 (0.9)	221 (0.7)	178 (0.6)	132 (0.8)	310 (0.7)
47 (4.8)	158 (5.2)	37 (3.4)	195 (4.7)	301 (4.0)	103 (3.6)	404 (3.8)	835 (4.6)	689 (6.0)	1,524 (5.1)	1,340 (4.5)	839 (5.3)	2,179 (4.8)
46 (4.7)	152 (5.0)	34 (3.1)	186 (4.5)	285 (3.8)	91 (3.1)	376 (3.6)	774 (4.3)	640 (5.6)	1,414 (4.8)	1,256 (4.2)	775 (4.9)	2,031 (4.5)
1 (0.1)	6 (0.2)	3 (0.3)	9 (0.2)	16 (0.2)	12 (0.4)	28 (0.3)	61 (0.3)	49 (0.4)	110 (0.4)	84 (0.3)	64 (0.4)	148 (0.3)
82 (8.4)	208 (6.9)	56 (5.1)	264 (6.4)	466 (6.1)	191 (6.6)	657 (6.3)	1,098 (6.0)	888 (7.8)	1,986 (6.7)	1,855 (6.2)	1,166 (7.3)	3,021 (6.6)
45 (4.6)	116 (3.9)	24 (2.2)	140 (3.4)	178 (2.3)	68 (2.3)	246 (2.3)	312 (1.7)	187 (1.6)	499 (1.7)	649 (2.2)	294 (1.9)	943 (2.1)
17 (1.8)	59 (2.0)	16 (1.4)	75 (1.8)	213 (2.8)	81 (2.8)	294 (2.8)	636 (3.5)	547 (4.8)	1,183 (4.0)	926 (3.1)	650 (4.1)	1,576 (3.5)
16 (1.6)	20 (0.7)	10 (0.9)	30 (0.7)	38 (0.5)	26 (0.9)	64 (0.6)	55 (0.3)	101 (0.9)	156 (0.5)	127 (0.4)	146 (0.9)	273 (0.6)
4 (0.4)	13 (0.4)	6 (0.5)	19 (0.5)	37 (0.5)	16 (0.6)	53 (0.5)	95 (0.5)	53 (0.5)	148 (0.5)	153 (0.5)	76 (0.5)	229 (0.5)
60 (6.2)	155 (5.1)	71 (6.4)	226 (5.5)	456 (6.0)	206 (7.1)	662 (6.3)	1,553 (8.5)	1,418 (12.4)	2,971 (10.0)	2,230 (7.5)	1,715 (10.8)	3,945 (8.7)
16 (1.6)	25 (0.8)	10 (0.9)	35 (0.9)	78 (1.0)	22 (0.8)	100 (1.0)	152 (0.8)	86 (0.8)	238 (0.8)	271 (0.9)	121 (0.8)	392 (0.9)
30 (3.1)	87 (2.9)	46 (4.2)	133 (3.2)	300 (3.9)	145 (5.0)	445 (4.2)	1,194 (6.6)	1,167 (10.2)	2,361 (8.0)	1,615 (5.4)	1,370 (8.6)	2,985 (6.5)
14 (1.4)	43 (1.4)	15 (1.4)	58 (1.4)	78 (1.0)	39 (1.3)	117 (1.1)	1	165 (1.4)	372 (1.3)	344 (1.2)	224 (1.4)	568 (1.2)
21 (2.2)	12 (0.4)	14 (1.3)	26 (0.6)	29 (0.4)	20 (0.7)	49 (0.5)	79 (0.4)	77 (0.7)	156 (0.5)	154 (0.5)	127 (0.8)	281 (0.6)
3 (0.3)	9 (0.3)	3 (0.3)	12 (0.3)	11 (0.1)	4 (0.1)	15 (0.1)	26 (0.1)	19 (0.2)	45 (0.2)	49 (0.2)	30 (0.2)	79 (0.2)
335 (34.5)	1,382 (45.9)	522 (47.3)	1,904 (46.3)	3,712 (48.8)	1,298 (44.8)	5,010 (47.7)	6,692 (36.8)	3,401 (29.8)	10,093 (34.1)	12,091 (40.7)	5,375 (33.9)	17,466 (38.3)
5 (0.5)	44 (1.5)	10 (0.9)	54 (1.3)	163 (2.1)	11 (0.4)	174 (1.7)	197 (1.1)	39 (0.3)	236 (0.8)	407 (1.4)	62 (0.4)	469 (1.0)
15 (1.5)	115 (3.8)	27 (2.4)	142 (3.5)	366 (4.8)	95 (3.3)	461 (4.4)	695 (3.8)	259 (2.3)	954 (3.2)	1,189 (4.0)	387 (2.4)	1,576 (3.5)
25 (2.6)	258 (8.6)	35 (3.2)	293 (7.1)	745 (9.8)	116 (4.0)	861 (8.2)	1,624 (8.9)	398 (3.5)	2,022 (6.8)	2,654 (8.9)	552 (3.5)	3,206 (7.0)
