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Announcement of Population Data

Analysis on unidentified cases in which dental information was collected from 2014 to 2019 in Miyagi Prefecture, Japan

Moe Kosaka [a], Yuka Hatano [a,b], Kie Yoshida [a], Khongorzul Tsogtsaikhan [d], Isuruni Kuruppuarachchige [a], Toshihiko Suzuki [a,c,*]

[a] Division of Dental and Digital Forensics, Graduate School of Dentistry, Tohoku University, 4-1, Seiryo-machi, Aoba-ku, Sendai 980-8575, Japan
[b] Creative Interdisciplinary Research Division, Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, Aramaki aza Aoba 6-3, Aoba-ku, Sendai 980-8578, Japan
[c] International Research Institute of Disaster Science, Tohoku University, Aramaki aza Aoba 468-1, Aoba-ku, Sendai 980-8572, Japan
[d] Department of Operative Dentistry, School of Dentistry, Mongolian National University of Medical Sciences, S.Zorig street, Ulaanbaatar 14210, Mongolia

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ABSTRACT

This study aimed to summarize the characteristics of unidentified cases in which dental information was collected during 2014–2019 in Miyagi Prefecture and to discuss the challenges and social characteristics of dental identification in routine forensic work. Cases were selected and examined from the database of dental charts collected at Tohoku University and the database of the Miyagi Prefectural Police. The annual percentage of cases with matched dental findings ranged from 19.2 − 37.1%, and 80.6% of the cases were identified within four days using dental information. The most common age group was the 50–70 s. Males were more common in the 20–70 s, whereas females were more frequent in the 80–90 s age group. Utilization of dental information was lower for cases involving young people and those over 90 years of age. The number of unidentified cases and unspecified death cases in the central block was significantly higher than other regions. However, there were no significant differences in sex, age, and season between each region. Spearman's rank-order analysis of the unspecified deaths showed a strong correlation with the monthly average temperature ($\rho = 0.89$, $p < 0.01$).

Within the limitations of this study, the results provide valuable information on the long-term progress of routine dental identification work and could be useful as a reference for a statistical survey. Future research must examine the role of dental information in forensic identification by exploring the role of more specific background characteristics among autopsy cases.

1. Introduction

Dental information has played a key role as one of the primary characteristics supporting positive victim identification in recent years [1–6]. Types of cases that require dental information for identification are essentially unidentified cadavers that are decomposed, charred, and skeletonized, which make it difficult to identify the person. So many reports of Disaster Victim Identification (DVI) have been presented from every part of the world [7–13], and practical proposals of DVI protocols have been established based on past disasters, accidents, and crime cases [14–18]. Furthermore, several reports have contributed to the improvement of forensic odontology, including the investigation of oral identifiers [19–23], utilization of computed tomography [24] or flat panel X-ray detectors [25], age estimation using the tooth/pulp ratio [26–27], racemization of aspartic acid in teeth [28], development of dental identification systems [29], and questionnaire surveys [30]. These beneficial reports lead to the development of standard practices used for routine identification.

Referring to the current situation in Japan, more forensic staff, including forensic odontologists, are needed because of the increasing number of forensic autopsies and the enactment of new laws in 2012, 2013, and 2018 regarding the cause of death and identification. However, only select odontologists are involved in dental identification, with even fewer odontologists specializing in forensic odontology. Moreover, departments of forensic odontology are limited in number and unevenly distributed throughout the country, localized mainly in urban areas.

Previous studies have reported the statistical analysis of autopsy cases [31–32] and dental identification cases in other countries [33–35],

* Corresponding author.
E-mail address: suzk@tohoku.ac.jp (T. Suzuki).

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Ichioka et al. have reported the numbers of dental identification and police dentists in the Kansai region of Japan [36]. However, no domestic or international reports have discussed detailed data regarding cases of dental identification in terms of parameters such as gender, age differences, seasonal differences, cause of death, and other background characteristics of the deceased. In other words, the actual condition of routine identification work is not well known. Therefore, it is essential to understand dental identification circumstances and share the information for practical purposes.

