For the dissatisfaction with EOL care, 'dissatisfaction with physician's treatment of physical symptoms' was the most highly associated with potential psychiatric disorders (OR = 3.44). Unrelieved pain of female cancer patients during their last months of life showed a positive association with psychological morbidity such as sleep disorders in the widowers 4–5 years after bereavement [29]. Additionally, EOL care discussions are associated with less aggressive medical care, such as ventilation and resuscitation and less major depressive disorders in bereaved caregivers [15]. Therefore, satisfactory discussions about physical treatment in EOL care are helpful not only for the patients but also for the caregivers' psychological adjustment. Another factor, 'dissatisfaction with time spent communicating with patients' was significantly associated (OR = 1.55). A recent systematic review of communication with terminally ill patients and their families [30] indicated a lack of quantitative study. Communication skills training for healthcare professionals to improve discussions between patients and caregivers about EOL issues fostering realistic forms of hope is an essential future task for preventive intervention of spousal morbidity after bereavement [30].

We derived several implications for practice and research. In practice, we could obtain the following several indicators for early detection of high-risk spouses prior to the patient's death: 'patients using psychiatric consultation service', 'patients with stomach cancer', 'bereaved with a history of psychiatric disorder', 'dissatisfaction with time spent communicating with patients', and 'dissatisfaction with physician's treatment of physical symptoms'. Along with the early detection of spouses with these risk factors, nurse-assisted [31] or pharmacist-assisted [32] psychiatric referral programs using the 'Distress and Impact Thermometer' might be useful for directly evaluating psychological distress among spouses in EOL practice. In research, we could obtain the following possible strategies for preventive intervention of spousal morbidity after bereavement: assistance for improving 'discussions with physicians about physical treatment in EOL care' and 'discussions between patients and caregivers about EOL issues' would be effective. Development of communication skills training for healthcare professionals to improve these discussions must be considered in future research.

For the study limitations, first, the lack of an exact response rate was a critical methodological limitation. Nevertheless, we believe our estimated sample rate (31%) was adequate because the population of bereaved spouses included those who had died after the patient's death. Second, two sample biases might exist. One was caused by the data collection site, a single cancer center in Japan. However, we do not believe that this institutional bias had a serious effect on the representation of Japanese bereaved spouses of cancer patients because 90% of cancer patients in Japan die in a hospital [19]. In addition, the bereaved with high impaired mental health might have been more motivated to take part in the study. This might have resulted in an inflated number of potential psychiatric disorders. Third, this was a cross-sectional study, and we could not discuss the time course of the prevalence or any causality between impaired mental health and associated factors. In addition, it remains possible that there was a recall bias in answering the question about dissatisfaction with EOL care because it was such a long period for a retrospective report by the bereaved who had lost their partner several years earlier. Fourth, other important factors were not investigated in this study, such as the bereaved spouse's 'style of attachment to the deceased', 'function level among family members', 'perception of the dying process and whether this was traumatic', and 'available social support'. Finally, we have no objective data on EOL care; individuals whose spouses died 7 years ago would likely have had a very different experience in the oncology care setting compared with those whose spouses died more recently.

Conclusions

Nearly half the bereaved spouses showed potential psychiatric disorders even 7 years after bereavement. Patients' psychological distress, bereaved spouses' history of psychiatric disorder, and dissatisfaction with EOL care were indicators of high-risk spouses.

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Conflicts of interest

All authors declare that the answers to the questions on your competing interest form are all 'No' and therefore have nothing to declare.

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Causes of death in forensic autopsy cases of malnourished persons

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ABSTRACT

Purpose: Medical examiners and forensic pathologists often encounter emaciated bodies in postmortem examinations. However, the main disease that caused death is often not clear and measures to prevent the unexpected death of malnourished persons have not been established. In this study, we examined the underlying causes of death among a large number of forensic autopsy cases that showed emaciation to clarify the features of sudden, unexpected death in malnourished persons.

Methods: Documents of autopsy cases without putrefaction handled during 2007–2010 by the Tokyo Medical Examiner's Office were reviewed ($n = 7227$). The body mass index (BMI) was calculated for each case. The causes of death for cases with severe malnutrition (BMI < 16; $n = 885$) were closely examined.

Results: About 70% of all deaths in malnourished cases (BMI < 16) was due to disease, and the causative diseases are more varied than in those with less severe malnutrition and those without malnutrition (BMI ⩾ 16). A higher proportion of malnutrition as the cause of death was observed in younger persons for both sexes, and a higher proportion of having a history of psychiatric diseases was observed in younger deceased women. In addition, a higher proportion of alcohol-related digestive diseases was observed especially in younger men, some of whom had a history of alcohol dependence. On the other hand, the proportion of organic diseases, such as neoplasms and gastroduodenal ulcer, was higher in older deceased persons, especially among men. Around 70% of all respiratory diseases comprised pneumonia in both sexes. Among non-disease-related causes of death, poisoning was the most frequent cause in women under 55 years old (35.3%), with the majority having had a history of psychiatric disease.

Conclusions: Because autopsy cases of malnourished persons show various causes of death, physicians have to pay more attention in making death diagnosis in such cases. From a preventative point of view, early detection of organic diseases, a better approach toward managing psychiatric diseases, and implementation of vaccination for pneumonia will contribute to reduction of future unexpected deaths among malnourished persons.

1. Introduction

Obesity is known to increase the risk of cardiovascular disease [1] and has been associated with sudden death of circulatory disease origin among forensic autopsy cases [2,3]. Accordingly, obesity across all age groups is considered a major public health problem worldwide, and justifiably many countries are preoccupied with finding ways to decrease obesity rates [4,5].

On the other hand, being underweight is also associated with increased risks of morbidity and mortality in the older population [6]. Indeed, medical examiners and forensic pathologists often encounter emaciated bodies in postmortem examinations. Malnutrition is frequently associated with chronic diseases, which can lead to anorexia and in an increase in nutrient demands of the body [7,8]. In addition, malnourished persons may subsequently develop acute conditions, such as infection [8]. However, the important or frequent causes of death due to disease are not clear, and measures to prevent unexpected death in malnourished persons have not been established yet because of a lack of large-scale studies concerning such cases.

In this study, we examined the underlying causes of death in a large number of forensic autopsy cases that showed emaciation to clarify the features, and hence determine measures to prevent such deaths in malnourished persons.

2. Materials and methods

All sudden unexpected deaths in the special wards of Tokyo Metropolis are reported to Tokyo Medical Examiner's Office. Medical examiners perform autopsy, when they cannot determine a cause of death from a past history, death course and situational/external investigation of the deceased. We reviewed the documents of autopsy cases handled during 2007–2010 in the Tokyo Medical Examiner's Office ($N = 10,942$). Then, we selected the cases that

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did not show putrefaction and calculated the body mass index (BMI) in each case by using the value of height and weight ($n = 7227$). To select particularly lean deceased to clarify the features of death cause among malnourished persons, we considered as malnourished cases those with a BMI of <16 ($n = 885$), because cases with a BMI of <16 are defined as severe underweight according to the World Health Organization classification [9]. Causes of death were classified according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) [10]. We used the chi-square test for independence for comparison of causes of death from disease between malnourished cases (BMI < 16) and "less severely malnourished and non-malnourished cases" (BMI ⩾ 16). Then, the malnourished cases were divided into four groups according to age (20–54, 55–64, 65–74 and 75–), and the chi-square test for independence was also used to analyze correlation between death cause (or prevalence of psychiatric disease) and age among the malnourished cases. The chi-square test for independence was performed by two means, according to the four age groups and according to the two age groups (under 65 years old, above 65 years old). Values of $P < 0.05$ were considered statistically significant. The ethical committee of the Tokyo Medical Examiner's Office approved the protocol of this study.

3. Results

3.1. Manner of death and non-disease-related causes of death in malnourished cases

The proportion of the cases with emaciation (BMI < 16) is higher in older deceased persons for both sexes (Fig. 1). Around 70% of all deaths were due to disease irrespective of age group and sex (Table 1).

Fig. 1. Proportion of the autopsy cases with emaciation (BMI < 16) across all age groups.

Among non-disease-related causes of death, two cases were confirmed to be deaths due to starvation. One deceased person was identified as homeless, and another was an elderly woman neglected by her family. In men, around 50% of non-disease-related causes of deaths in those younger than 75 years old was due to hypothermia. Poisoning by sedative or psychotropic drugs was the most frequent cause of death in women under 55 years old (36.8%), with the majority having had a history of psychiatric disease. Blunt trauma due to a fall was the most frequent in older persons for both sexes (42.4% in men, 30.8% in women).

3.2. Disease-related causes of death in malnourished cases

First, we compared the causative diseases of death between the malnourished cases (BMI < 16) and "less severely malnourished and non-malnourished cases" (BMI ⩾ 16). Although more than 60% of disease-related deaths were due to circulatory diseases in cases with a BMI of ⩾16, the proportion of circulatory diseases was significantly lower in malnourished cases. On the other hand, the proportions of respiratory diseases, neoplasms, and endocrine/nutritional/metabolic diseases were significantly higher in malnourished cases for both sexes than in "less severely malnourished and non-malnourished cases" (Fig. 2a and b). In addition, the proportions of digestive diseases and certain infectious/parasitic diseases were higher in malnourished cases among men (Fig. 2a).