19 (2.0)	89 (3.0)	30 (2.7)	119 (2.9)	256 (3.4)	96 (3.3)	352 (3.4)	434 (2.4)	282 (2.5)	716 (2.4)	797 (2.7)	415 (2.6)	1,212 (2.7)
36 (3.7)	260 (8.6)	38 (3.4)	298 (7.2)	676 (8.9)	171 (5.9)	847 (8.1)	1,027 (5.6)	519 (4.5)	1,546 (5.2)	2,000 (6.7)	734 (4.6)	2,734 (6.0)
42 (4.3)	224 (7.4)	89 (8.1)	313 (7.6)	545 (7.2)	243 (8.4)	788 (7.5)	818 (4.5)	628 (5.5)	1,446 (4.9)	1,623 (5.5)	969 (6.1)	2,592 (5.7)
14 (1.4)	0 (0.0)	45 (4.1)	45 (1.1)	0 (0.0)	67 (2.3)	67 (0.6)	102 (0.9)	102 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	230 (0.5)
18 (1.9)	1 (0.0)	59 (5.3)	60 (1.5)	4 (0.1)	97 (3.3)	101 (1.0)	1 (0.0)	105 (0.9)	106 (0.4)	6 (0.0)	281 (1.8)	287 (0.6)
99 (10.2)	156 (5.2)	74 (6.7)	230 (5.6)	326 (4.3)	130 (4.5)	456 (4.3)	592 (3.3)	318 (2.8)	910 (3.1)	1,192 (4.0)	573 (3.6)	1,765 (3.9)
62 (6.4)	235 (7.8)	115 (10.4)	350 (8.5)	631 (8.3)	272 (9.4)	903 (8.6)	1,304 (7.2)	751 (6.6)	2,055 (6.9)	2,223 (7.5)	1,172 (7.4)	3,395 (7.4)
95 (9.8)	311 (10.3)	119 (10.8)	430 (10.5)	934 (12.3)	330 (11.4)	1,264 (12.0)	3,904 (21.5)	2,016 (17.6)	5,920 (20.0)	5,245 (17.6)	2,510 (15.8)	7,755 (17.0)
4 (0.4)	4 (0.1)	2 (0.2)	6 (0.1)	22 (0.3)	0 (0.0)	22 (0.2)	54 (0.3)	35 (0.3)	89 (0.3)	85 (0.3)	37 (0.2)	122 (0.3)
34 (3.5)	174 (5.8)	48 (4.3)	222 (5.4)	599 (7.9)	154 (5.3)	753 (7.2)	2,975 (16.4)	1,305 (11.4)	4,280 (14.5)	3,779 (12.7)	1,527 (9.6)	5,306 (11.6)
57 (5.9)	133 (4.4)	69 (6.3)	202 (4.9)	313 (4.1)	176 (6.1)	489 (4.7)	875 (4.8)	676 (5.9)	1,551 (5.2)	1,381 (4.6)	946 (6.0)	2,327 (5.1)
89 (9.2)	201 (6.7)	53 (4.8)	254 (6.2)	324 (4.3)	158 (5.5)	482 (4.6)	370 (2.0)	305 (2.7)	675 (2.3)	967 (3.3)	541 (3.4)	1,508 (3.3)
10 (1.0)	28 (0.9)	6 (0.5)	34 (0.8)	30 (0.4)	10 (0.3)	40 (0.4)	28 (0.2)	15 (0.1)	43 (0.1)	94 (0.3)	33 (0.2)	127 (0.3)
28 (2.9)	61 (2.0)	22 (2.0)	83 (2.0)	132 (1.7)	89 (3.1)	221 (2.1)	181 (1.0)	160 (1.4)	341 (1.2)	399 (1.3)	277 (1.7)	676 (1.5)
1 (0.1)	8 (0.3)	2 (0.2)	10 (0.2)	7 (0.1)	5 (0.2)	12 (0.1)	7 (0.0)	16 (0.1)	23 (0.1)	23 (0.1)	23 (0.1)	46 (0.1)
50 (5.1)	104 (3.5)	23 (2.1)	127 (3.1)	155 (2.0)	54 (1.9)	209 (2.0)	154 (0.8)	114 (1.0)	268 (0.9)	451 (1.5)	208 (1.3)	659 (1.4)
8 (0.8)	13 (0.4)	5 (0.5)	18 (0.4)	24 (0.3)	16 (0.6)	40 (0.4)	33 (0.2)	20 (0.2)	53 (0.2)	77 (0.3)	52 (0.3)	129 (0.3)
161 (16.6)	382 (12.7)	150 (13.6)	532 (12.9)	908 (11.9)	390 (13.5)	1,298 (12.4)	2,522 (13.9)	1,749 (15.3)	4,271 (14.4)	3,966 (13.3)	2,369 (14.9)	6,335 (13.9)
51 (5.3)	111 (3.7)	35 (3.2)	146 (3.5)	232 (3.1)	86 (3.0)	318	442 (2.4)	305 (2.7)	747 (2.5)	837 (2.8)	452 (2.8)	1,289 (2.8)