Since the establishment of our laboratory in 2013, dental identification has been routinely conducted in Miyagi Prefecture, the most populous prefecture in the Tohoku district, in the northern part of Japan. Additionally, Miyagi Prefecture is one of the leading regions of forensic autopsy operations in Japan owing to its two institutions of forensic medicine.

In this study, cases in which dental information was collected from unidentified individuals in the Miyagi Prefecture between 2014 and 2019 were analyzed. The aim was to summarize these cases and to understand the current situation, as well as to discuss the challenges and social significance of dental identification in Miyagi prefecture.

2. Materials and methods

2.1. Survey of unidentified cases

Cases were selected and investigated from the database of dental charts collected at Tohoku University and the database of the Miyagi Prefectural Police Department's Coroner's Office, Investigation Division 1, during the 6-year period from 2014 to 2019. Forensic autopsies in Miyagi Prefecture were performed in one forensic institution until April 2017. However, after the establishment of a new forensic department, forensic autopsies were performed in two institutions from May 2017. Approval was obtained from the Ethics Committee of Tohoku University Graduate School of Dentistry (No. 2020-3-029).

First, all the cases identified using dental information were extracted and the following items were investigated: 1) the ratio of cases identified by dental information of the annual number of unidentified cases, 2) number of dental identification cases collected in our laboratory, 3) number of days for identification, and 4) other identification methods used in addition to dental findings.

The unidentified cases for which dental information was collected were also categorized. The dental information contained information on dental charts, intraoral photographs, dentures, extracted teeth, and any descriptions of oral-related findings. The following items were investigated: 1) Sex: categorized as male, female, and unspecified. 2) Age: classified as under 10, 10 s, 20 s, 30 s, 40 s, 50 s, 60 s, 70 s, 80 s, 90 s, and unspecified. 3) Season: considering the seasonal changes in Japan, the seasons were classified as Winter: December–February, Spring: March–May, Summer: June–August, and Autumn: September–November. 4) Region: according to the data available on the official website of the Miyagi Prefectural Police [37], the region was divided into the following four blocks: coastal block, northern block, central block, and southern block (Fig. 1). 5) Cause of death: based on the Manual for Completing Death Certificates (Autopsy Forms) issued by the Ministry of Health, Labour and Welfare (2020 edition) [38], the following categories were selected: deaths from disease and natural causes; drowning; injuries from fire and flame; unspecified deaths; and others. 6) Information used for identification: the categories were as follows: use of dental findings collected in our laboratory, use of dental findings collected in other institutions, and use of other identification methods. Dental findings collected in other institutions included statements by dental examiners and medicolegal experts in Miyagi Prefecture. Other identification methods included the use of DNA testing, facial identification, personal belongings, and fingerprints.

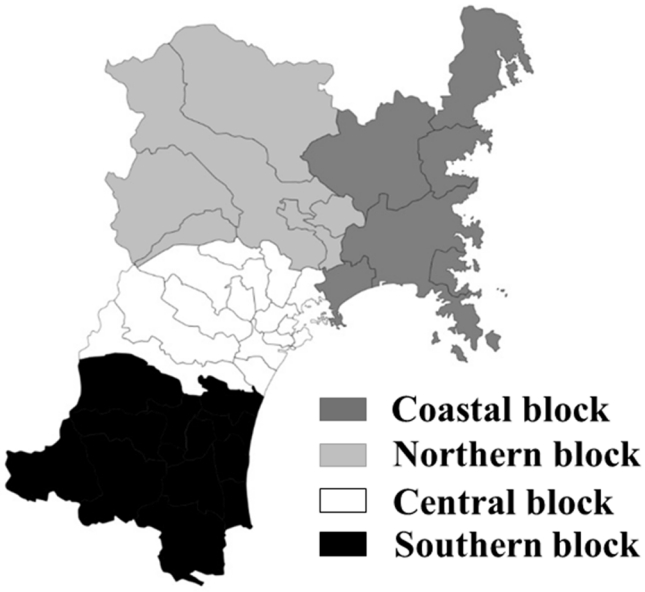

Fig. 1. Regions of Miyagi Prefecture used in this study. Miyagi Prefecture is divided into four blocks, as illustrated.