We next compared the proportions of each disease in malnourished cases (BMI < 16) among age groups. In men, the proportion of digestive diseases tended to be higher in younger deceased persons ($P = 0.020$ according to the four age groups, $P = 0.003$ according to the two age groups), and the proportion of malnutrition tended to be higher in younger deceased persons ($P = 0.028$ according to the two age groups, not significant according to the four age group). On the other hand, the proportion of neoplasms tended to be higher in older persons ($P = 0.046$ according to the four age groups, $P = 0.024$ according to the two age groups) (Table 2a). In women, the proportion of malnutrition was also higher in younger persons ($P < 0.001$ by two means) (Table 2b).

Among digestive diseases, alcoholic liver/pancreatic disease was more prevalent in younger persons, especially in men ($P = 0.007$ according to the four age groups, $P = 0.010$ according to the two age groups) (Table 3). We noted chronic alcoholism (alcohol dependence) in the history of some cases of alcoholic liver/pancreatic disease in both sexes. On the other hand, the proportion of gastroduodenal ulcer was higher than that of alcohol-related digestive diseases in persons above 55 years old for both sexes. Around 70% of respiratory diseases comprised infectious diseases, mainly pneumonia in both sexes. The majority of infectious/parasitic diseases were respiratory tuberculosis in both sexes.

Table 1
Manner of death according to sex and age group (BMI < 16)

Manner of death	Total case		Age group							
			20–54		55–64		65–74		75–	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Disease	424 (76.0%)	224 (68.5%)	60 (75.0%)	39 (63.9%)	134 (77.0%)	38 (73.1%)	120 (75.5%)	46 (79.3%)	110 (75.9%)	101 (64.7%)
Non-disease related cause	126 (22.6%)	98 (30.0%)	17 (21.3%)	19 (31.1%)	38 (21.8%)	14 (26.9%)	37 (23.3%)	10 (17.2%)	34 (23.4%)	55 (35.3%)
Unknown	8 (1.4%)	5 (1.5%)	3 (3.8%)	3 (4.9%)	2 (1.1%)	0	2 (1.3%)	2 (3.4%)	1 (0.7%)	0
Total	558 (100%)	327 (100%)	80 (100%)	61 (100%)	174 (100%)	52 (100%)	159 (100%)	58 (100%)	145 (100%)	156 (100%)

Parentheses indicate the proportion of the corresponding manner of death to total death in each group.

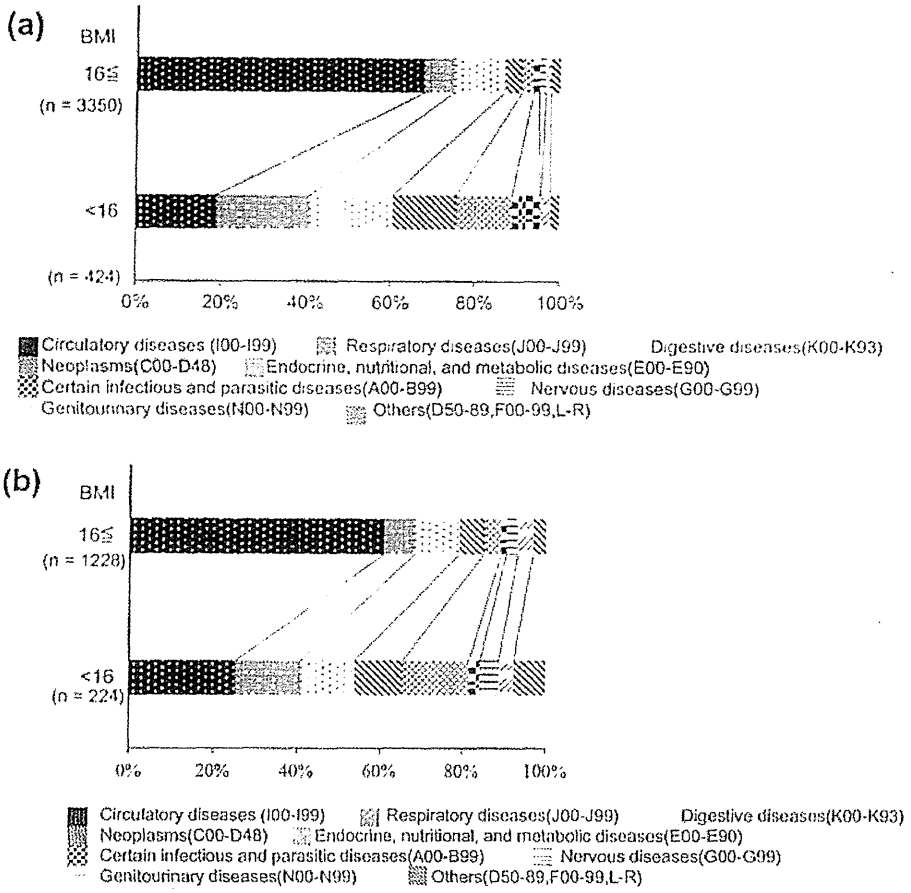

Fig. 2. Comparison of disease-related causes of death between the malnourished cases (BMI < 16) and "less severely malnourished and non-malnourished cases" (BMI ≥ 16). The ICD code for each classification is shown in parenthesis (a: male, b: female).

Third, we examined the medical histories among the cases that were confirmed to be deaths due to malnutrition. Psychiatric disorders, including alcohol dependence, eating disorders, and depression, were the most frequently observed conditions, especially in women. The proportion of psychiatric diseases in women tended to be higher in younger deceased persons ($P = 0.026$ according to the two age groups, not significant according to the four age groups) (Table 4).

4. Discussion

In our previous study on medico-legal diagnosis of deaths in areas without a medical examiner [11], the majority of the cases classified as "death due to malnutrition or starvation" did not undergo autopsy. Physicians may tend to indicate "malnutrition" as the underlying cause of death when the deceased person shows emaciation. However, as shown in this study, the proportion of malnutrition as the underlying cause of death is not as high as expected (only around 10% among disease-related deaths) (Tables 2a and 2b). Thus, the absence of autopsy among such cases might have led to inaccurate mortality statistics, which may have negative implications for public health.

Several important age-associated physiologic changes predispose an elderly person to weight loss, such as declining chemosensory function (smell and taste), reduced efficiency of chewing, and slowed gastric emptying [12,13]. This is evident from the higher proportion of older deceased persons with emaciation in this study. Nevertheless, the causes of death of older persons varied like in the young and middle-aged groups. Thus, physicians should not readily make diagnoses such as "death due to old age" because various diseases or injuries, and sometimes even neglect, may be the underlying causes of death among the elderly with emaciation.

Although various causes of death were noted among the malnourished cases, we observed several features that could be used as targets for the prevention of future unexpected deaths. About 70% of respiratory-related deaths in malnourished cases (BMI < 16) in this study comprised infections, mainly pneumonia. Several studies have shown the effectiveness of the 23-valent pneumococcal polysaccharide vaccine (PPV) for middle-aged and older adults in preventing pneumococcal pneumonia, the most common respiratory pathogen [14,15]. PPV, together with annual influenza vaccination, may reduce the number of unexpected deaths among the malnourished population.

The higher proportion of psychiatric diseases in women confirmed to have died of malnutrition (under 65 years old), in addition to the higher proportion of deaths due to alcohol-related digestive diseases in men (under 55 years old), suggests that psychiatric diseases may be strongly associated with death among malnourished young or middle-aged persons. On the other hand, a higher proportion of deaths due to organic diseases that may be treatable if detected early, such as neoplasms and gastroduodenal ulcer, was observed in middle-aged or older persons. A better approach toward managing nutritional status for psychiatric patients, early detection of organic disease by means of periodic medical checkups, and improvement in participation rate for medical checkups will be helpful in preventing deaths associated with malnutrition.

Table 2a
Classification of disease according to age group (men; BMI < 16).

Cause of death	Total case	Age group			
		20–54	55–64	65–74	75–
Circulatory disease (I00–I99)	81 (19.1%)	14 (23.3%)	19 (14.2%)	22 (18.3%)	26 (23.6%)
Respiratory disease (J00–J99)	93 (21.9%)	14 (23.3%)	21 (15.7%)	28 (23.3%)	30 (27.3%)
Digestive disease (K00–K99)	83 (19.6%)	13 (21.7%)	37 (27.6%)	16 (13.3%)	17 (15.5%)*
Neoplasms (C00–D48)	64 (15.1%)	4 (6.7%)	17 (12.7%)	26 (21.7%)	17 (15.5%)*
Malnutrition (E40–46, 50–64)	44 (10.4%)	7 (11.7%)	20 (14.9%)	11 (9.2%)	6 (5.5%)
Certain infectious and parasitic diseases (A00–B99)	27 (6.4%)	4 (6.7%)	11 (8.2%)	8 (6.7%)	4 (3.6%)
Others	32 (7.5%)	4 (6.7%)	9 (6.7%)	9 (7.5%)	10 (9.1%)
Total death from disease	424 (100%)	60 (100%)	134 (100%)	120 (100%)	110 (100%)

Parentheses in cause of death indicate ICD code for each classification. Other parentheses indicate the proportion of the corresponding cause of death to total death from disease in each group.
* $P < 0.05$ (according to the four age groups).

Table 2b
Classification of disease according to age group (women; BMI < 16).