(20.7% response rate), covering 45,970 diabetic patients (22,182 collected by Web-based questionnaire and 23,788 collected by paper-based questionnaire). Exclusion of 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, subject number will not be the same for all parameters. Results are for all subjects unless specified as pertaining to autopsy cases.

We analyzed in particular the relationship between vascular diseases (chronic renal failure including diabetic nephropathy, ischemic heart diseases and cerebrovascular diseases) 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 the cases and autopsy cases in Tables 1 and 2, respectively.

The most frequent cause of all 45,708 death cases was malignant neoplasia, accounting for 17,510 cases (38.3%), followed by

infectious diseases in 7,771 (17.0%) and vascular diseases (chronic renal failure, ischemic heart diseases and cerebrovascular diseases) in 6,824 (14.9%). The most common malignancy was lung cancer in 3,213 cases (7.0%), followed by liver cancer in 2,748 (6.0%) and pancreatic cancer in 2,600 (5.7%). Of the deaths from vascular diseases, ischemic heart diseases and cerebrovascular diseases accounted for 2,183 (4.8%) and 3,028 (6.6%), respectively, and those from chronic renal failure accounted for 1,613 (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 3,955 subjects (8.7%) died from heart diseases other than ischemic heart diseases, and most of them (2,994, 6.6%) were due to heart failure. Of the deaths from cerebrovascular diseases, cerebral infarction, the cause of death in 1,581 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, 5,312 (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 the 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 had 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 years and 1.6:1 for those aged ≥ 70 years.

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 years. The mortality rate as a result of chronic renal failure due to diabetic nephropathy was not reported in subjects aged ≤ 29 years, and it was

approximately 2–3% for subjects aged ≥ 30 years. The mortality rate as a result of myocardial infarction increased to approximately 4–5% for subjects aged ≥ 40 years. The mortality rate as a result of cerebrovascular diseases was 6–8% for subjects aged ≥ 30 years, with deaths from cerebral hemorrhage being more common for subjects aged ≤ 49 years and those from cerebral infarction more prevalent for subjects aged ≥ 60 years.

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

The mortality rate as a result of pneumonia increased with age, reaching 20.0% in the subjects aged ≥ 70 years, and 80.7% of deaths from pneumonia were found in the subjects aged ≥ 70 years.

The mortality rate as a result of diabetic coma was as high as 14.6% in the subjects aged 10–19 years and 10.4% in those aged 20–29 years, 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 levels of glycemic control were divided into two groups: better $< 8.4\%$ and poorer $\geq 8.4\%$ in NGSP levels).

The average age at the time of death was 72.6 years in all the subjects, 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 glycemic control with almost all the causes 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), in particular, renal failure due to diabetic nephropathy (4.7 years). On the other hand, for subjects who died from renal failure 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 years 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

The data on HbA1c levels and estimated duration of diabetes were available for 1,503 of the 6,824 subjects who died from vascular diseases (Table 5). As approximately 90% of patients

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

Glycemic control	Better (n = 16,911)			Poorer (n = 3,437)			Total (n = 20,348)		
	Male	Female	Mean	Male	Female	Mean	Male	Female	Mean
Causes of death									
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
Non-diabetic 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
Subarachnoidal 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
Arythmia	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 the causes	71.6	75.1	72.8	70.0	73.5	71.2	71.4	74.9	72.6

Values are years. NAFLD, non-alcoholic fatty liver disease.

had better glycemic control, comparison between those with better and poorer control was difficult, and analysis was carried out only on the relationship between causes of death and duration of diabetes.

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

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

Glycemic control	Vascular diseases	Ischemic heart diseases											
		Diabetic nephropathy			Myocardial infarction			Angina pectoris			Total		
		Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
	Duration of diabetes (years)	192	139	331 (100.0%)	316	184	500 (100.0%)	19	15	34 (100.0%)	335	199	534 (100.0%)
Better	≤4	28	22	50 (15.1)	45	28	73 (14.6)	6	5	11 (32.4)	51	33	84 (15.7)
	5~9	24	11	35 (10.6)	46	20	66 (13.2)	2	0	2 (5.9)	48	20	68 (12.7)
	10≤	124	88	212 (64.0)	149	93	242 (48.4)	8	10	18 (52.9)	157	103	260 (48.8)
Total		176	121	297 (89.7)	240	141	381 (76.2)	16	15	31 (91.2)	256	156	412 (77.2)
Poorer	≤5	1	1	2 (0.6)	11	8	19 (3.8)	1	0	1 (2.9)	12	8	20 (3.7)
	5~10	1	0	1 (0.3)	19	9	28 (5.6)	0	0	0 (0.0)	19	9	28 (5.2)
	11≤	14	17	31 (9.4)	46	26	72 (14.4)	2	0	2 (5.9)	48	26	74 (13.9)
Total		16	18	34 (10.3)	76	43	119 (23.8)	3	0	3 (8.8)	79	43	122 (22.8)

Values in parentheses are percentage.

