

# Sudden death in the working population

## A collaborative study in Central Japan

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**Aim** Few epidemiological data are available describing the sudden death of persons in their prime. This study aims to elucidate when and how sudden death occurs among employees.

**Methods** A total of 196 775 employees from 10 workplaces in Central Japan were surveyed for non-traumatic sudden death during 1989–1995. Demographic data and information regarding onset were collected by their workplace healthcare professionals.

**Results** We identified 251 male and 13 female cases of sudden death. The annual incidence was 21.9 (for men) and 5.7 (for women) per 100 000 population. Sudden death occurred more frequently in April when the new business year starts (risk ratio [95% confidence interval],

1.62 [0.94–2.79]) than in other months, without seasonality. Sudden death peaked on Sundays (risk ratio, 1.90 [1.20–2.99]) and Saturdays (risk ratio, 1.36 [0.83–2.21]) as compared with weekdays, and was likely to occur in the small hours (risk ratio, 1.71 [0.94–3.10] at 00–0300 h and 1.47 [0.79–2.72] at 0300–0600 h vs at 0900–1200 h. Only 17% of employees died at work, which was significantly less than expected ( $P < 0.001$ ).

**Conclusion** These findings differed from those of elderly people and suggest that sudden death of persons in their prime is related to occupational stress and its relief. (Eur Heart J 1999; 20: 338–343)

**Key Words:** Sudden death, employee, monthly variation, daily variation, circadian variation, activity.

## Introduction

Unexpected sudden death has accounted for 15–20% of all deaths and 50–80% of coronary deaths in industrialized countries<sup>[1,2]</sup>, and the proportion has remained almost unaltered for decades<sup>[3]</sup>. Since the incidence of sudden death has been considered thus far to be age-dependent, the results of conventional population- or hospital-based studies have mainly reflected the situation of the elderly, so few epidemiological data are available on the younger population<sup>[4]</sup>. The sudden death of a man in his prime has a great impact on his family and company, both psychologically and economically. We herewith present a report on the descriptive epidemiology of employee sudden death, based on our Central Japan Workplace Collaborative Study.

## Methods

Seven private companies (four manufacturers and three service- or finance-related) and three public offices, located in Aichi Prefecture, in Central Japan, provided the subjects for this study. The total number of employees was 196 775 (164 017 men and 32 758 women) in 1995, and this remained virtually the same during the observation period, under the so-called lifetime employment system. (The structure of this population is shown in Table 1.)

In this study, sudden death was defined as non-traumatic death occurring within 24 h of the onset of acute symptoms or signs<sup>[5]</sup> without previous difficulties in working. Sudden-onset, irreversible, extensive brain damage was also included, even if cardiac function was preserved. Healthcare professionals of each workplace routinely obtain the vital status and health conditions of their relevant employees according to the Industrial Safety and Health Law<sup>[6]</sup>. Thus, case identification is presumed to be complete. We collected the information on sudden death victims during 1989–1995, which

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**Table 1** Incidence of sudden death among employees of 10 major workplaces in Central Japan in 1989–1995

Age	Male			Female			Total		
	No. Sudden death(s)	No. Employees	(Incidence)	No. Sudden death(s)	No. Employees	(Incidence)	No. Sudden deaths	No. Employees	(Incidence)
~19	1	5176	(2.8)	1	1718	(8.3)	2	6894	(4.1)
20~24	3	18 128	(2.4)	1	11 842	(1.2)	4	29 970	(1.9)
25~29	9	25 878	(5.0)	2	6431	(4.4)	11	32 309	(4.9)
30~34	12	23 740	(7.2)	1	2816	(5.1)	13	26 556	(7.0)
35~39	19	19 712	(13.8)	0	2100	(0.0)	19	21 812	(12.4)
40~44	25	20 710	(17.2)	3	2348	(18.3)	28	23 058	(17.3)
45~49	46	21 800	(30.1)	2	2266	(12.6)	48	24 066	(28.5)
50~54	63	16 751	(53.7)	2	1673	(17.1)	65	18 424	(50.4)
55~59	64	10 766	(84.9)	1	1300	(11.0)	65	12 066	(77.0)
60~	9	1356	(94.8)	0	264	(0.0)	9	1620	(79.4)
Total	251	164 017	(21.9)	13	32 758	(5.7)	264	196 775	(19.2)

Number of employees is for 1995.

