COMMUNITY HEALTH

# Assessment of Application of ICD-11 Coding to Two Recent Geothermal Activity-Related Deaths in Japan

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## ABSTRACT

***Objective:*** **The WHO released the 11th version of International Classification of Diseases (ICD) in 2018 and it was adopted in the World Health Assembly in 2019. Member States are supposed to start reporting the morbidity and mortality data of them from 2022. New IT assisting tools and new chapters were added in this revision. To assess chapters regarding externally caused injury and poisoning, including the extension code chapter, we conducted trial coding of two lethal geothermal cases in Japan.**

***Methods:*** **Information was retrieved from open-access newspaper websites, and two cases of death were coded according to ICD-11 in comparison with ICD-10.**

***Cases:*** **One case was of a soldier on a volcanic slope who was fatally injured by volcanic scoriae in a sudden eruption, and the other was of a clerk working for a hot spring museum who was intoxicated by carbon dioxide or suffocated by replacing oxygen by carbon dioxide.**

***Conclusion:*** **Using stem codes (four-character categorization) only, which are the minimum-level reporting requirement for mortality internationally, it was difficult to compare geothermal incidents among Member States. Further maintenance and improvement of ICD is necessary.**

## KEY WORDS

**ICD-11, geothermal activity, volcanic scoria, poisonous gas, planetary health**

## INTRODUCTION

The International Classification of Diseases and Related Health Problems (ICD) is the international standard for systematic recording, reporting, analysis, interpretation, and comparison of mortality and morbidity data collected in various countries or areas and at different times. The statistics are widely used for medical research, monitoring of public health, evaluation of health interventions, and planning and follow-up of health care[1)].

The current classification began after the International List of Causes of Death (ICD-1) was adopted at the meeting of the International Statistical Institute in 1900. The ICD has been revised cyclically almost every 10 years since, and as of 2017 the 10th version of ICD was translated into 43 languages and used by 115 countries. On 18 June 2018, almost 30 years after the issue of ICD-10 and periodic maintenance, the ICD-11 version was released, and was adopted at the World Health Assembly (WHA) in 2019. Following endorsement, Member States will start reporting using ICD-11 on 1 January 2022[1)].

Japan joined in the use of ICD in 1900, and even before the issue of ICD-11in 2018, has tried to incorporate it into our society by conducting field trials using the ICD-beta version, as has been done in other countries[2)].

In addition to provision of renovated IT tools for users, the following new chapters were added[3)]:

Chapter 04 Diseases of the immune system
Chapter 07 Sleep-wake disorders
Chapter 17 Conditions related to sexual health
Chapter 26 Supplementary Chapter Traditional Medicine Conditions ― Module 1
Chapter V Supplementary section for functioning assessment
Chapter X Extension Codes

Systematic explanation of new and revised contents from ICD-10 are published elsewhere[1)].

The year 2018 opened with successive occurrence of two geothermal activity-related deaths. One case was the death of a soldier on a volcanic slope, and the other of a clerk at a famous hot spring site. Chapters XIX and XX of ICD-10 were moved to Chapter 22, "Injury, poisoning or certain other consequences of external causes," and Chapter 23, "External causes of morbidity or mortality," of ICD-11, which are key chapters describing the coding of these cases. Since it has not been long since its adoption, our search yielded few reports on the revision of description of coding of externally caused deaths and related statistics[4)]. No reports were found related to geothermal activities.

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**Table 1: Case 1: A soldier death after being hit by volcanic scoria.**

A middle-aged male soldier was declared dead on arrival. He was transported to a hospital after being injured, having been hit on his back by volcanic scoria. While being transported, he said he felt he had severe damage in his lung. He was undergoing ski training on the slope of a volcano, and had saved his subordinate by covering him when it suddenly erupted.

**ICD-10**

Tabular list codes

- Chapter XIX Injury, poisoning and certain other consequences of external causes

| | |
|---|---|
| Three-character categories | S27 Injury of other and unspecified intrathoracic organs |
| Four-character subcategories | S27.9 Injury of unspecified intrathoracic organ |
| Five-character subcategories* | S27.90 Injury of unspecified intrathoracic organ, with open wound (This seems to be the case.) |
| (*Only used in Japan) | S27.91 Injury of unspecified intrathoracic organ, without open wound |

- Chapter XX External causes of morbidity and mortality

Block X30-X39 Exposure to forces of nature

| | |
|---|---|
| Three-character categories | X35 Victim of volcanic eruption |
| Four-character subcategories* | X35.3 Victim of volcanic eruption, sport or athletic area |
| (*Only used in Japan) | |