Continued on the next page

Table 6 | Treatment of diabetes and vascular diseases as cause of death in Japanese Diabetic patients during 2001–2010

Causes of death	Diabetic nephropathy			Ischemic heart diseases									Cerebrovascular diseases		
				Myocardial infarction			Angina pectoris			Total			Hemorrhage		
	Male	Female	Total	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
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
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
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
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
Total	746	557	1,303 (105.60%)	1,258	777	2,035 (101.62%)	84	64	148 (97.30%)	1,342	841	2,183 (101.33%)	650	294	944 (97.88%)

Continued on the next page

Relationship between death caused by vascular diseases, treatment for diabetes, and complications and concomitant diseases

Treatment for diabetes and deaths caused by vascular diseases

As shown in Table 6, treatment 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 and concomitant diseases, and death 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 of almost all the complications and concomitant diseases was much lower than that 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 of complications and concomitant diseases in the autopsy subjects was higher than that of all the subjects, probably because the evaluation of complications and concomitant diseases was based on the autopsy records in

Cerebrovascular diseases

Hemorrhage			Infarction			Subarachnoidal hemorrhage			Others			Total		
Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
138	48	186 (100.0%)	209	142	351 (100.0%)	22	27	49 (100.0%)	36	16	52 (100.0%)	405	233	638 (100.0%)
30	16	46 (24.7)	50	36	86 (24.5)	6	13	19 (38.8)	12	5	17 (32.7)	98	70	168 (26.3)
17	7	24 (12.9)	33	17	50 (14.2)	1	2	3 (6.1)	6	1	7 (13.5)	57	27	84 (13.2)
67	20	87 (46.8)	88	60	148 (42.2)	14	8	22 (44.9)	14	9	23 (44.2)	183	97	280 (43.9)
114	43	157 (84.4)	171	113	284 (80.9)	21	23	44 (89.8)	32	15	47 (90.4)	338	194	532 (83.4)
6	2	8 (4.3)	9	7	16 (4.6)	1	2	3 (6.1)	1	0	1 (1.9)	17	11	28 (4.4)
5	2	7 (3.8)	2	4	6 (1.7)	0	0	0 (0.0)	1	0	1 (1.9)	8	6	14 (2.2)
13	1	14 (7.5)	27	18	45 (12.8)	0	2	2 (4.1)	2	1	3 (5.8)	42	22	64 (10.0)
24	5	29 (15.6)	38	29	67 (19.1)	1	4	5 (10.2)	4	1	5 (9.6)	67	39	106 (16.6)

Infarction			Subarachnoidal hemorrhage			Others			Total			Others			All		
Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
172	117	289 18.28%	20	40	60 21.98%	28	8	36 15.65%	324	216	540 17.83%	4,934	2,568	7,502 19.14%	5,572	3,005	8,577 18.76%
357	229	586 37.07%	32	42	74 27.11%	44	23	67 29.13%	649	368	1,017 33.59%	8,965	4,381	13,346 34.05%	10,291	5,201	15,492 33.89%
357	235	592 37.44%	46	52	98 35.90%	70	38	108 46.96%	733	447	1,180 38.97%	10,714	5,713	16,427 41.91%	12,406	6,751	19,157 41.91%
4	2	6 0.38%	0	0	0 0.00%	0	1	1 0.43%	5	3	8 0.26%	49	26	75 0.19%	59	31	90 0.20%
75	70	145 9.17%	21	17	38 13.92%	16	9	25 10.87%	177	127	304 10.04%	1,887	962	2,849 7.27%	2,278	1,242	3,520 7.70%
929	652	1,581 (102.34%)	127	146	273 (98.90%)	154	76	230 (103.04%)	1,860	1,168	3,028 (100.69%)	25,853	13,341	39,194 (102.56%)	29,801	15,907	45,708 (102.47%)

which detailed data were available; however, it should be noted that the data may be insufficient for the analysis, because the number of autopsy subjects who died from vascular diseases was as low as 140 subjects, and that only 68% of those who died from diabetic nephropathy were reported to have diabetic nephropathy as a concomitant disease.

Diabetic retinopathy and neuropathy were both common in diabetic patients who eventually died from diabetic nephropathy in all the subjects, as well as in the autopsy subjects, and the incidence of coronary artery diseases was high in diabetic patients who died from ischemic heart diseases. Hypertension was present in 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 in the three previous surveys, several changes were made in the present survey, including availability of the Web option, making five of the 13 questions mandatory to answer and expanding subjects to 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 that of the last survey despite that 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

Table 7 | Complications in Japanese diabetic patients with vascular diseases as causes of death - study of a total number of 6,514 cases during 2001–2010