Incidence is shown as the number of deaths per year per 100 000.

included age, sex, date, time, symptoms, activity, and witnessing status at the event. Circumstances of death were mainly indicated by the victim's family members or workplace colleagues. The cause of death was identified by death certificates.

All chronological data were categorized and assessed for frequency. Data on time of onset were compiled in eight 3-h intervals. Seven victims who were described as dying in the morning hours and nine in the afternoon hours, as well as 49 in unknown hours, were excluded from the analysis of circadian variation. We also made a subanalysis on chronology limited to the cases of instantaneous (within-1-hour) cardiac death.

Frequency distribution was assessed for homogeneity using a chi-square test for goodness of fit. Risk ratio, adjusted for age and sex, and its 95% confidence interval of high and low incident period were also calculated by means of logistic regression using the plateau (when present) or the nadir as a reference on statistical package SAS version 6.08 (SAS Institute, Cary, North Carolina, U.S.A.). A *P* value of <0.05 was considered statistically significant.

## Results

A total of 264 cases (251 male and 13 female) of sudden death occurred among 196 775 employees from 10 workplaces in Central Japan in 1989–1995. An average 37.7 cases of sudden death occurred every year, and we found no linear yearly trend in incidence. While there were only 21 cases of sudden death in 1991 when the business situation was good, 48 sudden deaths occurred in 1995 when there was an economic recession.

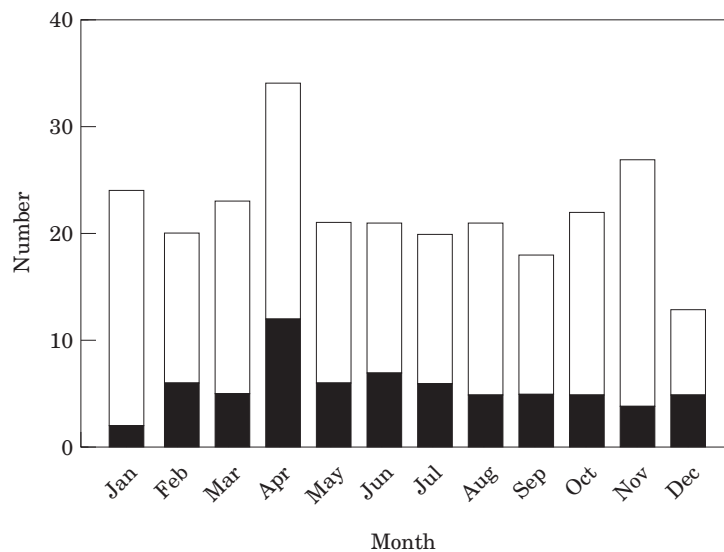
The number and rate of incidence of sudden deaths stratified by sex and age are shown in Table 1. The annual incidence was 21.9 and 5.7 per 100 000 population for men and women, respectively. Sudden death was infrequent in the younger generation, but increased with age from 2.4 among male employees

20–24 years of age to 94.8 among those ≥60 years per 100 000 per year. The incidence was not comparable between the sexes because of the few middle-aged female employees and cases in this cohort.

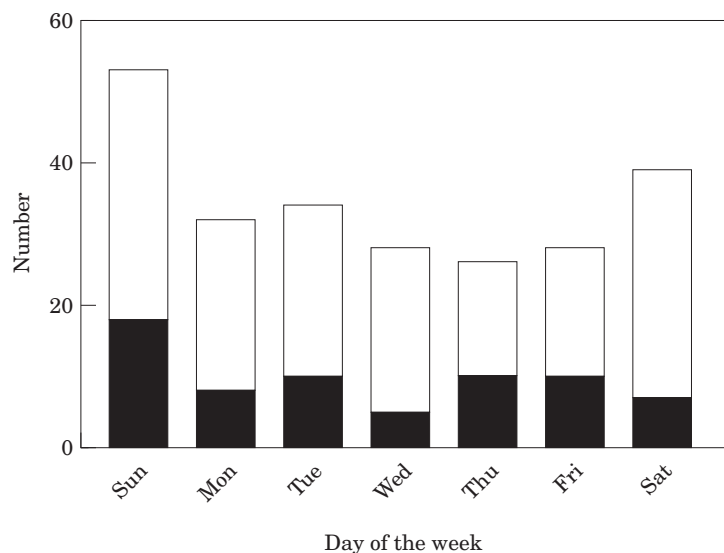
Clinical diagnoses of sudden death included acute heart failure (100 cases), acute myocardial infarction (43 cases), hypertrophic or dilated cardiomyopathy (four cases), and aortic dissection (two cases) [subtotal of cardiovascular diseases, 153 cases, 58.6%]; subarachnoid haemorrhage (41 cases), cerebral haemorrhage (25 cases), and cerebral infarction (eight cases) [subtotal of cerebrovascular diseases, 79 cases, 30.3%]; pneumonia (six cases), and bronchial asthma (five cases) [subtotal of respiratory diseases, 15 cases, 5.7%]; gastrointestinal bleeding (three cases); and epilepsy (three cases). Out of 264 victims, nine had experienced myocardial infarction and eight had angina pectoris before the events. Two men were known to have cardiomyopathies and two others had valvular heart diseases. Nine had experienced cerebrovascular diseases and six had bronchial asthma. Sudden death victims who had preexisting structural heart diseases were significantly older than those without such diseases (age, 52.2 vs 47.9; *P*<0.05).