2.2. Statistical analyses

The Kruskal–Wallis test (Dann–Bonferroni correction) was used (SPSS version 23.0, IBM SPSS Statistics, Armonk, NY, USA) to determine differences among the sexes, which were stratified by age. Furthermore, the differences in the number of cases in each region were studied. The correlation between the monthly average temperature, the amount of precipitation for each region [39], and the top three causes of death were examined using Spearman's rank-order correlation coefficient.

3. Results

3.1. Unidentified cases identified by dental information

The Miyagi Prefecture police handled a total of 733 unidentified cases during the study period, and 201 of the cases had matched antemortem and postmortem dental findings. Antemortem dental findings included dental charts provided by family dentists. Postmortem dental findings included dental charts which dentists completed and dental information which medicolegal experts or police officers recorded. Antemortem and postmortem dental information was matched by forensic odontologists or the deceased's personal dentist, and cases which were considered to be the same person with a high probability were classified as "unidentified cases identified by dental information."

The annual percentage of cases with matched dental findings ranged from 19.2% to 37.1%. Our laboratory collected dental information from 33.3% of the cases in 2014; however, this percentage increased to 59.1–82.9% during 2015–2019. Regarding the days per result for identification of the cases which were identified by dental information in this survey, about 80.6% of all the cases were identified within four days. While 7% of the cases needed over 20 days for identification using dental information, and the longest case took 98 days. The cases with a long identification period were concentrated in 2014 and 2015 (71.4%). Among the 35 cases that were identified through a combination of methods, the most common method was DNA testing (23 cases). However, for 95.2% of cases, where dental findings were collected, identification was achieved solely through dental information.

3.2. Unidentified cases for which dental information was collected

3.2.1. The differences of sexes, seasons, cause of death, and utilization of dental information with age

Of the 401 cases for which dental information was collected over a 6-year period, 272 were male, 128 were female, and one was unspecified. There were no seasonal, regional, or yearly differences in sex. The most common age group ranged between the 50 s and 70 s. Regarding the age-wise sex distribution, there were more males than females in the 20 s–70 s age group; the ratio of females increased in the 80 s–90 s age group. A Kruskal–Wallis test for age in the different sexes showed significantly higher results for older females ($p < 0.05$, Fig. 2).

Comparing seasonal changes by the age group, the number of cases was highest in spring among those in the 20 s–40 s and unspecified age groups, whereas the number of cases tended to be highest in summer for those 50 years of age and older (Fig. 3). As shown in Fig. 4, cases with an unspecified cause of death were the most common in almost all the age groups; fire was the second most common cause, especially among middle-aged individuals. Drowning was the third most frequent cause of death with no peak and among many age groups, except those under 10, 10 s, and over 90. Death due to illness began to appear as a common cause of death in the 40 s and was the most frequent cause among cases in the 60 s (Fig. 4).

Regarding the association between seasonal changes and causes of death, the highest percentage of fire was reported in winter, the number of drownings marginally increased from winter to spring, and distribution patterns were similar in summer and autumn (Fig. 5). There was no large seasonal difference in the use of identification methods; the percentage of utilization of dental information remained almost constant throughout the six years (47.0–58.7%).