**ICD-11**

List of top-level categories

- Chapter 22 Injury, poisoning or certain other consequences of external causes

| | |
|---|---|
| Four-character categories (Stem code) | NB32 Injury of other or unspecified intrathoracic organs |
| Five-character subcategories | NB32.7 Multiple injuries of intrathoracic organs |
| | Or NB32.8 Injury of other specified intrathoracic organs |
| | Or NB32.Y Other specified injury of other or unspecified intrathoracic organs |
| | Or NB32.Z Injury of other or unspecified intrathoracic organs, unspecified |
| | (Depends on details of the death certificate for this case.) |

- Chapter 23 External causes of morbidity or mortality

Exposure to extreme forces of nature (BlockL1PJ0)

| | |
|---|---|
| Four-character categories (Stem code) | PJ04 Victim of volcanic eruption |

Chapter X Extension Codes

| | | |
|---|---|---|
| Dimensions of external causes | XE214 | Exposure to object, not elsewhere classified |
| | XE4UV | Exposure to being struck by moving object |
| Activity when injured | XE545 | Paid work |
| | XE729 | Educational activity |
| Type of place | XE7K0 | Sports and athletics area |
| | XE7WU | Skiing or snowboarding area |
| Objects or living things involved in causing injury | | |
| | XE6MP | Material, not elsewhere classified |
| | XE4BY | Natural material |
| | XE83R | Rock, stone, not elsewhere classified |
| Alcohol use in injury event | XE47R | Alcohol use, no information available |
| Psychoactive drug use in injury even | XE43G | Psychoactive drug use, no information available |
| Type of sport or exercise activity | XE9X7 | Type of sport or exercise activity, skiing - alpine or downhill |
| | XE8CR | Type of sport or exercise activity, skiing - Nordic cross country |
| Phase of sport or exercise activity | XE9ET | Phase of sport or exercise activity - Training or practice |
| Occupation | XE5G8 | Occupation - armed forces |

Japan, where volcanoes are abundant and some are active, has had many geothermal activity-related casualties in the past, yet no case has been seen in any field trials conducted by National Institute of Health[2].

We therefore need to overview the applicability of ICD-11 for these cases, in order to analyze and compare the trends of morbidity of mortality by this kind of external cause globally. In this study, we attempted to assess how ICD-11 could be applied to these two cases.

## METHODS

By extracting information from news websites on two geological activity-related deaths that occurred early in 2018 (Case 1: A soldier death on a volcano, and Case 2: A clerk death at a historic hot spring site), we investigated how the new ICD could be applied to these cases in comparison with ICD-10. We used coding tables from ICD-10 and ICD-11 as found on the WHO website[5].

Our purpose was not to code the mortality details, but to assess the applicability of ICD-11 through these incidents. By coding the details of these casualties, readers can easily identify the detailed conditions of the

**Table 2: Case 2: A clerk death caused by $CO_2$ intoxication in a hot spring museum.**

A middle-aged clerk working for a sightseeing agency in Kobe died from supposed suffocation or intoxication, in a historical hot spring site. About two and a half hours had passed since the ventilator was switched off after hours. It was assumed that carbon dioxide gas leakage from under the ground was pooled at the bottom of the site. Scene investigation revealed that the content of $CO_2$ was elevated up to 14.5%. Gasses such as carbon monoxide and hydrogen sulfide were not detected.

**ICD-10**

Tabular list codes

- Chapter XIX Injury, poisoning and certain other consequences of external causes

| | | |
|---|---|---|
| Three-character categories | T59 | Toxic effect of other gases, fumes and vapours |
| Four-character subcategories | T59.7 | Carbon dioxide |
| | T71 | Asphyxiation (If decrease in the concentration of O2 was severer for this case) |

- Chapter XX External causes of morbidity and mortality

Block X40-X49 Accidental poisoning by and exposure to noxious substances

| | |
|---|---|
| Three-character categories | X47 Accidental poisoning by and exposure to carbon monoxide and other gases and vapours |
| Four-character subcategories* (*only used in Japan) | |
| | X47.5 Accidental poisoning by and exposure to carbon monoxide and other gases and vapours, trade and service area |

**ICD-11**

List of top-level categories

- Chapter 22 Injury, poisoning or certain other consequences of external causes

| | |
|---|---|
| Four-character categories (Stem code) | NE60 Harmful effects of or exposure to noxious substances, chiefly nonmedicinal as to source, not elsewhere classified (in case of $CO_2$ poisoning for this case) |
| | Or NF05 Asphyxiation (in case of $O_2$ decrease severer for this case) |