The time from onset of symptoms to death differed depending on the triggering disease. Among 131 victims of cardiac death whose onset-to-death time was precisely recorded, 69 (52.7%) died within 1 h and 32 (24.4%) within 1–3 h. For 89 whose death was of other than cardiac origin, only nine (10.1%) and 11 (12.4%) died within 1 and 1–3 h, respectively. Thus, most cardiac deaths occurred instantaneously.

The monthly distribution of 264 cases of sudden death is shown in Fig. 1. Sudden death peaked in April (34 cases; risk ratio, 1.62; 95% confidence interval, 0.94–2.79), and was lowest in December (13 cases; risk ratio, 0.67; 95% confidence interval, 0.34–1.31), while there were 18–27 cases in each of the remaining months (reference for risk ratio, June, *n*=21). This unequal distribution did not reach statistical



**Figure 1** Monthly patterns of sudden death among 196 775 employees of 10 major workplaces in Central Japan in 1989-1995. ■ = instantaneous cardiac death; □ = other sudden death.



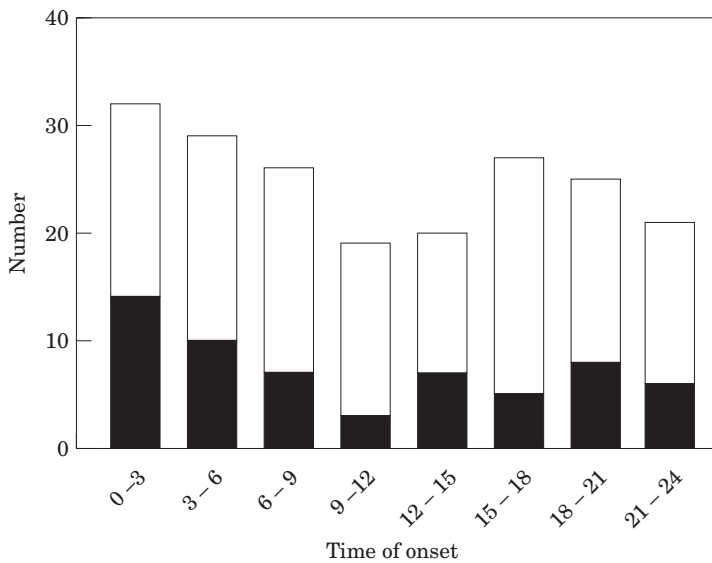
**Figure 2** Daily patterns of sudden death among 196 775 employees of 10 major workplaces in Central Japan in 1989-1995. ■ = instantaneous cardiac death; □ = other sudden death.

significance. We also examined the seasonal pattern, but found no significant variation: 78 cases in spring (March to May), 62 in summer (June to August), 67 in autumn (September to November), and 57 in winter (December to February).

When stratified by clinical diagnosis, sudden death from cardiovascular diseases was frequent (16 cases) in April, that from cerebrovascular diseases was common (8-11 cases) in the cold season (January to April), and that from respiratory diseases was relatively common (3-4 cases) in April and May. However, these variations were of no statistical significance. When further limited to instantaneous cardiac death, April

(12 cases) was still prominent in incidence compared with other months (2-7 cases).