Cause of death	Total case	Age group			
		20–54	55–64	65–74	75–
Circulatory disease (I00–I99)	57 (25.4%)	6 (15.4%)	8 (21.1%)	13 (28.3%)	30 (29.7%)
Respiratory disease (J00–J99)	35 (15.6%)	4 (10.3%)	6 (15.8%)	8 (17.4%)	17 (16.8%)
Digestive disease (K00–K99)	29 (12.9%)	3 (7.7%)	7 (18.4%)	3 (6.5%)	16 (15.8%)
Neoplasms (C00–D48)	26 (11.6%)	5 (12.8%)	2 (5.3%)	5 (10.9%)	14 (13.9%)
Malnutrition (E40–46, 50–64)	29 (12.9%)	12 (30.8%)	8 (21.1%)	7 (15.2%)	2 (2.0%)**
Certain infectious and parasitic diseases (A00–B99)	6 (2.7%)	1 (2.6%)	1 (2.6%)	0	4 (4.0%)
Others	42 (18.8%)	8 (20.5%)	6 (15.8%)	10 (21.7%)	18 (17.8%)
Total death from disease	224 (100%)	39 (100%)	38 (100%)	46 (100%)	101 (100%)

Parentheses in cause of death indicate ICD code for each classification. Other parentheses indicate the proportion of the corresponding cause of death to total death from disease in each group.
** $P < 0.01$ (according to the four age groups).

Table 3
Subclassification of digestive diseases according to age group (men; BMI < 16).

Cause of death	Total case	Age group			
		20–54	55–64	65–74	75–
Alcoholic liver disease, alcoholic-induced chronic pancreatitis (K70, K86.0)	23 (27.7%)	8 (61.5%)	11 (29.7%)	1 (6.3%)	3 (17.6%)**
Gastroduodenal ulcer (K25, 26)	42 (50.6%)	2 (15.4%)	21 (56.8%)	9 (56.3%)	10 (58.8%)
Others	18 (21.7%)	3 (23.1%)	5 (13.5%)	6 (37.5%)	4 (23.5%)
Total death from digestive diseases	83 (100%)	13 (100%)	37 (100%)	16 (100%)	17 (100%)

Parentheses in cause of death indicate ICD code for each classification. Other parentheses indicate the proportion of the corresponding cause of death to total digestive diseases in each group.
** $P < 0.01$ (according to the four age groups).

Table 4
The cases having psychiatric diseases among cases confirmed death due to malnutrition (BMI < 16).

Sex	Total case	Age group			
		20–54	55–64	65–74	75–
Women	12	7	4	1	0
	(29, 41.4%)	(12, 58.3%)	(8, 50.0%)	(7, 14.3%)	(2, 0%)
Men	8	2	3	2	1
	(44, 18.2%)	(7, 28.6%)	(20, 15.0%)	(11, 18.2%)	(6, 16.7%)
Both	20	9	7	3	1
	(73, 27.4%)	(19, 47.4%)	(28, 25.0%)	(18, 16.7%)	(8, 12.5%)

Parentheses indicate the total numbers of the cases certified death from malnutrition and the proportions of the cases having psychiatric diseases in each group.

In conclusion, the causes of death among malnourished persons are more varied than those among non-malnourished ones. Thus, physicians have to pay more attention in making a death diagnosis in such cases. From a preventative point of view, early detection of organic diseases, a better approach toward managing psychiatric diseases, and implementation of vaccination to prevent pneumonia will contribute to reducing future unexpected deaths associated with malnutrition.

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Medicolegal death of homeless persons in Tokyo Metropolis over 12 years (1999–2010)

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ABSTRACT

Background: Recently, the number of homeless persons in Japan has steadily decreased. However, it is not certain whether unexpected death of the homeless have actually decreased in proportion to decrease in total number of cases.
Methods: The documentation of medicolegal deaths among homeless persons handled in the Tokyo Medical Examiner's Office during 1999–2010 were reviewed, and we compared the number and manner/cause of death between cases occurring before 2004 and those occurring after 2004. In addition, we compared manner/cause of death between homeless and non-homeless persons.
Results: The number of medicolegal deaths of homeless persons remained almost the same during the study period in spite of a marked decrease in the total number of homeless persons after 2004. Age distribution shifted to older after 2004, and a higher proportion of the deceased had longer postmortem periods after 2004. Comparison between the manners/causes of death of the cases occurring before 2004 and those occurring after 2004 showed little difference. Disease constituted about 70% of all cases, and causes of death from disease were more various than those of non-homeless persons. Certain specific patterns included a higher proportion of death from circulatory disease in elderly homeless persons and a higher proportion of death from alcohol-related digestive disease and tuberculosis among younger homeless persons. Regarding accidental death, hypothermia was a leading cause of death irrespective of age group.
Conclusion: Aging and isolation among homeless persons might contribute to an unchanged number of medicolegal death of them. In addition to measures to address frequent causes of death in each age group, better intervention for isolated homeless persons might be a key factor to prevent unexpected deaths of homeless persons in the future.

1. Introduction

The number of homeless persons in Japan increased during the 1990s, when the bubble economy collapsed, and homelessness became a major social problem in Japan at the beginning of the 21st century, as in most other countries [1,2]. Many homeless people lack health insurance and obtain medical care only sporadically, resulting in them being undertreated for common medical problems [3]. Indeed, homeless people are reported to die from a variety of preventable causes, such as pulmonary tuberculosis, in other countries [4–6]. Similarly, a previous study conducted in 2000 in Osaka City, the second largest city in Japan, showed that many homeless people died untimely deaths from preventable causes such as pneumonia, malnutrition, and starvation [2]. After that, the Japanese government closely examined the actual situation of the homeless in 2003, finding that 47.4% of homeless people had some physical complaint and that majority of them did not have access to medical treatment [1].

Accordingly, the Japanese government and that of each municipality started to take comprehensive measures to address homeless problems, such as supplying temporary shelters, providing jobs, and securing health guidance/medical consulting [7]. As a result, the number of homeless persons in Japan has steadily decreased from 25,296 (in 2003) to 10,209 (in 2011) [1,8]. However, it is not certain whether health problems among homeless people have improved in accordance with the decrease in total number of homeless persons. In this study, we investigated changes in the number and manner/cause of death in cases of medicolegal death of homeless persons in the special wards of Tokyo Metropolis during 1999–2010, when a marked decrease in the total number of homeless persons was observed. This study aims to contribute to future improved health strategies for homeless persons by clarifying the nature of critical health problems among them.

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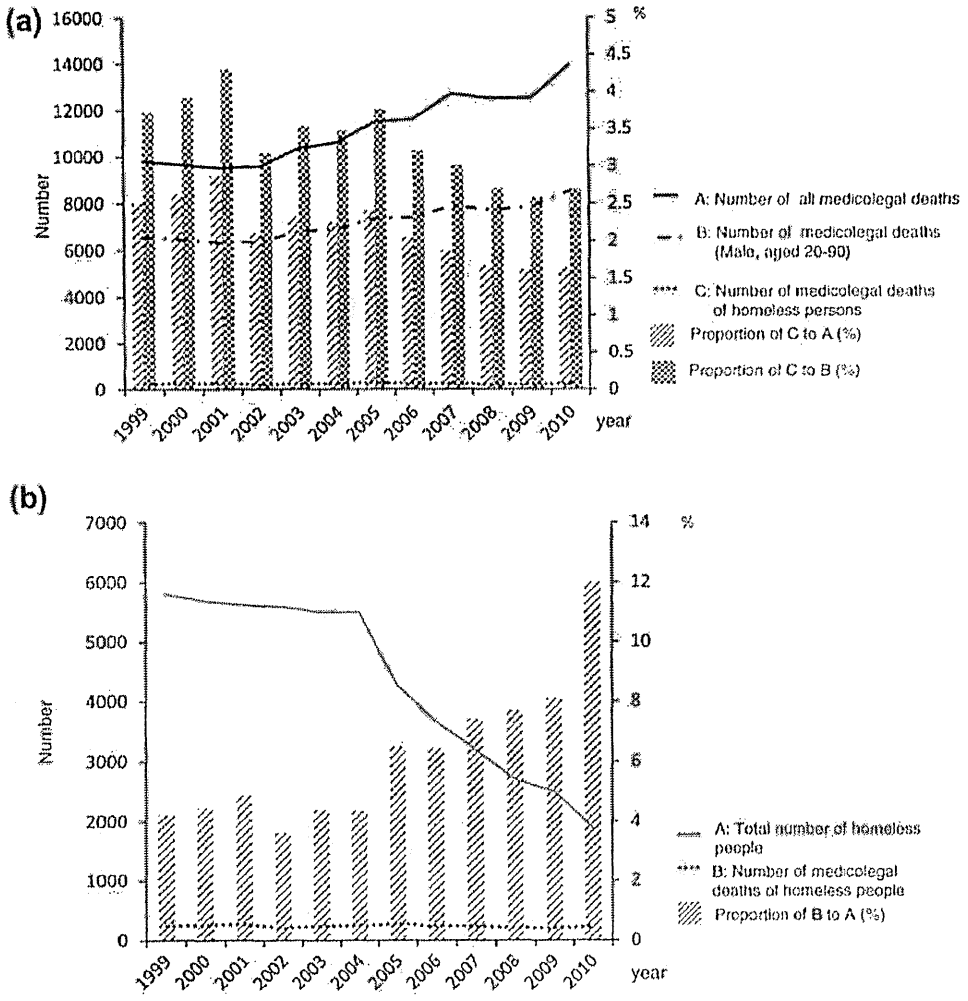

Fig. 1. (a) Change in total number of medicolegal death and medicolegal deaths of homeless persons during 1999–2010 in the special wards of Tokyo Metropolis. (b) Change in total number of homeless persons and medicolegal deaths of homeless persons during 1999–2010 in the special wards of Tokyo Metropolis.