- Chapter 23 External causes of morbidity or mortality

Block Unintentional exposure to or harmful effects of substances chiefly nonmedicinal as to source (BlockL3-PB3)

| | |
|---|---|
| Four-character categories (Stem code) | PB36 Unintentional exposure to or harmful effects of other or unspecified substances chiefly nonmedicinal as to source |

Chapter X Extension Codes

| | | |
|---|---|---|
| Aetiology | XB4Q | Environmental |
| | XB5G | Occupation as cofactor |
| Dimensions of external causes | XE3SH | Exposure to or harmful effects of substances |
| | XE13E | Poisoning or toxic effect of exposure to substance |
| Activity when injured | XE545 | Paid work |
| Type of place | XE7GY | Recreational area, cultural area, or public building |
| Objects or living things involved in causing injury | | |
| | XE63H | Hot object or substance, not elsewhere classified |
| | XE3BS | Hot air or gas |
| Alcohol use in injury event | XE47R | Alcohol use, no information available |
| Psychoactive drug use in injury event | XE43G | Psychoactive drug use, no information available |
| Economic activity | XE4JS | Economic activity, hotels or restaurants |
| Occupation | XE17U | Occupation - clerks, secretaries |
| Substances | XM57J2 | Carbon dioxide (gas) |

casualty, since each incident involved only one casualty. Thus, even though we extracted the information from open-access news sources, we tried to avoid describing specific information that is irrelevant to this trial coding of the mortality.

## CASES

Descriptions of the deaths and their trial codings are shown in Tables 1 and 2.

### CASE 1

A middle-aged male soldier was declared dead on arrival. He was transferred to a hospital after being injured, having been hit on his back by volcanic scoriae. While being transferred, he said he felt he had severe damage in his lung. He was undergoing ski training on the slope of a volcano nearby a famous hot spring sightseeing site when it suddenly erupted without any notice (Volcanic alert level 1), and had saved his subordinate by covering him when it erupted. Including two others severely injured, there were many injured by scoriae. He was the only casualty[6]. Trial coding of this mortality case is shown in Table 1.

### CASE 2

A middle-aged clerk at a hot spring museum historic site died from

asphyxia or carbon dioxide ($CO_2$) intoxication. Two and a half hours after the ventilation was switched off after closure of the museum, he fell down while searching for a cat, and was found lying down near the bottom of the site. Investigation restaged the ambient $CO_2$ to be 14.5%[7]. Trial coding of this case is shown in Table 2.

## DISCUSSION

We described two cases of death related to geological activity. The first was caused by being directly hit by volcanic scoriae, and the second was by suffocation or $CO_2$ poisoning. We showed how these deaths could be categorized by ICD-11 in comparison to ICD-10.

In Case 1, the casualty suffered from severe injury caused by volcanic scoriae. In ICD-11, we referred to Chapter 22, "Injury, poisoning or certain other consequences of external causes," and Chapter 23, "External causes of morbidity or mortality." Four-character categories are used for minimum international reporting, called 'stem codes,' and are categorized as NB32 of Chapter 22 in combination with PJ04 of Chapter 23. Subcategories were also used for further categorization. In this case, as shown in Table 1, if the details of the death certificate had been available, five-character codes could have been generated. Moreover, in ICD-11, Chapter X, "Extension Codes," has been added to provide additional detail as multiple coding, with the morbidity or mortality classified in other chapters. The coding contains Severity Scale Value, Temporality, Aetiology, and other categories[8]. Using relevant categories, it was possible to categorize the case. However, it was clearly not possible to use the minimum four-character stem codes to distinguish among deaths by scoria, by ashes, or by pyroclastic flow. For reference, we classified the death using the codes provided in ICD-10 in reference to Block X35-39, "Exposure to forces of nature," of Chapter XX, "External causes of morbidity and mortality," and easily found X35, "Victim of volcanic eruption." In ICD-10, three-character codes were used for international reporting. Using either version, the mortality in the case of this soldier would be reported as more or less relevant to geothermal activity.

Case 2 was reported as death by suffocation or carbon dioxide poisoning. The scene investigation revealed that the content of carbon dioxide in the ambient air had risen up to 14.5% two and a half hours after the ventilation had been switched off. In cases of suspected gas poisoning, it is difficult to distinguish death caused by suffocation due to replacement of air by poisonous gas from death by intoxication by the poisonous gas itself at increased concentration over poisoning level with survival level of oxygen content. In addition, the concentration of carbon dioxide tends to increase in a corpse[9]. The fact that investigation revealed that the content of carbon dioxide was 14.5% led us to assume the death was due to intoxication. If the oxygen content in normal air is 20%, even if the normal air was contaminated with 15% poisonous gas, the remaining oxygen level would have been as follows:

(100%-15%) X 20% = 17%.