Of the cases where dental information was collected, the ratio of utilization of that information was over 50% between 40 s and 80 s, while it was marginally lower among young people in the 20 s and 30 s and those over 90 years of age (Fig. 6). Incidentally, the people who reported finding cadavers outdoors were fishermen, construction workers, surveying technicians, or passers-by. Indoors, the cadavers were found by neighbors, relatives (non-resident), caretakers, management company staff, water meter attendants, and civil servants.

3.2.2. Regional differences

Regional differences were examined for the 401 cases for which dental information was collected over the research period. Table 1 shows the regional background information, including the population, number of dental clinics, and number of dental examiners who cooperated with the police. There are 25 police stations in Miyagi prefecture, and one or two dental examiners are enrolled by each police station. The central block had the largest population with a slight increase from 2014 to 2019, while the other three blocks decreased a little during the research period. For the central block, the results showed a significantly higher total number of unidentified cases and the number of cases of unspecified death compared with the other three blocks (Kruskal–Wallis test, $p < 0.05$, Table 2). Besides, Table 2 shows that the ratio of cases for which dental information was collected to the total number of unidentified cases increased generally since 2015. In contrast, the ratio of cases that were identified by dental information to the total number of unidentified cases varied with the year and region, with no clear tendency.

3.2.3. Correlation between cause of death and monthly temperature in Miyagi Prefecture

The three most common causes of death in this study were unspecified, fire, and drowning. The monthly temperature data and the amount of precipitation for each region were extracted from statistical data of the Japan Meteorological Agency [39]. To examine the differences between each region, representative measurement points of two cities were selected in each region and the standard deviations (SD) were calculated for 2014–2019. The SD of the monthly temperature of each of these regional points was small, within 1.1 °C throughout the examination period in this study. Thus, the monthly temperature in Sendai city, which is the seat of the prefectural government located in the central block, was used for the statistical analysis as the representative data for Miyagi prefecture. While the amount of precipitation was generally greater in summer and autumn in every region, there were variations in each year.

According to the results of Spearman's rank-order correlation coefficient, the number of unspecified deaths revealed a strong correlation with the monthly average temperature ($\rho = 0.89$, $p < 0.01$; Fig. 7). In contrast, we did not find a correlation between the number of fires and drownings cases and the monthly temperature. Furthermore, there was no correlation between the amount of precipitation and the three main

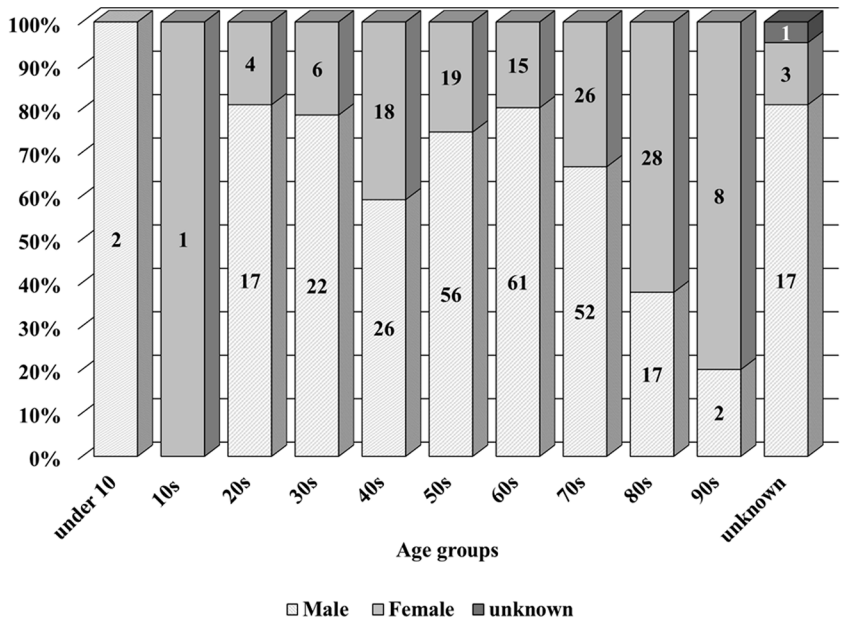

Fig. 2. Sex and the number of cases in each age group. The bar graph indicates the number of unidentified cases for which dental information was collected (n = 401).