2. Materials and methods

2.1. Study sample

All medicolegal deaths in the Special wards of Tokyo Metropolis are reported to the Tokyo Medical Examiner's Office. We reviewed the documents concerning medicolegal deaths handled in the Tokyo Medical Examiner's Office during 1999–2010 and selected cases that were considered to be homeless. We considered as homeless those "who, for no reason, occupy city parks, rivers, roads, stations, and other facilities as the living space to lead their daily lives," as defined in the "Law Concerning Special Measures to Support Self-Reliance of the Homeless" [9]. In addition, we also considered persons who stayed for long periods of time in flophouses as homeless for the purposes of this study. Criminal cases are usually transferred to other facilities (Forensic Department of Medical Faculty of Universities) for judicial autopsy, and such cases are excluded from this study. The total number of medicolegal deaths of homeless persons during the study period was 2842 (autopsy rate: 54.8%), and the proportion to total cases handled in the Tokyo Medical Examiner's Office was 2.1%. Men comprised 98.3% of the cases, and age distributed from 23 to 90 (mean age: 61.5). According to the demographic features of the homeless deceased, we selected the non-homeless cases those gender were male (aged 20–90) as a control ($n = 83{,}375$, autopsy rate: 24.5%). Age and manner/cause of death were closely examined in such cases. Data regarding the total number of homeless in the special wards of Tokyo Metropolis in each year was cited from those reported the Bureau of Social Welfare and Public Health, Tokyo Metropolitan Government [11].

2.2. Comparison of the manners/causes of death

Causes of death were classified according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) [10]. We divided cases into two age groups (i.e., under 60 and above 60 years) when we compared the manners/causes of death between the cases before 2004 and those after 2004. In addition, we divided the cases into four age groups ($\leqslant 49$, 50–59, 60–69, $\geqslant 70$) when we analyzed the relationship between manner/cause of death and age regarding homeless persons.

2.3. Statistical analysis

We used the chi-squared test for independence for statistical analysis, and values of $P < 0.05$ were considered statistically significant. The chi-square test was performed in two ways (i.e. among total cases, among only autopsied cases) regarding specific causes of death, and we considered each cause of death to be significant when both of the results were significant. The ethical committee

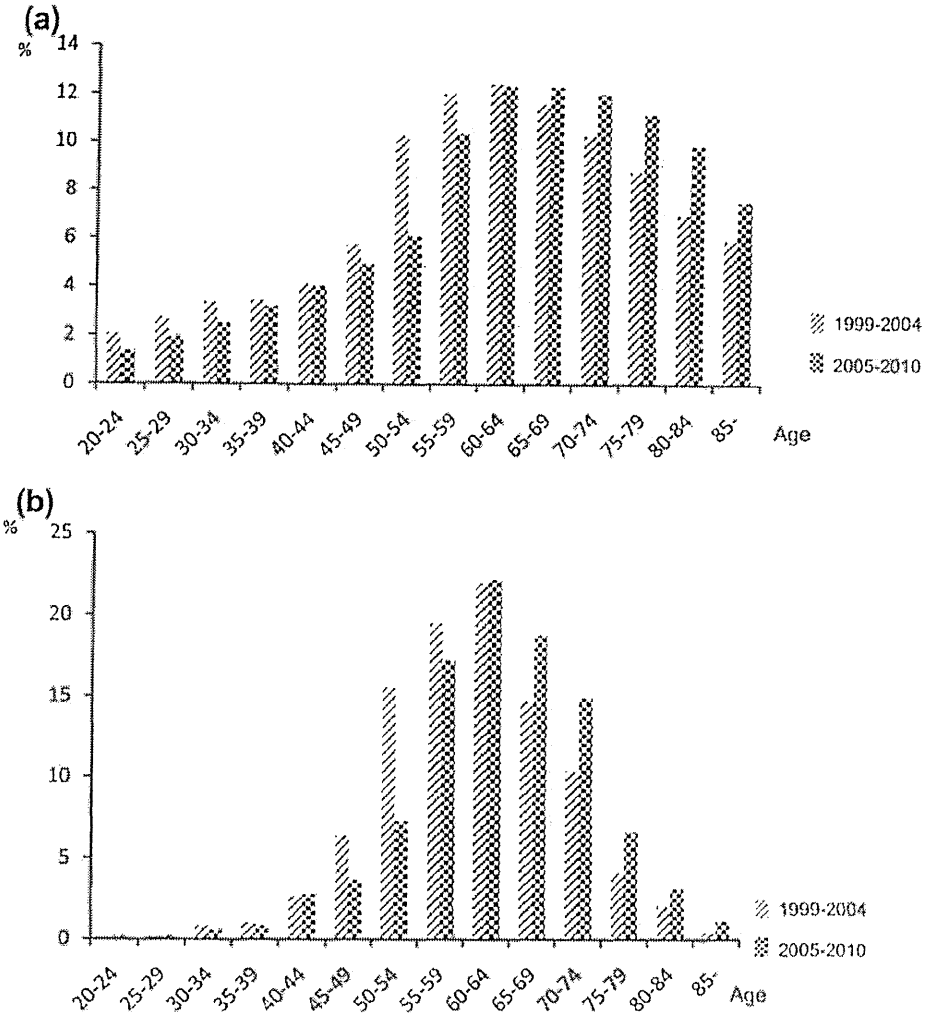

Fig. 2. (a) Age distribution of medicolegal deaths of non-homeless persons during 1999–2004 and 2005–2010 in the special wards of Tokyo Metropolis. (b) Age distribution of medicolegal deaths of homeless persons during 1999–2004 and 2005–2010 in the special wards of Tokyo Metropolis.

ible 1a
mparison of the manner of death for non-homeless persons between the two groups (cases in 1999–2004 and in 2005–2010) according to age groups.

	Age <60				Age ≥60			
	1999–2004	%	2005–2010	%	1999–2004	%	2005–2010	%
Disease	7918 (4122)	47.5	7706 (3905)	49.3**	16,436 (3452)	77.0	23,330 (3803)	78.5**
Accident	1924 (582)	11.6	1453 (594)	9.3**	1967 (555)	9.2	2409 (823)	8.1**
Suicide	5754 (162)	34.5	5216 (193)	33.3*	2223 (59)	10.4	2455 (69)	8.3**
Undetermined external cause	494 (326)	3.0	464 (332)	3.0	249 (171)	1.2	275 (207)	0.9**
Unknown	568 (320)	3.4	803 (289)	5.1**	483 (212)	2.3	1248 (288)	4.2**
Total	16,658 (5512)	100	15,642 (5313)	100	21,358 (4449)	100	29,717 (5190)	100

Parentheses indicate the number of autopsied cases.
% Indicate the proportion of each manner of death to the total number of deaths in each group.
* $P < 0.05$.
** $P < 0.01$.

of the Tokyo Medical Examiner's Office approved the protocol of this study.

3. Results

3.1. Demographic changes in medicolegal death of homeless persons and non-homeless persons over 12 years

As shown in Fig. 1a, the total number of medicoleal deaths handled in the Tokyo Medical Examiner's Office (and also the number of control case) steadily increased, especially after 2005. On the other hand, the number of medicolegal deaths of homeless persons in each year remained almost the same during the study period, resulting in a lower proportion of medicolegal death of homeless to total medicolegal cases (and control case) after 2005. However, as shown in Fig. 1b, the total number of homeless persons steadily decreased in the special wards of Tokyo Metropolis, especially after 2004, which was similar to the trend in the whole of Japan [1,8]. As a result, proportions of medicolegal death of homeless persons to total numbers of homeless persons became higher after 2004.

Table 1b
Comparison of the manner of death for homeless persons between the two groups (cases in 1999–2004 and in 2005–2010) according to age groups.

	Age <60				Age ≥60			
	1999–2004	%	2005–2010	%	1999–2004	%	2005–2010	%
Disease	458 (308)	68.2	292 (202)	63.8	586 (323)	75.0	676 (330)	72.6
Accident	112 (69)	16.7	83 (64)	18.1	130 (80)	16.6	152 (96)	16.3
Suicide	63 (1)	9.4	44 (1)	9.6	29 (0)	3.7	49 (2)	5.3
Undetermined external cause	18 (16)	2.7	8 (6)	1.7	12 (8)	1.5	23 (17)	2.5
Unknown	21 (8)	3.1	31 (6)	6.8*	24 (13)	3.1	31 (8)	3.3
Total	672 (402)	100	458 (279)	100	781 (424)	100	931 (453)	100

Parentheses indicate the number of autopsied cases.
% Indicate the proportion of each manner of death to the total number of deaths in each group.
* $P < 0.05$.

Table 2a
Comparison of the major causes of death for non-homeless persons between the two groups (cases in1999–2004 and in 2005–2010) according to age groups.