Vascular diseases	Diabetic nephropathy			Ischemic heart diseases								
	Male	Female	Total	Myocardial infarction			Angina pectoris			Total		
				Male	Female	Total	Male	Female	Total	Male	Female	Total
Complications	746	557	1,303	1,258	777	2,035	84	64	148	1,342	841	2,183
Diabetic nephropathy	42.1% (314)	41.5% (231)	41.8% (545)	18.0% (227)	18.0% (140)	18.0% (367)	10.7% (9)	12.5% (8)	11.5% (17)	17.6% (236)	17.6% (148)	17.6% (384)
Kidney diseases other than diabetic nephropathy	1.5 (11)	1.4 (8)	1.5 (19)	2.9 (37)	3.0 (23)	2.9 (60)	6.0 (5)	1.6 (1)	4.1 (6)	3.1 (42)	2.9 (24)	3.0 (66)
Retinopathy	174 (130)	162 (90)	169 (220)	118 (148)	130 (101)	122 (249)	8.3 (7)	14.1 (9)	10.8 (16)	11.5 (155)	13.1 (110)	12.1 (265)
Neuropathy	131 (98)	120 (67)	127 (165)	75 (94)	82 (64)	78 (158)	6.0 (5)	6.3 (4)	6.1 (9)	7.4 (99)	8.1 (68)	7.7 (167)
Gangrene	4.8 (36)	4.8 (27)	4.8 (63)	3.4 (43)	2.3 (18)	3.0 (61)	2.4 (2)	0.0 (0)	1.4 (2)	3.4 (45)	2.1 (18)	2.9 (63)
Cerebrovascular diseases	164 (122)	102 (57)	137 (179)	120 (151)	138 (107)	127 (258)	10.7 (9)	12.5 (8)	11.5 (17)	11.9 (160)	13.7 (115)	12.6 (275)
Hemorrhage	1.2 (9)	0.7 (4)	1.0 (13)	0.9 (11)	0.5 (4)	0.7 (15)	2.4 (2)	1.6 (1)	2.0 (3)	1.0 (13)	0.6 (5)	0.8 (18)
Infarction	141 (105)	95 (53)	12.1 (158)	107 (134)	127 (99)	11.4 (233)	7.1 (6)	10.9 (7)	8.8 (13)	10.4 (140)	12.6 (106)	11.3 (246)
Subarachnoidal hemorrhage	0.0 (0)	0.0 (0)	0.0 (0)	0.1 (1)	0.1 (1)	0.1 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.1 (1)	0.1 (1)	0.1 (2)
Others	1.1 (8)	0.0 (0)	0.6 (8)	0.4 (5)	0.4 (3)	0.4 (8)	1.2 (1)	0.0 (0)	0.7 (1)	0.4 (6)	0.4 (3)	0.4 (9)
Ischemic heart diseases	130 (97)	113 (63)	123 (160)	236 (297)	227 (176)	232 (473)	11.9 (10)	28.1 (18)	18.9 (28)	22.9 (307)	23.1 (194)	23.0 (501)
Myocardial infarction	70 (52)	39 (22)	5.7 (74)	140 (176)	124 (96)	13.4 (272)	7.1 (6)	10.9 (7)	8.8 (13)	13.6 (182)	12.2 (103)	13.1 (285)
Angina pectoris	60 (45)	7.4 (41)	6.6 (86)	9.6 (121)	10.3 (80)	9.9 (201)	4.8 (4)	17.2 (11)	10.1 (15)	9.3 (125)	10.8 (91)	9.9 (216)
Heart diseases other than ischemic heart diseases	8.2 (61)	12.2 (68)	9.9 (129)	8.4 (106)	9.4 (73)	8.8 (179)	11.9 (10)	7.8 (5)	10.1 (15)	8.6 (116)	9.3 (78)	8.9 (194)
Peripheral artery diseases	90 (67)	65 (36)	7.9 (103)	6.1 (77)	6.3 (49)	6.2 (126)	8.3 (7)	7.8 (5)	8.1 (12)	6.3 (84)	6.4 (54)	6.3 (138)
Hypertension	26.1 (195)	34.3 (191)	29.6 (386)	27.2 (342)	32.9 (256)	29.4 (598)	25.0 (21)	28.1 (18)	26.4 (39)	27.0 (363)	32.6 (274)	29.2 (637)
Dyslipidemia	7.0 (52)	10.4 (58)	8.4 (110)	13.8 (173)	14.9 (116)	14.2 (289)	9.5 (8)	15.6 (10)	12.2 (18)	13.5 (181)	15.0 (126)	14.1 (307)