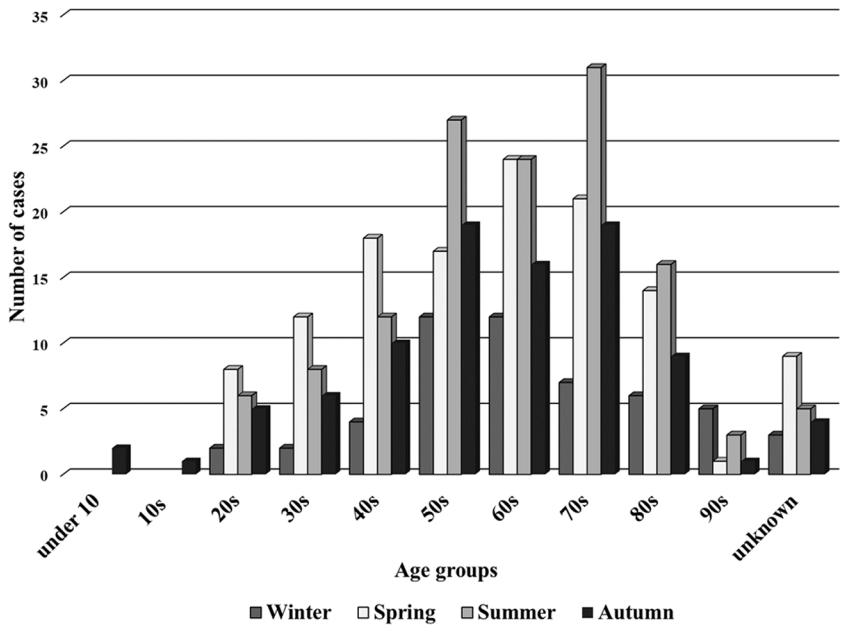

Fig. 3. Seasonal changes in each age group. The bar graph indicates the number of unidentified cases for which dental information was collected in each season (n = 401).

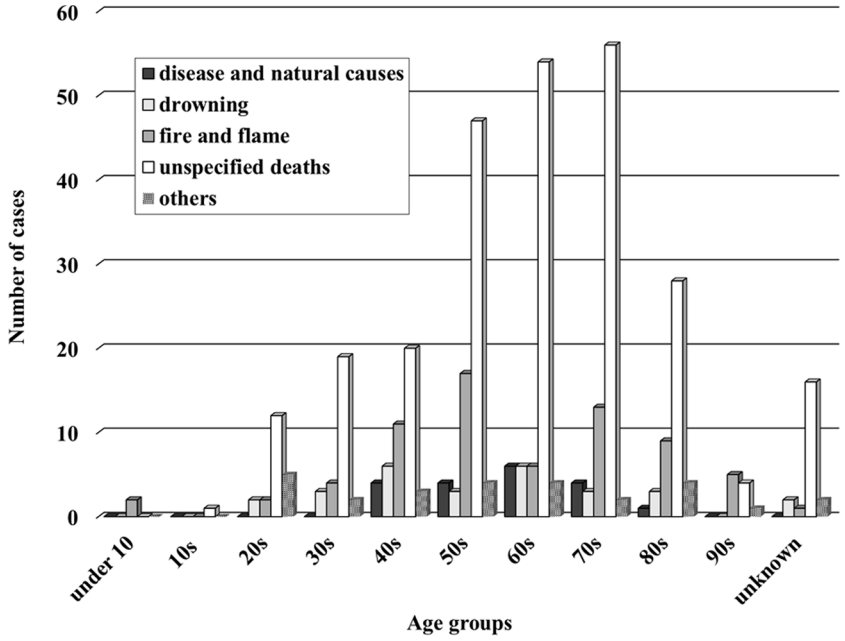

Fig. 4. Cause of death in each age group. The bar graph indicates the number of cases for each cause of death (n = 401).

causes of death.