	Age <60				Age ≥60			
	1999–2004	%	2005–2010	%	1999–2004	%	2005–2010	%
Disease								
Circulatory disease	4679 (2716)	28.1	4723 (2535)	30.2	11,561 (2081)	54.1	15,999 (2127)	53.8
Ischemic heart disease	2472 (1295)	14.8	2434 (1136)	15.6	8153 (1260)	38.2	11,222 (1184)	37.8
Cerebrovascular disease	976 (517)	5.9	1044 (535)	6.7	1717 (273)	8.0	2326 (325)	7.8
Other circulatory disease	1231 (904)	7.4	1245 (864)	8.0	1691 (548)	7.9	2451 (618)	8.2
Respiratory disease	415 (282)	2.5	351 (239)	2.2	1335 (408)	6.3	1893 (434)	6.4
Influenza and pneumonia	212 (158)	1.3	205 (152)	1.3	832 (289)	3.9	943 (264)	3.2**
Other respiratory disease	203 (124)	1.2	146 (87)	0.9*	503 (119)	2.4	950 (170)	3.2
Digestive disease	1745 (631)	10.5	1507 (561)	9.6	1634 (474)	7.7	2262 (572)	7.6
Alcohol-related digestive disease	1154 (352)	6.9	1006 (293)	6.4	782 (160)	3.7	1137 (157)	3.8
Gastroduodenal ulcer	140 (109)	0.8	158 (105)	1.0	219 (141)	1.0	438 (198)	1.5
Other digestive disease	451 (170)	2.7	343 (163)	2.2	633 (173)	3.0	687 (217)	2.3
Certain infectious and parasitic diseases	130 (91)	0.8	101 (69)	0.6	212 (85)	1.0	248 (78)	0.8
Tuberculosis	82 (58)	0.5	53 (39)	0.3	142 (59)	0.7	125 (41)	0.4**
Other infectious disease	48 (33)	0.3	48 (30)	0.3	70 (26)	0.3	123 (37)	0.4
Neoplasms	211 (89)	1.3	244 (86)	1.6	709 (204)	3.3	1264 (304)	4.3**
Malnutrition	145 (65)	0.9	111 (60)	0.7	218 (50)	1.0	343 (72)	1.2
Other diseases	593 (248)	3.6	669 (355)	4.3*	767 (150)	3.6	1321 (216)	4.4*
Accident								
Hypothermia	57 (48)	0.3	53 (48)	0.3	71 (61)	0.3	88 (76)	0.3
Blunt force injury	388 (87)	2.3	330 (94)	2.1	512 (136)	2.4	740 (221)	2.5
Traffic injury	897 (71)	5.4	534 (54)	3.4	469 (45)	2.2	359 (43)	1.2
Heatstroke	23 (19)	0.1	51 (38)	0.3**	11 (5)	0.1	112 (45)	0.4**
Other external causes	559 (357)	3.4	485 (360)	3.1	904 (308)	4.2	1110 (438)	3.7**

Parentheses indicate the number of autopsied cases.
% Indicate the proportion of each cause of death to the total number of deaths in Table 1a.
* $P < 0.05$.
** $P < 0.01$ (both among total cases and among autopsied cases).

Age distribution slightly shifted to older cases in 2005–2010 compared to 1999–2004, both in homeless deceased and in non-homeless deceased (Fig. 2a and b).

3.2. Change in the manner and cause of death among homeless persons and non-homeless persons during 1999–2010

Regarding manner of death of non-homeless persons, the proportion of death from disease tended to increase and the proportions of death by accidents and suicide tended to decrease among those in 2005–2010 compared with those in 1999–2004 (Table 1a). Though such tendencies were not observed in homeless persons, the "unknown" category tended to be higher among those in 2005–2010 compared with those in 1999–2004 (especially under 60), similar to non-homeless persons (Table 1b). As most of the deceased certified as having an unknown manner of death showed severe decomposition due to delay of detection, we compared the proportion of the deceased with longer postmortem periods (above 7 days) for all cases between before 2004 and after 2004. Interestingly, a higher proportion of the deceased with longer postmortem periods was observed in 2005–2010, both among non-homeless and homeless persons (non-homeless: 10.8% in 1999–2004, 12.8% in 2005–2010; $P < 0.01$. homeless: 5.1% in 1999–2004, 7.2% in 2005–2010; $P < 0.05$).

Regarding specific causes of death among non-homeless persons, there were total 9 items (specific causes of death) those were considered to be statistically significant. A higher proportion of death due to heatstroke was observed both under and over 60 years old in 2005–2010 (Table 2a). Regarding homeless persons, there were less items (4 specific causes of death) compared to those among non-homeless persons. Death due to heatstroke tended to be higher among cases in 2005–2010 under 60 years old, similar to non-homeless persons (Table 2b).

3.3. Comparison of manner/cause of death between homeless persons and non-homeless persons

Regarding manner of death, a higher proportion of accidental death and a lower proportion of suicidal death were observed among homeless persons, both in 1999–2004 and 2005–2010 (Table 3a). Regarding specific cause of death from disease, whereas a proportion of death from circulatory disease was lower than

Table 2b
Comparison of the major causes of death for homeless persons between the two groups (cases in1999–2004 and in 2005–2010) according to age groups.

	Age <60				Age ⩾60			
	1999–2004	%	2005–2010	%	1999–2004	%	2005–2010	%
Disease								
Circulatory disease	150 (100)	22.3	112 (70)	24.5	276 (130)	35.3	332 (129)	35.7
Ischemic heart disease	64 (45)	9.5	52 (31)	11.4	167 (78)	21.4	207 (65)	22.2
Cerebrovascular disease	38 (16)	5.7	36 (21)	7.9	50 (20)	6.4	61 (20)	6.6
Other circulatory disease	48 (39)	7.1	24 (18)	5.2	59 (32)	7.6	64 (44)	6.9
Respiratory disease	63 (50)	9.4	32 (29)	7.0	74 (57)	9.5	80 (48)	8.6
Influenza and pneumonia	53 (42)	7.9	25 (24)	5.5	59 (47)	7.6	60 (40)	6.4
Other respiratory disease	10 (8)	1.5	7 (5)	1.5	15 (10)	1.9	20 (8)	2.1
Digestive disease	157 (103)	23.4	76 (51)	16.6**	115 (70)	14.7	116 (63)	12.5
Alcohol-related digestive disease	88 (57)	13.1	35 (21)	7.6**	40 (18)	5.1	37 (12)	4.0
Gastroduodenal ulcer	37 (33)	5.5	22 (17)	4.8	32 (29)	4.1	47 (39)	5.0
Other digestive disease	32 (13)	4.8	19 (13)	4.1	43 (23)	5.5	32 (12)	3.4*
Certain infectious and parasitic diseases	29 (23)	4.3	23 (20)	5.0	27 (17)	3.5	24 (15)	2.6
Tuberculosis	27 (22)	4.0	20 (18)	4.4	21 (13)	2.7	18 (13)	1.9
Other infectious disease	2 (1)	0.3	3 (2)	0.7	6 (4)	0.8	6 (2)	0.6
Neoplasms	17 (15)	2.5	14 (12)	3.1	41 (24)	5.2	59 (41)	6.3
Malnutrition	29 (12)	4.3	15 (11)	3.3	22 (11)	2.8	28 (16)	3.0
Other diseases	13 (5)	1.9	20 (9)	4.4	31 (14)	4.0	37 (18)	4.0
Accident								
Hypothermia	53 (43)	7.9	47.(43)	10.2	63 (49)	8.1	79 (66)	8.5
Blunt force injury	16 (9)	2.4	7 (3)	1.5	18 (8)	2.3	27 (7)	2.9
Traffic injury	8 (0)	1.2	4 (0)	0.9	16 (3)	2.0	11 (1)	1.2
Heatstroke	1 (1)	0.1	9 (7)	2.0**	6 (3)	0.8	15 (12)	1.6
Other external causes	34 (16)	5.1	16 (11)	3.5	27 (17)	3.5	20 (10)	2.1

Parentheses indicate the number of autopsied cases.
% Indicate the proportion of each cause of death to the total number of deaths in Table 1b.
* $P < 0.05$.
** $P < 0.01$ (both among total cases and among autopsied cases).

Table 3a
Comparison of manner of death between homeless persons and non-homeless persons.

	1999–2004				2005–2010			
	Control	%	Homeless	%	Control	%	Homeless	%
Disease	24,354 (7574)	64.1	1044 (631)	71.9**	31,036 (7708)	68.4	968 (532)	69.7
Accident	3891 (1137)	10.2	242 (149)	16.7**	3862 (1417)	8.5	235 (160)	16.9**
Suicide	7977 (221)	21.0	92 (1)	6.3**	7671 (262)	16.9	93 (3)	6.7**
Undetermined external cause	743 (497)	2.0	30 (24)	2.1	739 (539)	1.6	31 (23)	2.2
Unknown	1051 (532)	2.8	45 (21)	3.1	2051 (577)	4.5	62 (14)	4.5
Total	38,016 (9961)	100	1453 (826)	100	45,359 (10,503)	100	1389 (732)	100

Parentheses indicate the number of autopsied case.
% Indicate the proportion of each manner of death to total number of deaths in each group.
* $P < 0.01$.

non-homeless persons, higher proportions of respiratory disease, digestive disease, infectious disease, neoplasms and malnutrition were observed among homeless persons. Regarding death by accident, whereas death by traffic accident was lower than non-homeless persons, higher proportions of death by hypothermia (in both periods) and heatstroke (in 2005–2010) were observed among homeless persons (Table 3b). When we divided cases into two age groups (under 60 and above 60 years) and compared the manners/causes of death between homeless and non-homeless persons before 2004 and those after 2004, similar results were also observed (data not shown).

3.4. The manner and cause of death among medicolegal deaths of homeless persons during 1999–2010 according to age

We further examined the manner and cause of death of all homeless deceased during the study period according to more detailed age groups (i.e., ⩽49, 50–59, 60–69, and ⩾70). The proportion of death from disease was higher in older individuals ($P < 0.01$), whereas the proportion of death by suicide was higher in younger cases ($P < 0.01$) (Table 4a). Among suicides, we found that 24 cases (13.0%) had psychiatric disorders, such as depression and schizophrenia, in their past histories.

Subclassification of death from disease showed higher proportions of circulatory diseases and neoplasms in older cases and a higher proportion of digestive diseases and "certain infectious and parasitic diseases" in younger cases (Table 4b). Alcohol-related digestive diseases comprised 66.7% of digestive diseases among cases under 50 years old. The vast majority of death from "certain infectious and parasitic diseases" was comprised of pulmonary tuberculosis cases. Death by hypothermia was a leading cause of accidental death (about 50% of total accidental death). No significant differences according to age were observed in terms of major causes of accidental death, such as hypothermia or blunt force injury.