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

Vascular diseases	Diabetic nephropathy			Ischemic heart diseases								
	Male	Female	Total	Myocardial infarction			Angina pectoris			Total		
				Male	Female	Total	Male	Female	Total	Male	Female	Total
Complications	13	9	22	45	30	75	0	2	2	45	32	77
Diabetic nephropathy	69.2% (9)	66.7% (6)	68.2% (15)	35.6% (16)	23.3% (7)	30.7% (23)	0.0% (0)	0.0% (0)	0.0% (0)	35.6% (16)	21.9% (7)	29.9% (23)
Kidney diseases other than diabetic nephropathy	7.7 (1)	11.1 (1)	9.1 (2)	6.7 (3)	6.7 (2)	6.7 (5)	0.0 (0)	0.0 (0)	0.0 (0)	6.7 (3)	6.3 (2)	6.5 (5)
Retinopathy	23.1 (3)	33.3 (3)	27.3 (6)	17.8 (8)	26.7 (8)	21.3 (16)	0.0 (0)	0.0 (0)	0.0 (0)	17.8 (8)	25.0 (8)	20.8 (16)
Neuropathy	23.1 (3)	33.3 (3)	27.3 (6)	13.3 (6)	26.7 (8)	18.7 (14)	0.0 (0)	0.0 (0)	0.0 (0)	13.3 (6)	25.0 (8)	18.2 (14)
Gangrene	7.7 (1)	0.0 (0)	4.5 (1)	6.7 (3)	6.7 (2)	6.7 (5)	0.0 (0)	0.0 (0)	0.0 (0)	6.7 (3)	6.3 (2)	6.5 (5)
Cerebrovascular diseases	53.8 (7)	22.2 (2)	40.9 (9)	13.3 (6)	30.0 (9)	20.0 (15)	0.0 (0)	0.0 (0)	0.0 (0)	13.3 (6)	28.1 (9)	19.5 (15)
Hemorrhage	7.7 (1)	0.0 (0)	4.5 (1)	2.2 (1)	0.0 (0)	1.3 (1)	0.0 (0)	0.0 (0)	0.0 (0)	2.2 (1)	0.0 (0)	1.3 (1)
Infarction	46.2 (6)	22.2 (2)	36.4 (8)	11.1 (5)	26.7 (8)	17.3 (13)	0.0 (0)	0.0 (0)	0.0 (0)	11.1 (5)	25.0 (8)	16.9 (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 (0)	0.0 (0)	3.3 (1)	1.3 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	3.1 (1)	1.3 (1)
Ischemic heart diseases	46.2 (6)	22.2 (2)	36.4 (8)	35.6 (16)	40.0 (12)	37.3 (28)	0.0 (0)	0.0 (0)	0.0 (0)	35.6 (16)	37.5 (12)	36.4 (28)
Myocardial infarction	23.1 (3)	11.1 (1)	18.2 (4)	22.2 (10)	26.7 (8)	24.0 (18)	0.0 (0)	0.0 (0)	0.0 (0)	22.2 (10)	25.0 (8)	23.4 (18)
Angina pectoris	23.1 (3)	11.1 (1)	18.2 (4)	13.3 (6)	13.3 (4)	13.3 (10)	0.0 (0)	0.0 (0)	0.0 (0)	13.3 (6)	12.5 (4)	13.0 (10)
Heart diseases other than ischemic heart diseases	0.0 (0)	11.1 (1)	4.5 (1)	8.9 (4)	20.0 (6)	13.3 (10)	0.0 (0)	0.0 (0)	0.0 (0)	8.9 (4)	18.8 (6)	13.0 (10)
Peripheral artery diseases	0.0 (0)	11.1 (1)	4.5 (1)	15.6 (7)	20.0 (6)	17.3 (13)	0.0 (0)	0.0 (0)	0.0 (0)	15.6 (7)	18.8 (6)	16.9 (13)
Hypertension	38.5 (5)	66.7 (6)	50.0 (11)	48.9 (22)	56.7 (17)	52.0 (39)	0.0 (0)	0.0 (0)	0.0 (0)	48.9 (22)	53.1 (17)	50.6 (39)
Dyslipidemia	15.4 (2)	33.3 (3)	22.7 (5)	24.4 (11)	26.7 (8)	25.3 (19)	0.0 (0)	0.0 (0)	0.0 (0)	24.4 (11)	25.0 (8)	24.7 (19)

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questions were low, which requires improvement in future surveys.

The number of deaths in men was approximately 2-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 that of females⁸. According to the Outline of the Report of Vital Statistics in 2010 (Tables 6–2 The number

of death and mortality [per 100,000 people] according to gender and age groups [by 5 years] and gender differences), the number of deaths in men was 1.2-fold greater than that in women in a Japanese general population⁹. Thus, our data on differences between sexes was in accordance with the above data.

Comparison of the results of the surveys on causes of death in Japanese diabetic patients periodically conducted in the same