4. Discussion

In this study, we conducted a statistical review of the cases in which dental information was collected in Miyagi Prefecture over the past six years, and the characteristics revealed in cases where dental identification may be necessary. The percentage of cases in which dental information was used for identification showed no major changes during the survey period and generally remained constant. Moreover, the annual number of cases identified based on dental information did not change significantly throughout the study period. Compared to that reported previously for the Kansai region in Japan [36], the annual rate of dental identification cases in Miyagi prefecture seemed to be somewhat higher, although a simple comparison may not be appropriate because many factors differ from region to region. Nevertheless, the rate of dental identification works were still deemed to be low.

It is expected that increasing the number of odontologists who are experienced in dental identification would provide a better environment to prepare not only for future contingencies such as natural disasters and accidents, but also daily identification work—the more detailed the collected dental information, the faster and more accurate the identification. Previous studies have also suggested that it is desirable for odontologists and not medicolegal experts to obtain dental findings whenever possible [13–14,16]. Needless to say, multidisciplinary collaboration is requisite [11–12]. Identification using DNA testing

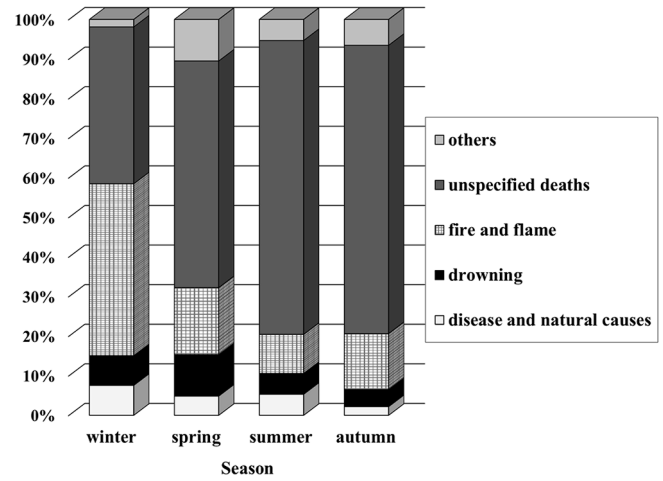

Fig. 5. Seasonal changes in association with the cause of death. The bar graph indicates the percentage of cases for each cause of death (n = 401).

generally takes approximately 7–10 days, whereas dental identification was often achieved within four days in this research period. This indicates that dental identification is a relatively rapid means of identification. For the cases which took a long time for identification, dental charts were taken, and other identification methods were performed, such as DNA analysis. Some of these cadavers were only partial bones including cranial and mandible bones. Most cases were found without their belongings or with no information about the individual or relatives. Thus, final decision for identification was judged with multiple results, leading to the extended period for personal identification.

According to the demographic data of Miyagi Prefecture [40], the ratio of males to females mostly remained constant from 2014 to 2019, with 48.9% males and 51.1% females. In contrast, the proportion of males was consistently higher (60.6–76.8%) in cases where dental information was collected, regardless of the season and region surveyed. These results were consistent with the reports of more unidentified cases of males in Japan [33]. However, there was a greater percentage of cases of females among those aged 80 years and older in this study. According to the Comprehensive Survey of Living Conditions 2019 [41], the number of one-person or two-person (couple) households have increased among those aged 65 and older. For one-person households, the age range was higher in females. This could be because the average life expectancy of females is higher than that of males. Furthermore, the proportion of cases solved by dental identification was lower for the younger and older age groups (>90 years). For the former, the low rate of dental consultation might have affected the results. However, for the latter, one possible explanation is that dental findings may have been deemed difficult to use in cases with a few remaining teeth or were edentulous. Although dentures and oral feature findings may be key for identification even in edentulous cases [18,42], this fact is not widely known. As a result, it is likely that a forensic odontologist may not be requested in such cases, or even if dental information is collected, other identification methods, such as DNA testing and fingerprints, may be used.