Daily distribution of sudden death is shown in Fig. 2 for 241 cases, whose exact dates of onset were identified. Sudden death occurred most frequently on Sunday (53 cases; risk ratio, 1.90; 95% confidence interval, 1.20-2.99), followed by Saturday (39 cases; risk ratio, 1.36; 95% confidence interval, 0.83-2.21), far outnumbering those of other days of the week (26-34 cases per each; reference for risk ratio, Wednesday,  $n=28$ ). This daily variation was statistically significant ( $P=0.02$ ). When stratified by clinical diagnosis, sudden death from cardiovascular diseases was frequent on



**Figure 3** Circadian patterns of sudden death among 196 775 employees of 10 major workplaces in Central Japan in 1989–1995. ■=instantaneous cardiac death; □=other sudden death.

Sunday (35 vs 15–22 cases), and that from cerebrovascular diseases was common at weekends (13–14 vs 7–10). Sunday was also the most critical day for instantaneous cardiac death (18 vs 5–10 cases).

Figure 3 shows the circadian variation of sudden death categorized at 3-h intervals for 199 cases whose times of onset were identified. While only 19 cases of sudden death occurred at 0900–1200 h (reference), 32 occurred at 00–0300 h (risk ratio, 1.71; 95% confidence interval, 0.94–3.10) and 29 at 0300–0600 h (risk ratio, 1.47; 95% confidence interval, 0.79–2.72). We found another peak of incidence at 1500–1800 h (27 cases; risk ratio, 1.65; 95% confidence interval, 0.90–3.01). However, this variation was statistically insignificant. Circadian variation was mainly caused by death from cardiovascular diseases (41 cases 00–0600 h vs 23 cases 0900–1500 h). The same trend was shown when limited to instantaneous cardiac death (24 cases in the small hours and 10 cases around noon).

The activity at the time of sudden death was identified for 221 cases (Table 2). While 38 persons (17.2%) died at work, 183 (82.8%) succumbed when not at work. According to the research on time-consumption in daily life published by the Japan Broadcasting Corporation (NHK)<sup>[7]</sup>, employees living in Central Japan laboured for 2220 h (25.3%) and commuted for 330 h (3.8%), on average, out of 8760 h in 1995. Thus, the incidence of sudden death during labour and commuting hours was lower than expected ( $P<0.001$ ).

Among 38 victims who died suddenly at work, 19 died during a light job, eight while commuting/travelling, and six during a short break. Among 183 sudden deaths outside the workplace, 37 occurred during sleep and 28 while resting. Ten and nine persons died suddenly during bathing and toilet activities,

respectively, which take only a short time (less than 1 h). Eight subjects died suddenly during sport activities, lasting on average 35 min on weekdays and about 1 h at weekends, according to the NHK research<sup>[7]</sup>. Since physicians or nurses at companies conducted the investigation, details were not always available on sudden deaths which did not occur on the premises.

Among 162 cases of sudden death whose witnessing status was recorded, 113 cases (69.8%) were witnessed and 49 (30.2%) were not. Fifty-eight cases

**Table 2** Activities at the time of sudden death among 196 775 employees of 10 major workplaces in Central Japan in 1989–1995

At work	38 (17.2%)	During labour (Light job)	19
		(Intermediate job)	2
		(Heavy job)	1
		While commuting/travelling	8
		During a break	6
		In toilet	1
		Unclear	1
Off work	183 (82.8%)	During sleep	37
		At rest	28
		When bathing	10
		In toilet	9
		During a meal	8
		During sports activities	8
		During hobby	6
		During housework	5
		While driving	4
		While dressing	3
		While talking	3
		During a walk	2
		During coitus	1
		Unclear	60
			(n=221)

were witnessed by family members and 32 by workplace colleagues. Whether and how such by-standers resuscitated victims was unknown.

Incipient symptoms and signs of the events were described for 132 persons. They included syncope or collapse for 30, dyspnoea for 23, general discomfort or paleness for 21, headache for 16, and chest tightness for 10. Prior to the events, 32 victims had complained of prodromal symptoms: general fatigue in seven, common cold in five, fever or subfever in four, and vague discomfort, chest tightness, headache, gastrointestinal trouble, and stiff neck in three, respectively.

## Discussion

We investigated the incidence of sudden death in a large working population for the first time, and found that April, weekends, and midnight were the periods with an increased risk of sudden death. Even if limited to instantaneous cardiac death, these chronological patterns were essentially unaltered. Moreover, most sudden deaths occurred when away from the workplace.