Cerebrovascular diseases															
Hemorrhage			Infarction			Subarachnoidal hemorrhage			Others			Total			
Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	
650	294	944	929	652	1,581	127	146	273	154	76	230	1,860	1,168	3,028	
18.9% (123)	8.5% (25)	15.7% (148)	12.6% (117)	10.9% (71)	11.9% (188)	7.9% (10)	5.5% (8)	6.6% (18)	12.3% (19)	10.5% (8)	11.7% (27)	14.5% (269)	9.6% (112)	12.6% (381)	
1.8 (12)	4.1 (12)	2.5 (24)	3.4 (32)	2.8 (18)	3.2 (50)	2.4 (3)	4.1 (6)	3.3 (9)	3.2 (5)	5.3 (4)	3.9 (9)	2.8 (52)	3.4 (40)	3.0 (92)	
120 (78)	54 (16)	100 (94)	79 (73)	57 (37)	70 (110)	63 (8)	62 (9)	62 (17)	52 (8)	39 (3)	48 (11)	90 (167)	56 (65)	77 (232)	
7.8 (51)	24 (7)	61 (58)	45 (42)	46 (30)	46 (72)	24 (3)	5.5 (8)	40 (11)	2.6 (4)	5.3 (4)	3.5 (8)	54 (100)	42 (49)	49 (149)	
1.5 (10)	1.0 (3)	1.4 (13)	2.6 (24)	1.4 (9)	2.1 (33)	0.8 (1)	0.7 (1)	0.7 (2)	0.6 (1)	1.3 (1)	0.9 (2)	1.9 (36)	1.2 (14)	1.7 (50)	
163 (106)	153 (45)	160 (151)	185 (172)	163 (106)	176 (278)	110 (14)	15.1 (22)	132 (36)	11.7 (18)	17.1 (13)	13.5 (31)	167 (310)	159 (186)	164 (496)	
6.2 (40)	6.5 (19)	6.3 (59)	1.5 (14)	0.6 (4)	1.1 (18)	3.1 (4)	2.1 (3)	2.6 (7)	0.6 (1)	2.6 (2)	1.3 (3)	3.2 (59)	2.4 (28)	2.9 (87)	
8.6 (56)	7.8 (23)	8.4 (79)	16.0 (149)	15.2 (99)	15.7 (248)	5.5 (7)	6.8 (10)	6.2 (17)	7.1 (11)	9.2 (7)	7.8 (18)	12.0 (223)	11.9 (139)	12.0 (362)	
0.9 (6)	0.3 (1)	0.7 (7)	0.3 (3)	0.0 (0)	0.2 (3)	2.4 (3)	4.1 (6)	3.3 (9)	0.0 (0)	0.0 (0)	0.0 (0)	0.6 (12)	0.6 (7)	0.6 (19)	
0.6 (4)	0.7 (2)	0.6 (6)	0.6 (6)	0.5 (3)	0.6 (9)	0.0 (0)	2.1 (3)	1.1 (3)	3.9 (6)	5.3 (4)	4.3 (10)	0.9 (16)	1.0 (12)	0.9 (28)	
100 (65)	48 (14)	84 (79)	11.1 (103)	10.7 (70)	10.9 (173)	6.3 (8)	8.9 (13)	7.7 (21)	11.7 (18)	11.8 (9)	11.7 (27)	104 (194)	91 (106)	99 (300)	
4.2 (27)	0.3 (1)	3.0 (28)	5.4 (50)	4.1 (27)	4.9 (77)	2.4 (3)	4.1 (6)	3.3 (9)	3.2 (5)	2.6 (2)	3.0 (7)	4.6 (85)	3.1 (36)	4.0 (121)	
5.8 (38)	4.4 (13)	5.4 (51)	5.7 (53)	6.6 (43)	6.1 (96)	3.9 (5)	4.8 (7)	4.4 (12)	8.4 (13)	9.2 (7)	8.7 (20)	5.9 (109)	6.0 (70)	5.9 (179)	
4.5 (29)	6.5 (19)	5.1 (48)	8.8 (82)	14.4 (94)	11.1 (176)	3.9 (5)	5.5 (8)	4.8 (13)	9.7 (15)	11.8 (9)	10.4 (24)	7.0 (131)	11.1 (130)	8.6 (261)	
2.0 (13)	2.4 (7)	2.1 (20)	4.4 (41)	3.4 (22)	4.0 (63)	1.6 (2)	2.1 (3)	1.8 (5)	5.8 (9)	1.3 (1)	4.3 (10)	3.5 (65)	2.8 (33)	3.2 (98)	
32.5 (211)	25.2 (74)	30.2 (285)	28.1 (261)	27.1 (177)	27.7 (438)	24.4 (31)	25.3 (37)	24.9 (68)	25.3 (39)	23.7 (18)	24.8 (57)	29.1 (542)	26.2 (306)	28.0 (848)	
7.2 (47)	7.1 (21)	7.2 (68)	10.0 (93)	8.3 (54)	9.3 (147)	7.1 (9)	11.0 (16)	9.2 (25)	7.8 (12)	13.2 (10)	9.6 (22)	8.7 (161)	8.6 (101)	8.7 (262)	

Cerebrovascular diseases															
Hemorrhage			Infarction			Subarachnoidal hemorrhage			Others			Total			
Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	
9	4	13	11	6	17	3	2	5	4	2	6	27	14	41	
22.2% (2)	50.0% (2)	30.8% (4)	45.5% (5)	50.0% (3)	47.1% (8)	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)	
0.0 (0)	0.0 (0)	0.0 (0)	9.1 (1)	0.0 (0)	5.9 (1)	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)	
11.1 (1)	0.0 (0)	7.7 (1)	9.1 (1)	33.3 (2)	17.6 (3)	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)	
22.2 (2)	25.0 (1)	23.1 (3)	9.1 (1)	33.3 (2)	17.6 (3)	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)	
0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	16.7 (1)	5.9 (1)	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)	
0.0 (0)	25.0 (1)	7.7 (1)	27.3 (3)	16.7 (1)	23.5 (4)	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)	
0.0 (0)	25.0 (1)	7.7 (1)	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)	7.1 (1)	2.4 (1)	
0.0 (0)	0.0 (0)	0.0 (0)	27.3 (3)	16.7 (1)	23.5 (4)	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)	
0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	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)	
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)	25.0 (1)	0.0 (0)	16.7 (1)	3.7 (1)	0.0 (0)	2.4 (1)	
22.2 (2)	0.0 (0)	15.4 (2)	9.1 (1)	16.7 (1)	11.8 (2)	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)	
11.1 (1)	0.0 (0)	7.7 (1)	9.1 (1)	16.7 (1)	11.8 (2)	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)	
11.1 (1)	0.0 (0)	7.7 (1)	0.0 (0)	0.0 (0)	0.0 (0)	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)	
11.1 (1)	25.0 (1)	15.4 (2)	18.2 (2)	16.7 (1)	17.6 (3)	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)	
0.0 (0)	0.0 (0)	0.0 (0)	9.1 (1)	16.7 (1)	11.8 (2)	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)	
33.3 (3)	75.0 (3)	46.2 (6)	45.5 (5)	50.0 (3)	47.1 (8)	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)	
22.2 (2)	25.0 (1)	23.1 (3)	9.1 (1)	16.7 (1)	11.8 (2)	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)	