4. Discussion

In 2003 and 2008, the Ministry of Health, Labour and Welfare published "A fundamental policy for supporting self-reliance of the homeless" [7,12]. Those policies mentioned pulmonary tuberculosis should be adequately treated and prevented disease among

Table 3b
Comparison of the major causes of death between homeless persons and non-homeless persons.

	1999–2004				2005–2010			
	Control	%	Homeless	%	Control	%	Homeless	%
Disease								
Circulatory disease	16,240 (4797)	42.7	426 (230)	29.3**	20,722 (4662)	45.7	444 (199)	32.0**
Ischemic heart disease	10,625 (2555)	27.9	231 (123)	15.9**	13,656 (2320)	30.1	259 (96)	18.6**
Cerebrovascular disease	2693 (790)	7.1	88 (36)	6.1	3370 (860)	7.4	97 (41)	7.0
Other circulatory disease	2922 (1452)	7.7	107 (71)	7.4	3696 (1482)	8.1	88 (62)	6.3*
Respiratory disease	1750 (690)	4.6	137 (107)	9.4**	2244 (673)	4.9	112 (77)	8.1**
Influenza and pneumonia	1044 (447)	2.7	112 (89)	7.7**	1148 (416)	2.5	85 (64)	6.1**
Other respiratory disease	706 (243)	1.9	25 (18)	1.7	1096 (257)	2.4	27 (13)	1.9
Digestive disease	3379 (1105)	8.9	272 (173)	18.7**	3769 (1133)	8.3	192 (114)	13.8**
Alcohol-related digestive disease	1936 (512)	5.1	128 (75)	8.8%**	2143 (450)	4.7	72 (33)	5.2
Gastroduodenal ulcer	359 (250)	0.9	69 (62)	4.7**	596 (303)	1.3	69 (56)	5.0**
Other digestive disease	1084 (343)	2.9	75 (36)	5.2	1030 (380)	2.3	51 (25)	3.7
Certain infectious and parasitic diseases	342 (176)	0.9	56 (40)	3.9**	349 (147)	0.8	47 (35)	3.4**
Tuberculosis	224 (117)	0.6	48 (35)	3.3**	178 (80)	0.4	38 (31)	2.7**
Other infectious disease	118 (59)	0.3	8 (5)	0.6	171 (67)	0.4	9 (4)	0.6
Neoplasms	920 (293)	2.4	58 (39)	4.0**	1508 (390)	3.3	73 (53)	5.3**
Malnutrition	363 (115)	1.0	51 (23)	3.5**	454 (132)	1.0	43 (27)	3.1**
Other diseases	1360 (398)	3.6	44 (19)	3.0	1990 (571)	4.4	57 (27)	4.1
Accident								
Hypothermia	128 (109)	0.3	116 (92)	8.0**	141 (124)	0.3	126 (109)	9.1**
Blunt force injury	900 (223)	2.4	34 (17)	2.3	1070 (315)	2.4	34 (10)	2.4
Traffic injury	1366 (116)	3.6	24 (3)	1.7*	893 (97)	2.0	15 (1)	1.1*
Heatstroke	34 (24)	0.1	7 (4)	0.5	163 (83)	0.4	24 (19)	1.7**
Other external causes	1463 (665)	3.8	55 (33)	3.8	1595 (798)	3.5	36 (21)	2.6

Parentheses indicate the number of autopsied case.
% indicate the proportion of each cause of death to total number of deaths in Table 3a.
** $P < 0.01$.
* $P < 0.05$ (both among total cases and among autopsied cases).

Table 4a
Manner of death for all homeless persons (during 1999–2010) according to age groups.

	Total cases	%	Age group							
			≤49	%	50–59	%	60–69	%	≥70	%
Disease	2012 (1163)	70.8	166 (118)	59.9	584 (392)	68.5	793 (462)	71.8	469 (191)	77.3**
Accident	477 (309)	16.8	35 (29)	12.6	160 (104)	18.8	184 (122)	16.7	98 (54)	16.1
Suicide	185 (4)	6.5	40 (1)	14.4	67 (1)	7.9	62 (1)	5.6	16 (1)	2.6**
Undetermined external cause	61 (47)	2.1	12 (11)	4.3	14 (11)	1.6	24 (16)	2.2	11 (9)	1.8
Unknown	107 (35)	3.8	24 (6)	8.7	28 (8)	3.3	42 (19)	3.8	13 (2)	2.1**
Total	2842 (1558)	100	277 (165)	100	853 (516)	100	1105 (620)	100	607 (257)	100

Parentheses indicate the proportion of each manner of death to the total number of deaths in each group.
** $P < 0.01$.

homeless persons, which appears to be reasonable because a high prevalence of tuberculosis among homeless people was reported [13]. However, no specific diseases other than tuberculosis were mentioned in those policies. Thus, we designed this study in order to clarify the nature of critical health problems among homeless people by investigating recent trends in medicolegal deaths of homeless persons.

The results of this study showed higher age distribution and higher proportion of deceased persons with longer postmortem intervals in recent years both among non-homeless and homeless deceased. Japan is now facing a rapidly aging society, and the latest national survey also indicated aging among homeless [8]. In addition, a decrease in total number of homeless persons might indicate isolation of residual homeless persons. Aging and isolation might be strongly associated with an increased/unchanged number of medicolegal death of non-homeless/homeless persons in recent years.

From the results of the analysis of manner/causes of death, manner/causes of death of homeless persons in Japan seemed not to change significantly over time. Death from disease constituted 70.8% of all cases of homeless persons, and causes of death from disease were more various than those of non-homeless deceased, which might reflect various background of homeless persons, such as malnutrition, alcohol-dependence, immune-compromised host. Though a proportion of death from circulatory disease was lower among homeless persons than non-homeless persons, analysis of cause of death according to detailed age classification revealed a higher proportion of death from circulatory disease in older cases. During medical checkups organized in 2003 for 917 homeless persons aged 55 years and above in Osaka City, the proportion of persons who were diagnosed as "requiring treatment" or "requiring detailed examination" for blood pressure was 35.2%, about four times higher than in general population [14]. Several factors, such as heavy alcohol intake and chronic psychological stress caused by homeless life, might increase the risk of hypertension, resulting in death from circulatory disease [15,16]. As the aging of the homeless and the longer periods being spent in a homeless state were

Table 4b
Causes of death for homeless persons according to form of disease according to age groups (during 1999–2010).

	Total case	%	Age group							
			≤49	%	50–59	%	60–69	%	≥70	%
Circulatory disease	870 (429)	30.6	48 (32)	17.3	214 (138)	25.1	340 (174)	30.8	268 (85)	44.2**
Ischemic heart disease	490 (219)	17.2	16 (11)	5.8	100 (65)	11.7	195 (94)	17.6	179 (49)	29.5**
Cerebrovascular disease	185 (77)	6.5	16 (9)	5.8	58 (28)	6.8	68 (28)	6.2	43 (12)	7.1
Other circulatory disease	195 (133)	6.9	16 (12)	5.8	56 (45)	6.6	77 (52)	7.0	46 (24)	7.6
Respiratory disease	249 (184)	8.8	17 (16)	6.1	78 (63)	9.1	106 (73)	9.6	48 (32)	7.9
Influenza and pneumonia	197 (153)	6.9	15 (14)	5.4	63 (52)	7.4	83 (62)	7.5	36 (25)	5.9
Other respiratory disease	52 (31)	1.8	2 (2)	0.7	15 (11)	1.8	23 (11)	2.1	12 (7)	2.0
Digestive disease	464 (287)	16.3	57 (39)	20.6	176 (115)	20.6	171 (106)	15.5	60 (27)	9.9**
Alcohol-related digestive disease	200 (108)	7.0	38 (29)	13.7	85 (49)	10.0	62 (29)	5.6	15 (1)	2.5**
Gastroduodenal ulcer	138 (118)	4.9	6 (4)	2.2	53 (46)	6.2	56 (49)	5.1	23 (19)	3.8
Other digestive disease	126 (61)	4.4	13 (6)	4.7	32 (3)	3.8	53 (28)	4.8	22 (7)	3.6
Certain infectious and parasitic diseases	103 (75)	3.6	21 (16)	7.6	31 (27)	3.6	38 (26)	3.4	13 (6)	2.1**
Tuberculosis	87 (66)	3.1	20 (16)	7.2	27 (24)	3.2	28 (20)	2.5	12 (6)	2.0**
Other infectious disease	16 (9)	0.6	1 (0)	0.4	4 (3)	0.5	10 (6)	0.9	1 (0)	0.2
Neoplasms	131 (92)	4.6	3 (2)	1.1	28 (25)	3.3	63 (40)	5.7	37 (25)	6.1**
Malnutrition	94 (50)	3.3	11 (8)	4.0	33 (15)	3.9	31 (19)	2.8	19 (8)	3.1
Others	101 (46)	3.6	9 (5)	3.2	24 (9)	2.8	44 (24)	4.0	24 (8)	4.0
Total death from disease	2012 (1163)	70.8	166 (118)	59.9	584 (392)	68.5	793 (462)	71.8	469 (191)	77.3

Parentheses indicate the number of autopsied cases.
% Indicate the proportion of each cause of death to the total number of deaths in Table 4a.
** $P < 0.01$ (both among total cases and among autopsied cases).

indicated in the latest national survey [8], much emphasis needs to be placed on measures to address hypertension (circulatory disease), especially for older homeless persons. On the other hand, the proportion of death from digestive disease and infectious disease were higher among younger homeless persons, and alcohol-related digestive disease and tuberculosis constituted a substantial portion of each disease in younger homeless persons. According to these results, measures to address alcohol abuse and tuberculosis require attention, especially for younger homeless persons.