The level of oxygen remaining was kept over survival level. Thus, for our assessment it was assumed that the clerk died due to intoxication rather than suffocation. Carbon dioxide levels over 10% induce convulsion and coma, leading to death[10]. Another news report stated that the $O_2$ content was as low as13-14%. We coded the case as suffocation, as shown Table 2.

$CO_2$ poisoning often occurs in relation not only to industry, but also to diving, other than exposure in the natural environment[11,12]. In this case again, using only the four-character categorization (stem code) used for international reporting, we could not characterize the aetiology at this level, so it was difficult to compare mortality over time and place in ICD-11. Further extension codes were needed. When ICD-10 was used, it was also not possible using only the internationally reporting level (three-character codes) such as T59 in combination with X47. However, using the four-character subcategorization of ICD-10, it was possible to identify the causal poisonous gas in the classification. However, using ICD-10, it was not possible to distinguish industrial cause from natural cause. Contrary to ICD-10, using ICD-11 it was possible to identify naturally induced intoxication with further subcategorization and detailed extension codes and not industry-related intoxication by our trial classification.

A look at these two cases, classified according to the 11th revised version of ICD after the launch of ICD-10 thirty years ago, reveals that it was difficult to compare and analyze the morbidity and mortality over time and place, using only a minimum international reporting level based on four-character categorization. Even with further character categorization and with extension codes, there was still a case with insufficient information to search the cause, as shown in Case 1, as to whether the death was caused by scoria or by pyroclastic flow. Our two trial codings using the 11th version of ICD led us to recognize that further maintenance and improvement of ICD shall be necessary.

Japan, located on the "Ring of Fire," suffers from numerous disasters with casualties, with another example being that of Mt. Ontake, where a great disaster was experienced in 2014 with at least 46 casualties, people who died after being hit by volcanic scoriae, when volcanic alert notice had not been issued, as in Case 1[13]. There are variety of health effects induced, such as reported in detail after the Mt. St. Helens Eruption in the USA in 1980[14]. As for the geothermal emission of poisonous levels of carbon dioxide, not only have we often experienced it, but Cameroon, Africa similarly suffered from it in the lake Nyos tragedy. Additionally, the kinds of volcanic gas emitted are not restricted to carbon dioxide, but can also include sulfur dioxide, hydrogen sulfide, carbon monoxide, and others[15].

Around 500 million people reside within a potential exposure range (100 km) of a volcano that has been active within recorded history[16], and there is a hypothesis that climate change directly influences volcanic emissions and in the era of global warming will be causing many health problems[17]. However, our technology still falls short of the ability to predict eruptions, and therefore we need to refine our technology with international collaboration to reduce casualties. For this purpose, sharing morbidity and mortality data is indispensable. A new concept of "planetary health" was proposed by the Rockefeller foundation-Lancet Commission in 2015, in attempt to understand the comprehensive relation of our whole planet and diversity and well-being of life[18]. If we try to analyze these geothermal cases in this connection in our preparation for disasters, we need to precisely grasp morbidity and mortality trends both geographically and chronologically.

Lastly and probably most importantly, this version has increased the categorizing codes up to more than 30,000 entries, and is believed to be used by more than 100 WHO Member States. Correct and timely coding among these states shall be an utmost requirement. For this purpose, each Member State is expected to pour their efforts to develop proficient and reliable coders[19,20]. Additionally, the coding must be based on morbidity or mortality certificates, and thus medical technique across given areas needs to be sufficiently equal to enable correct completion of the death certificate forms. However, currently there are settings in which the resources are low, and capacities to code causes of death in terms of the ICD 3- or 4-character schemes are lacking[21]. Eventually, we must develop human resources in health as well as health systems, as a whole, not only in terms of medical technicians, but also of health information staff. ICD-11 includes sets of training and well-elaborated website tools. We anticipate their use.

### Limitations

Details of death certificates are required to code details of the morbidity or mortality. However, our main purpose was to assess ICD-11 through trial codings of example cases, and not to provide exact details of categorization codes, to avoid trespassing against individual privacy as far as possible.

### Future directions

From now until the start of reporting in accordance with ICD-11 in 2022, each Member State will be preparing for their own implementation of the ICD. For this purpose, not only our two examples shown here, but a larger variety of case scenarios fitted to current local and global health issues need to be investigated.

## CONCLUSION

We assessed applicability of ICD-11 by trial coding of two geothermal activity-related lethal cases in Japan. Using stem codes alone, which are a minimum-level reporting requirement for mortality internationally, it seemed difficult to compare geothermal incidents. As we enter an era in which our planetary health is contemplated, there shall be necessity for further maintenance and improvement of the ICD.

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