manner, as well as the results of other Japanese surveys on causes of death, will be of great interest in terms of understanding changes in the clinical features of diabetic patients in Japan, and should also be useful for 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 2010¹⁰⁻¹², and the Outline of the Report of Vital Statistics in 2010⁹. In the present study, the most frequent cause of death was malignant neoplasia, followed by infectious diseases as the second most frequent and then vascular diseases. In the first and second surveys, the most frequent cause of death was vascular diseases, and malignant neoplasia was second, followed by infectious diseases, and the top two causes

Table 9 | Causes of death in Japanese general population and 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 ⁹ (n = 695,821)	Diabetic patients ⁴ (n = 9,737)	General population ¹⁰ (n = 793,014)	Diabetic patients ⁵ (n = 11,648)	General population ¹¹ (n = 970,331)	Diabetic patients ⁶ (n = 18,385)	General population ⁸ (n = 1,197,066)	Diabetic patients ¹⁷ (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

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

	1)1971~1980		2)1981~1990		3)1991~2000		4)2001~2010		Differences between 2) and 1)		Differences between 3) and 2)		Differences 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 ¹⁶	78.8 ¹⁶	75.9 ¹⁶	81.9 ¹⁶	77.6 ¹⁶	84.6 ¹⁶	79.6 ¹⁶	86.3 ¹⁶	+2.5	+3.1	+1.7	+2.7	+2.0	+1.7
B. Diabetic patients (mean ages at death in years)	63.1 ⁴	64.9 ⁴	66.5 ⁵	68.4 ⁵	68.0 ⁶	71.6 ⁶	71.4 ¹⁷	75.1 ¹⁷	+3.4	+3.5	+1.5	+3.2	+3.4	+3.5
Differences between A and B (B - A)	-10.3	-13.9	-9.4	-13.5	-9.6	-13.0	-8.2	-11.2						

exchanged positions in the third survey. It is noteworthy that the percentage of deaths from vascular diseases further declined and became the third cause. It is also of note that diabetic coma was the cause of death in 281 cases and hypoglycemic coma in 79 cases. Although their proportions are relatively low, clinicians should be aware of this possibility.

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 slightly decreased to 29.5% in 2010. This may support the 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 showed an increase in deaths from lung cancer and pancreatic cancer and a decrease in deaths from liver cancer, similar to the trend 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 has been reported to be slightly higher than that in the pooled analyses by the Committee on Diabetes Mellitus and Cancer¹³, although the results were not directly comparable to ours.

The proportion of death from vascular diseases has declined in the Japanese general population over the past four decades, and a similar trend was observed in diabetic patients. It was of note that the proportion in diabetic patients decreased from 26.8 to 14.9% (approximately half). For diabetic patients who died from vascular diseases, the proportion of deaths from ischemic heart diseases had decreased from 14.6 to 10.2% (approximately two-thirds) in the last survey and then greatly decreased to 4.8% in the present study. This is in contrast to 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, despite that the former had been consistently higher than the latter in the previous surveys. In Japan, the increasing ratio of death from ischemic heart diseases to that 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 the stricter control of blood lipids through the use of statins, and blood pressure through the use of antihypertensive agents, increased awareness of the importance of intensive diabetes management including glycemic control resulting from 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 the previous surveys and to 6.6% in the present survey. This may be a reflection of improvement 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 had tended to decrease in the previous surveys and 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 compared with that in the Japanese general population is still high, although the ratio has been significantly decreased from 12.8-fold to 5.6-fold to 3.8-fold in the previous surveys and to 1.8-fold in the present survey. The reason for the decreasing tendency may be the improved treatment for a variety of conditions associated with diabetes mellitus that allowed more diabetic patients to receive dialysis therapy and prevented 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 ranking cause of death, has risen slightly in both the Japanese general population and diabetic patients, with a consistently approximately 1.5-fold higher proportion 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 periods¹⁷. Although the life expectancy at birth is not directly comparable to the 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, 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, being reduced from 9.5–10 years to 8.2 years in men and from 13–14 years to 11.2 years in women. Given that 30 years have passed since the first survey was conducted, we considered that significant advances in treatment and control of diabetes during that time led to the improvement in the 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 in interpreting results obtained through questionnaire surveys, such as difficulties in standardizing diagnostic criteria and assessment criteria for the cause of death. However, we can state that the results collated from 45,708 subjects received from 241 institutions throughout the country clarify greatly 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 future, because it can clarify the current clinical features of Japanese diabetic patients by comparing the results with previous data.

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DISCLOSURE

The authors declare no conflict of interest.

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