Accidental death among homeless persons was more frequent than those of non-homeless persons, and did not decrease among homeless persons in recent years, in contrast to that of non-homeless persons. Hypothermia is a leading cause of accidental death irrespective of age group, and the majority of the cases were found outdoors in the winter season. Our study also showed tendency of recent increase in death by heatstroke among homeless persons. Although the number of temporary shelters for homeless people has increased in Tokyo Metropolis, the latest survey showed that the shelters were not always occupied sufficiently [17]. Thorough spread of information about shelters and patrols for isolated homeless people, not only in the winter season, but in the summer season may be preventive against such deaths.

The proportion of death by suicide among homeless persons was lower than that of non-homeless persons, however, the proportion of suicide slightly increased in recent years, and was significantly higher in younger homeless persons. Homeless people appear to have higher rates of mental illness compared to the domiciled [18,19]. A recent survey conducted in one area of Tokyo showed that 62.5% of homeless persons had psychiatric disorders and 57.0% of homeless persons were at risk of committing suicide [20]. Although our data did not reveal a close relationship between suicide and having a psychiatric disorder, which might be attributable to undiagnosed cases or limited information, further detailed analysis to detect a cause of suicide is needed, especially for younger homeless in the future.

5. Conclusions

Although Japan has succeeded in reducing the total number of homeless persons, aging and isolation among homeless persons in recent years might contribute to an unchanged number of medicolgal death of them. In addition to measures for frequent causes of death in each age group clarified in this study, better intervention for isolated homeless persons might be a key factor in the future.

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Case Report

An autopsy case of a homeless person with unilateral lower extremity edema

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ABSTRACT

We present an autopsy case of a homeless person showing remarkable unilateral lower extremity edema, which was strongly associated with the cause of death. A 55-year-old homeless man without any past medical history was found dead in a flophouse. External examination showed evidence of malnourishment and remarkable swelling of the right, lower extremity. Putrefactive discoloration in the same area was evident at the time of autopsy (approximately 30 h post-mortem). The autopsy revealed focal pneumonia in the right lower lobe, dehydration and chronic pancreatitis. Dissection of the edematous extremity revealed massive abscess formation in the subcutaneous tissue and superficial fascia around the right knee joint. Histopathological findings were compatible with necrotizing fasciitis and blood chemistry results showed an elevation of HbA1c (6.3%). The cause of death is considered to be necrotizing fasciitis and secondary pneumonia/dehydration. This case suggests that necrotizing fasciitis should be differentiated during post-mortem diagnosis, especially in cases showing lower extremity edema with early putrefactive changes. In addition, forensic pathologists should closely examine a lower extremity of such cases to detect a true cause of death, even if other pathological findings which can be a cause of death, such as pneumonia and dehydration, are observed in major internal organs.

1. Introduction

Medical examiners often encounter deceased individuals with bilateral lower extremity edema at inquest scenes. Bilateral lower extremity edema, which is usually a manifestation of generalized edema, and failure of vital organs (e.g., heart, liver, kidney) are commonly listed as causes of edema in the whole body [1]. Thus, if a decedent with bilateral, lower extremity edema also shows signs of illness, such as congestive heart failure or liver cirrhosis, medical examiners justifiably suspect that the cause of death may have resulted from the progress of the illness.

A decedent with unilateral, lower extremity edema is, on the other hand, less frequently encountered. Unilateral lower extremity edema is generally caused by regional problems (e.g., regional obstruction of venous or lymphatic flow, trauma) [1]. This increases the difficulty of judging whether the cause of edema was associated with the cause of death, based only on the external investigation. Here, we present an autopsy case showing remarkable unilateral, lower extremity edema and early putrefactive changes. In this case, the autopsy revealed a strong association of the edematous extremity with the cause of death, deep soft tissue infection (necrotizing fasciitis).

2. Case report

A 55-year-old man was found dead on a bed in a flophouse. He had lived on the streets for a long time, and came to the flophouse 2 weeks before his death. Seven days before his death, he requested a cold patch; however, there was no evidence as to how it was used. The individual complained of appetite loss on the day before his death, but he did not consult a doctor. An external examination performed approximately 12 h after his death, did not reveal any open injuries, but did reveal remarkable right, lower extremity edema with slight purple-green discoloration (Fig. 1a). No past or present diseases were evident that involved right, lower extremity edema, which may have suggested the cause of death.

A forensic autopsy was carried out about 30 h after his death. The decedent was 160 cm tall and weighed 41 kg (body mass index of 16.0). Upon autopsy, greenish, putrefactive discoloration was prominent in the right, lower extremity (Fig. 1b). Upon dissection of the body, moistness in the serous membrane of the thoracic/abdominal cavity was disappeared, and right lower lung was slightly indurated. Other macroscopic findings of internal organs included an atrophic, indurated pancreas and a muddy discoloration in the red pulp of the spleen. Dissection of the discolored skin of right lower extremity disclosed the absence of a fracture, but did reveal the presence of a massive abscess in the subcutaneous tissue and superficial fascia, mainly around the right knee joint (Fig. 2). The underlying muscle did not appear to be extensively involved. Abscess formation was not observed in the

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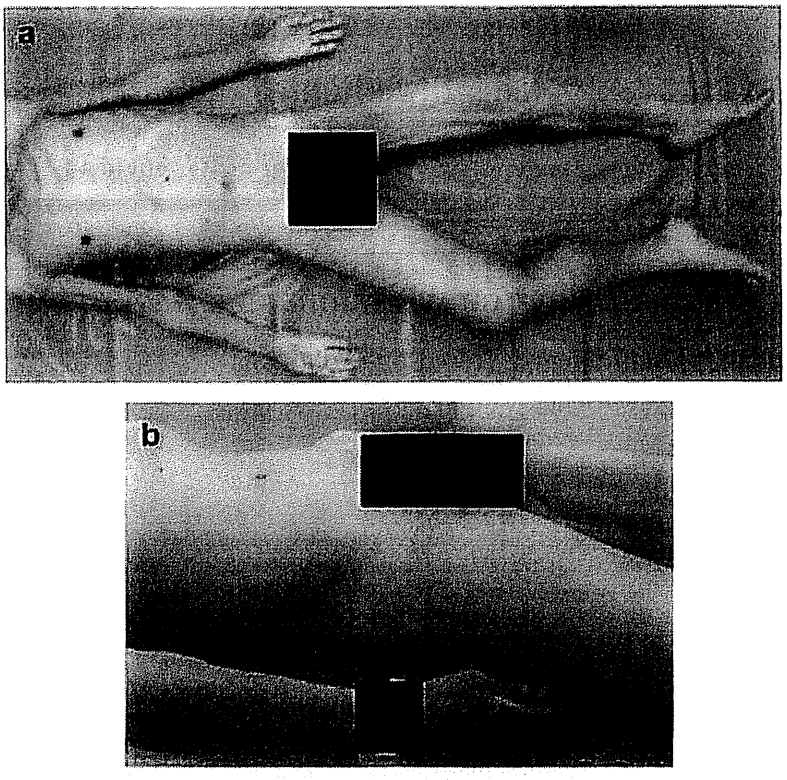

Fig. 1. Appearance of the decedent. (a) Remarkable right lower extremity edema with slight purple-green discoloration (approximately 12 h after death). (b) Putrefactive change was prominent in the right lower extremity at autopsy (approximately 30 h after death).

Fig. 2. Macroscopic findings of the right lower extremity. Dissection of the skin of the right lower extremity disclosed massive abscess formation in the subcutaneous tissue and superficial fascia, mainly around the knee joint.

pelvic space or around the rectum, and thrombi were not observed in the right external iliac artery or vein. Microscopic examination showed plentiful neutrophil infiltration in the subcutaneous tissue around the right knee and the perimysium of the right vastus lateralis muscle (Fig. 3a and b); some of the muscle cells were necrotic (Fig. 3b). Thrombi were seen in several micro-vessels in the subcutaneous tissue. Acinar atrophy, dilation of ducts and fibrosis were observed in the pancreas. Other findings included patchy neutrophil infiltrations in the right lower lung, acute tubular necrosis in the kidney and an increased number of plasma cells and macrophages in the red pulp of the spleen. No pathological findings relevant to cause of death were observed in other internal organs. Blood chemistry results showed an elevation of acetone (5.7 μg/mL) and HbA1c (6.3%) levels. *Escherichia coli* were cultured from the abscess. Any drugs were not detected from blood and gastric content by toxicological analysis. From the autopsy findings, the

