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Original Article

# Epidemiology of SARS-CoV-2 infection in nursing facilities and the impact of their clusters in a Japanese core city

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ABSTRACT

*Introduction:* Nursing facilities are vulnerable to coronavirus disease 2019 (COVID-19) due to the congregate nature of their housing, the older age of the residents, and the variety of their geriatric chronic conditions. Little is known about the impact of nursing facility COVID-19 on the local health system.

*Methods:* We collected data of COVID-19 cases in Nagasaki city from April 15, 2020 to June 30, 2021. We performed universal screening of the healthcare workers (HCWs) and the users of nursing facilities, once the first case of COVID-19 was detected within that facility. The community-dwelling people received testing if they had symptoms or if they were suspected of having close contact with the positive cases. The epidemiological survey for each COVID-19 case was performed by the public health officers of the local public health center.

*Results:* Out of 111,773 community-dwelling older adults (age ≥ 65 years) and 20,668 nursing facility users in Nagasaki city, we identified 358 and 71 COVID-19 cases, and 33 and 12 COVID-19 deaths, respectively, during the study period. The incidence rate ratios (IRRs) for COVID-19 and its deaths among the nursing facility users were 1.07 (95% confidence interval (CI), 0.82–1.39) and 1.97 (95%CI, 0.92–3.91) compared with the community-dwelling older adults. Four clusters, which had more than 10 COVID-19 cases, accounted for 60% (65/109) of the overall cases by the HCWs and the users.

*Conclusions:* The prevention of COVID-19 clusters is important to reduce the number of COVID-19 cases and deaths among the nursing facility population.

## 1. Introduction

Nursing facilities suffer from a disproportionate impact of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) mediated disease, COVID-19 [1]. The congregate settings of the nursing facilities, the older ages of the residents, and their widespread comorbidities constitute high risk environments for COVID-19 prevalence and severity [2]. In the U.S, over 20% of COVID-19 deaths were attributed to nursing home residents [3]. Similarly, nursing home residents were reported to account for at least 14% of COVID-19 deaths in Japan during the earliest phase of the pandemic [4]. Large-scale outbreaks of COVID-19 in nursing homes have also been reported globally [5–7]. However, to date, little is known about the impact of COVID-19 clusters in nursing facilities on the local health system.

Multiple strategies have been proposed to prevent the outbreak of COVID-19 in nursing facilities, including source control through the use of masks, enhancement of physical distancing measures, visitor restrictions, vaccination, symptom surveillance, and routine and outbreak

*Abbreviations:* ADL, activities of daily living; CI, confidence interval; COVID-19, coronavirus disease 2019; HCW, healthcare worker; IQR, interquartile range; IRR, incidence rate ratio; LAMP, loop-mediated isothermal amplification; LTCF, long-term care facility; MHLW, Ministry of Health, Labour, and Welfare; PCR, polymerase chain reaction; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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testing [8]. However, infection control in a nursing facility remains challenging as described by the following examples: 1) residents with dementia or depression may have difficulty complying with the obligation of wearing masks and other countermeasures, 2) visitor restrictions and the resulting social isolation may aggravate both their physical and mental conditions, 3) symptom surveillance is inadequate because older residents may be asymptomatic or sometimes manifest atypical symptoms [9,10]. Vaccines for COVID-19 have so far greatly reduced the risk of infection, but the long-term effectiveness of the vaccines and their protective effects against emerging SARS-CoV-2 variants are still of concern [11,12].

Here, we aimed to describe the epidemiology of COVID-19 in nursing facilities and the impact of their clusters on a Japanese local health system through the epidemiological data of 43 nursing facilities in Nagasaki city between July 2020 and June 2021.

## 2. Methods

### 2.1. Setting

Nagasaki city is the capital of Nagasaki prefecture, located on the northwest coast of Kyushu island. Its population is approximately 400,000 (as of January 2021, 31% of the 1.3 million people living in Nagasaki prefecture), and has the 15th largest population among the 62 core cities with populations over 200,000 [13–15]. The population of older adults who are ages above 65 is roughly 130,000 (33% of the population of Nagasaki city) [16]. Of those, 20,668 (16%) rely on care services, which are provided under long-term care insurance [17]. On April 15, 2020, Nagasaki city had its first case of COVID-19, three months after the first entry of COVID-19 into Japan [18]. Nagasaki city subsequently underwent four waves of a COVID-19 pandemic (Fig. 1), and the alpha variant (B.1.1.7) was introduced to Nagasaki city during the fourth wave. The delta variant (B.1.617.2) has not been detected in Nagasaki as of June 30, 2021.