Clinical diagnoses of sudden death were principally cardiovascular diseases including acute heart failure. Japanese physicians have tended to use 'acute heart failure' to describe a case of sudden death of clinically unknown aetiology. According to our unpublished review of the archives of nationwide postmortem examinations, about two-thirds of clinically unknown sudden deaths have been attributed to cardiovascular disorders, most of which were ischaemic heart diseases. Thus, cardiovascular diseases might be the leading cause of sudden death for this population as well. Subarachnoid haemorrhage was another important cause of sudden death, because it was four times higher than expected from the vital statistics of Japan<sup>[8]</sup>. Complaints of prodromal symptoms by the victims were non-specific. Thus, it seems difficult to predict sudden death from a physical complaint.

Sudden death was most frequent in April. In Japan, the business year starts in this month. Newcomers begin work, many employees change their responsibilities, and some children leave home for school. These events explain their high scores on the Holmes' social readjustment rating scale<sup>[9]</sup>, and can lead to cardiovascular instability such as vasomotor reaction<sup>[10]</sup> and platelet aggregation<sup>[11]</sup> resulting in critical events<sup>[12-15]</sup>. Although Central Japan can be terribly hot and humid in summer and cold in winter, we could find no seasonal variation in sudden death, as observed in the whole population of this area (our unpublished observation based on the vital statistics) and of some other regions<sup>[16-18]</sup>, in which sudden deaths of the elderly predominated. Thus, the younger generation might be able to withstand the poor climate but still be vulnerable to changes in the psychosocial environment. The reason for the low incidence of sudden death in December remains unknown, and further investigation into the psychosocial background is needed.

Sudden death also occurs most frequently on Sundays, followed by Saturdays. This weekend peak was attenuated among the total number of residents of this region (from our aforementioned study). The sudden-death-prone day is reported to be Monday in the United States<sup>[19]</sup>, and Saturday in New Zealand<sup>[20]</sup>. The way of life, such as how a person holidays, may vary by country and generation. Not a few Japanese employees bustle about even in their leisure time, resorts and roads are crowded on holidays, and one wonders whether stress, rather than rest or relaxation, results. One more possible explanation is binge drinking at weekends<sup>[21,22]</sup>. Excess alcohol intake may cause lactic acidosis, hypoglycaemia, and even coma in Japanese whose aldehyde dehydrogenase activity is congenitally low in general. However, how much alcohol was consumed before sudden death is unknown in this series.

In our study, the highest incidence of sudden death was in the small hours. Since some of the victim's family members may have failed to notice a sudden death during sleep and probably only discovered the dead person upon waking (leaving the exact time of onset undetermined), sudden death in the middle of the night might be more frequent than reported here. Until now, many western and some Japanese investigators<sup>[20,23-26]</sup> have demonstrated that sudden death occurred most frequently in the morning with or without a secondary peak in the afternoon or evening. However, some of them<sup>[25,26]</sup> also mentioned that the morning peak was diminished for younger people, and another investigator<sup>[27]</sup> reported that the peak of witnessed cases was observed during the night for young Thai workers. Coronary artery spasm, not uncommon among middle-aged Japanese people<sup>[28,29]</sup>, is usually induced late at night or early in the morning, and may play an important role in sudden death<sup>[30]</sup>. Thus, midnight may be a period of high risk for the younger working population.

Most sudden deaths in the Japanese working population occurred away from the workplace. This is consistent with the weekend and midnight peaks. Toilet and bath activities were circumstances presenting an increased risk during the daily routine<sup>[31]</sup>. Sport also posed a high risk, as already reported<sup>[32,33]</sup>. Several studies have shown that imbalances of sympathetic and parasympathetic tone can provoke coronary spasm or ventricular fibrillation<sup>[34-36]</sup>, and regular exercise and a certain kind of beta-blocking agent can suppress the incidence of sudden death even for those without myocardial infarction<sup>[33,37]</sup>. These findings suggest that autonomic stabilization may prevent sudden death.

Our study offers many suggestions about what triggers sudden death. Mental stress, particularly that induced by changes in the social environment, seems to be a key factor among persons in their prime. We are now conducting a nested case-control study in the same population to disclose hazardous or protective factors in this kind of premature death. By integrating the overall findings from these studies, we hope to be able to clarify

in detail the factors behind sudden death in the working population.

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