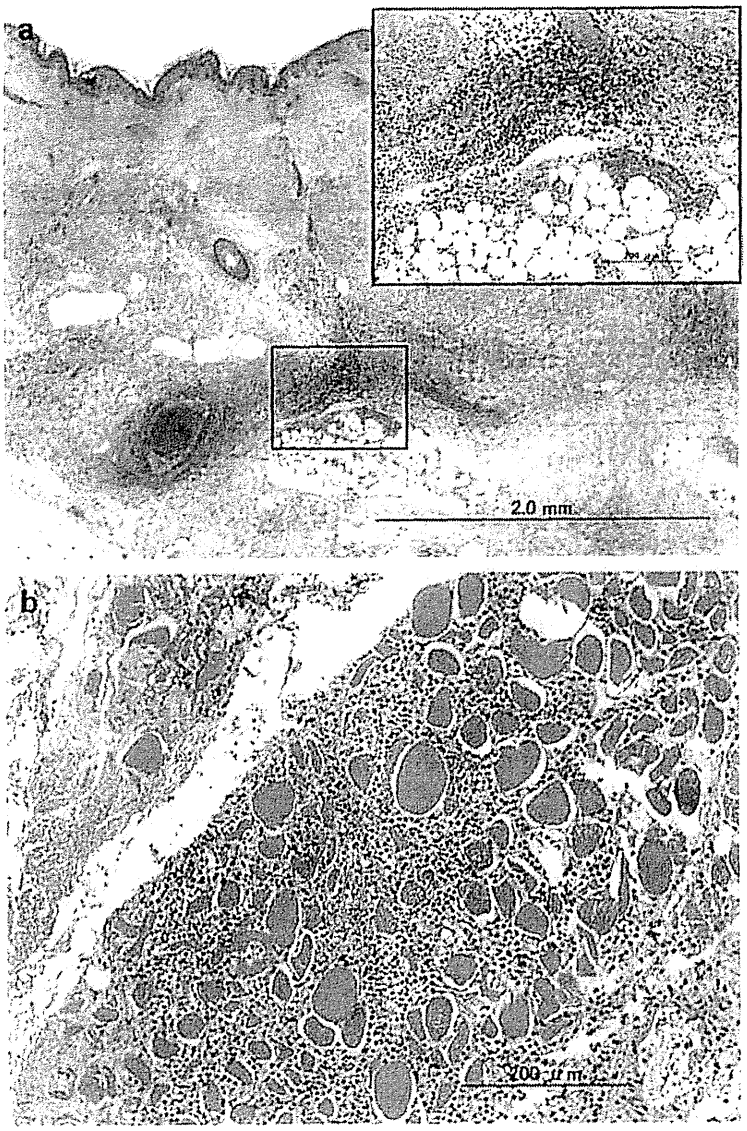

Fig. 3. Microscopic findings of the skin and muscle of the right lower extremity. (a) Plentiful neutrophil infiltration in the subcutaneous tissue. Inset: high magnification of the indicated space. (b) Neutrophil infiltration in the perimysium of the right vastus lateralis muscle. Some of the muscle cells were necrotic.

cause of death in the present case was thought to be necrotizing fasciitis, and secondary dehydration and pneumonia.

3. Discussion

Necrotizing fasciitis is a rare, soft tissue infection characterized by widespread fascial necrosis with relative sparing of the underlying muscle [2]. It involves the subcutaneous tissue and superficial fascia in a dissecting suppurative process [3]. In 1979 six diagnostic criteria were presented by Fisher [4] (Table 1), and the differential diagnosis of necrotizing fasciitis include bacterial synergistic gangrene, erysipelas and gas gangrene [3] (Table 2). Though several ante-mortem clinical information (e.g., reduced mental status) were unknown, the pathological findings of this case, particularly the site of inflammation/necrosis (subcutaneous tissue and superficial fascia), are compatible with necrotizing fasciitis. The other diseases differentiated can be ruled out by lack of wounds, bordered erythematous lesion and deep muscular lesion.

Necrotizing fasciitis is frequently associated with severe systemic toxicity. As a result, this type of tissue infection is usually rapidly fatal, unless recognized quickly and treated aggressively [2,3]. Host factors, such as diabetes mellitus (DM), protein-calorie malnutrition, hypoglobulinemia, and intravenous drug use are reported to be risk factors associated with necrotizing fasciitis [3]. DM impairs immune functions, such as phagocytosis, cell chemotaxis, delayed hypersensitivity skin tests, and lymphoproliferative response to mitogens [5–7]. Protein energy malnutrition is a common cause of secondary immune deficiency and susceptibility to infections [8]. DM resulting from chronic pancreatitis and malnutrition in this case is likely to have played crucial roles in the decedent's susceptibility to this infection.

The initiating factor for necrotizing fasciitis has been reported to be skin trauma (sometimes trivial) or an occult, enteric source of bacteria, such as a diverticular or an appendiceal abscess, but the initiating event often remains obscure [9,10]. Although the initiating factor in the present case was not evident, the lower extremities and perineal areas of homeless persons are generally not sanitary because of long periods of street life. In addition,

Table 1
Diagnostic criteria for necrotizing fasciitis (Fisher [4]).

1. Extensive necrosis of the fascia with extension to the overlying skin
2. Moderate to severe systemic intoxication with reduced mental status
3. Lack of primary muscle involvement
4. No evidence of clostridial infection in microbiological culture
5. No evidence of large vessel occlusion as the causative mechanism
6. Infiltration of leucocytes, local necrosis of the fascia and the surrounding tissue as well as microvascular thrombosis on histological examination

Table 2
Differential diagnosis of necrotizing fasciitis (Ref. [3]).

1. *Bacterial synergistic gangrene (Meleney's ulcer):* Usually seen postoperatively and located around drains or retention sutures
2. *Erysipelas:* Characterized by an erythematous area with sharply defined borders, induration, and marked pain
3. *Gas gangrene:* A deep infection usually found in contaminated wounds. It involves muscle as well as subcutaneous tissue

various factors common among homeless persons, such as alcohol abuse [11,12] and poverty may lead to alcohol-related liver and pancreatic diseases as well as malnutrition, all of which may result in compromised immunity, as was observed in this case. Thus, physicians should be aware of this disease in daily practice, especially when they see lower extremity edema in a homeless person.

An early putrefactive change, affecting the lower extremity, was a characteristic finding in this case. Massive numbers of bacteria at the affected site may have promoted the early, postmortem putrefactive changes. Though several potential causes, such as deep venous thrombosis or thrombophlebitis, cancer, cellulitis, and a fractured femur, should be differentiated in cases involving unilateral lower extremity edema [1], this case suggests that necrotizing fasciitis should also receive more attention as a possible cause of edema when an edematous extremity is accompanied by an early putrefactive change. In addition, forensic pathologists should closely examine a lower extremity of such cases to detect a true cause of death, even if other pathological findings which can be a cause of death, such as pneumonia and dehydration in this case, are observed in major internal organs before dissection of an extremity.

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Case Report

Accidental death of elderly persons under the influence of chlorpheniramine

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ABSTRACT

Older individuals are susceptible to accident, such as falls, some of which are fatal. In such cases, autopsies and toxicological analysis may be deemed unnecessary, especially if the critical injuries and manner of death can be determined conclusively based on information at the scene and an external investigation. Here, we report the results of two autopsies performed on elderly individuals who died accidentally under the influence of chlorpheniramine. These autopsies revealed valuable additional information.

Case 1: A woman in her 70s, who was living alone, was found dead under the stairs in her house. She had no history of a condition that could have led to sudden death. The autopsy revealed a neck fracture, multiple rib fractures, and a coccyx fracture. The histopathological findings showed fat embolisms in numerous small vessels of the interalveolar septum. Toxicological analysis of blood samples revealed the presence of chlorpheniramine (0.41 μg/ml).

Case 2: A woman in her 70s, who was living alone, was found dead in the bathtub in her house. There was no past medical history other than diabetes mellitus and vertigo. The autopsy revealed hyperinflated lungs and brown–red fluids in the trachea, but there was no evidence of a pathology or injury that could have induced a loss of consciousness. Toxicological analysis of the fluids in the right thoracic cavity revealed the presence of chlorpheniramine (0.57 μg/ml).

In both cases, re-examination of the scene after the autopsy revealed the presence of common cold medicine containing chlorpheniramine. The victim may have accidentally overdosed on common cold medicine. This overdose would have been compounded by anti-histamine-induced drowsiness. The present cases suggest that forensic pathologists should always notify physicians/pharmacists of findings pertaining to unexpected drug side effects. Such intervention would prevent many accidental deaths. In addition, each autopsy must be performed in conjunction with a detailed postmortem investigation. Such efforts would also increase the accuracy of the public health record's mortality statistics.

1. Introduction

Older persons are susceptible to accidental deaths such as falls [1] and motor-vehicle-related injuries [2]. Among patients with stroke or Parkinson disease, health-related problems can further undermine a vestibular system that has already been weakened by age-related changes [1]. If the external investigation identifies a likely cause of death, the autopsy and toxicological analysis may be foregone for such cases. This is the case in countries such as Japan, where the death inquiry system is still in a developmental stage [3]. If an autopsy and toxicological analysis is not performed, the potential contribution of unexpected factors is ignored (e.g., alcohol intake or the recent onset of disease). Here, we report the results revealed by two autopsies performed after accidental fatalities. In combination with toxicological analysis, the information obtained suggests that both individuals died under the influence of a chlorpheniramine overdose.

2. Case report

2.1. Case 1

A woman in her 70s, who was living alone, was found dead under the stairs in her house. She had undergone operations for bilateral femoral neck fractures and walked with difficulty, but there was no history of a condition that could have led to sudden death (e.g., ischemic heart disease). External examination of the deceased revealed bilateral bruises in the orbital area as well as bruises on the right cheek, the right shoulder, the right forearm, the upper back of the trunk, and the backs of both hip joints (Fig. 1a). A contusion was noted on the right forearm.

A forensic autopsy was carried out approximately 48 h after her death. The deceased was 147 cm tall and weighed 30 kg. The autopsy revealed a neck fracture (C7) (Fig. 1b), multiple rib fractures (right ribs 4–7, in the anterior axillary line), and a coccyx fracture.

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