The number of deaths due to fire increased in winter and could be attributed to the increased use of heating appliances. Moreover, a strong correlation was found between monthly average temperature and the

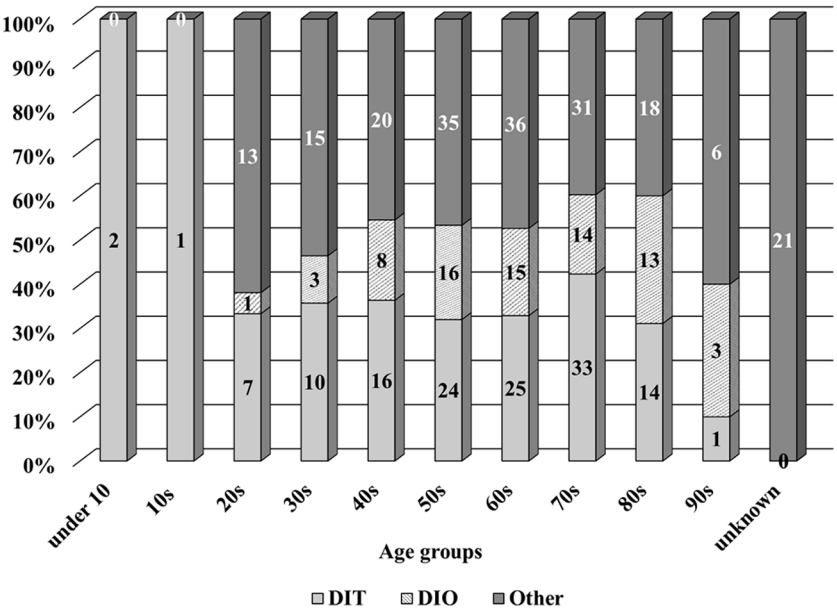

Fig. 6. Utilization of dental information for identification. The bar graph indicates the number of unidentified cases for which dental information was collected in each age group (n = 401). DIT: dental information obtained in our department. DIO: dental information obtained at another institution. Other: other identification methods. "Dental information obtained at another institution" included the Department of Forensic Medicine in our University, the Department of Forensic Medicine in other universities, and the dental clinics at which the suspected person received dental treatment. "Other identification methods" included DNA testing, facial identification, or using personal belongings and fingerprints.

Table 1
The basic information according to region.

	Population in 2014			Population in 2019			Dental conditions	
	Total	Male	Female	Total	Male	Female	No. DC	No.DE
Coastal block	355,089	172,139	182,950	336,100	164,593	171,507	135	6
Northern block	277,536	134,568	142,968	263,054	128,146	134,908	99	6
Central block	1,427,678	695,840	731,838	1,445,079	704,444	740,635	732	9
Southern block	267,690	131,334	136,356	258,927	127,914	131,013	98	5

These data were based on the database of Miyagi prefectural government and Miyagi prefecture dental association.
No. DC: Number of dental clinics.
No. DE: Number of dental examiners. There are two dental examiners in the Chuo-police station, and one in the other police stations.

Table 2
The statistical data for the four regions in Miyagi prefecture.

Coastal block						
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
D/T	35.0%	59.1%	54.5%	61.5%	68.2%	68.4%
ID/T	25.0%	13.6%	22.7%	30.8%	40.9%	10.5%
UI	20	22	22	26	22	19
US	4	6	7	8	11	8
Northern block						
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
D/T	33.3%	50.0%	77.8%	66.7%	60.0%	68.8%
ID/T	27.8%	28.6%	27.8%	50.0%	20.0%	18.8%
UI	18	14	18	12	5	16
US	2	4	8	7	2	9
Central block						
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
D/T	45.2%	54.0%	65.0%	51.2%	55.4%	51.4%
ID/T	24.7%	25.4%	26.7%	34.1%	42.2%	20.0%
UI	73	63	60	41	83	70
US	22	24	26	13	27	26
Southern block						
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
D/T	35.0%	63.2%	81.0%	40.0%	52.4%	37.0%
ID/T	25.0%	31.6%	42.9%	20.0%	19.0%	14.8%
UI	20	19	21	25	21	27
US	6	9	9	6	8	7

The ratio and total number were calculated for each region during the examination period.
D/T: The ratio of cases for which dental information was taken to the total number of unidentified cases.
ID/T: The ratio of cases which identified the deceased person by dental information to the total number of unidentified cases.
UI: Total number of unidentified cases in each region.
US: Number of cases of unspecified death in each region.

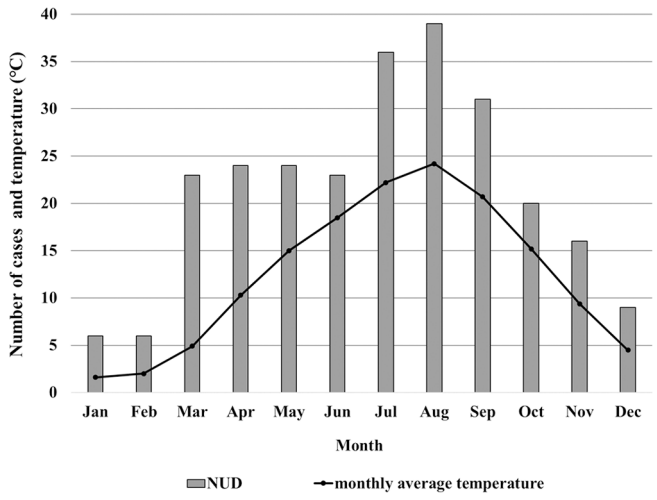

Fig. 7. Number of unspecified deaths and monthly average temperatures in Miyagi Prefecture. A strong correlation was observed between the number of unspecified deaths and the monthly average temperature (n = 401, Spearman's rank correlation coefficient, $\rho = 0.89$, $p < 0.01$). NUD: total number of unspecified deaths.

number of unspecified deaths. We speculate that as temperatures increase, the time for decomposition shortens and the detection of cadavers by odor increases. It seems more likely for people to notice abnormalities in the hotter months, when windows tend to remain open and outdoor activities increase.

According to previous reviews, there have been several instances of dental identification being used at a high rate both in open as well as closed disasters such as tsunamis, bushfires, and air craft crashes [8,17]. However, it must be noted that many factors may influence decision-making under such circumstances. For example, in case of the Indian Ocean Tsunami disaster in Thailand, it was reported that many non-Thai victims were identified by dental information; in contrast, the rate of utilization for Thai victims was quite low [7,9]. Namely, forensic odontologists have to consider the process of dental information collection and background of each case to determine how dental identification can be involved. This is also applicable to other forms of routine identification.

Forensic odontologists are expected to disseminate the information obtained through dental identification not only to those in the dental field but also to the general public, as this may increase the opportunity for dental consultation and aid in obtaining information on missing or unidentified individuals. Although the present data are localized, this study provide valuable information about the long-term progress of routine identification using forensic odontology and could be useful as a reference for other provincial cities to evaluate their unidentified cases. However, it must be noted that many cases requiring dental identification underwent serious postmortem changes that could have created a lag between the time of death and the time of discovery. Thus, it was difficult to examine the average period after death. This was one of the limitations in this study. There is a need to investigate the affecting factors and detailed intraoral conditions of the unidentified cases requiring dental information collection. Future research should include a detailed analysis of these factors based on the background characteristics such as economic status, medical history, and family structure.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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