Since the beginning of the pandemic, the Ministry of Health, Labour, and Welfare (MHLW) in Japan has made various attempts to protect the nursing facilities. By January 31, 2020, MHLW informed the nursing facilities about infection control measures for residents and health care workers (HCWs) [19]. On February 24, 2020, MHLW informed the residential care facilities to consider visitor restrictions and lockdown of the facilities [20]. On May 17, 2021, the government recommended periodic testing of the HCWs to prevent them from introducing COVID-19 into the facilities [21].

In Japan, COVID-19 vaccines were provided in the order of priority listing. In Nagasaki city, COVID-19 vaccination was initiated for medical staffs on March 8, 2021, and for older adults on April 12, 2021. As of July 4, 2021 in Nagasaki city, 70% of the older adults have received the first dose of COVID-19 vaccine, and 27% have received the second dose.

### 2.2. Testing strategies

In Nagasaki city, community-dwelling people received testing for COVID-19 either voluntarily through purchasing a commercial kit or at medical facilities, or at a testing facility of a local health center if they were recognized through epidemiological survey as a close contact of a COVID-19 case. All COVID-19 cases were confirmed with either polymerase chain reaction (PCR) or loop-mediated isothermal amplification (LAMP) assays [22,23]. PCR universal screening tests were performed at nursing facilities for the HCWs and users if a COVID-19 case was diagnosed within the facility. The targets for screening were determined by the capacity of the testing facility and the expected spread of COVID-19 within the facility based on the epidemiological survey. Screening tests were done within one to two days after the confirmation of the first case.

### 2.3. Definitions

The term “nursing facility” includes the long-term care facilities (LTCFs), short-stay services (short-term admission in residential care facilities), home care services, and day care services. The LTCFs include welfare facilities for older adults (nursing homes), healthcare facilities for older adults, sanatorium-type medical care facilities for older adults, and adult care homes. The community-based services include short-stay services, home care services, and day care services. We included monasteries as nursing facilities because they accommodate older adults similar to the LTCFs.

The term “users” of the nursing facilities indicates those who are ages 40 or above and receive care services under the long-term care insurance. We did not take into account those who receive care services without the qualification of the long-term care insurance because their activities of daily living (ADLs) are sufficient to not qualify for the insurance and are rare. People who are ages 40 to 64 can qualify for long-term care insurance if they are diagnosed with specific diseases such as early dementia, neurodegenerative disease, or stroke [17]. People who are ages 65 or above can qualify for long-term care insurance depending

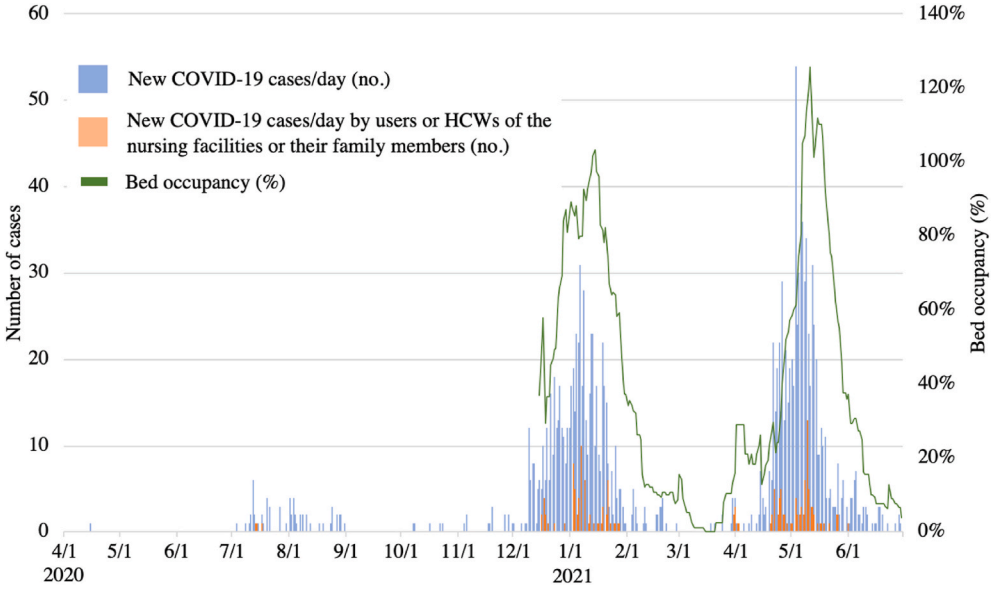


**Fig. 1.** COVID-19 cases in Nagasaki city from April 15, 2020 to June 30, 2021.
The number of new COVID-19 cases in Nagasaki city is drawn in blue bars, and the number of new COVID-19 cases related to nursing facilities is drawn in orange bars. The green line indicates the bed occupancy of medical facilities in Nagasaki city in percentage. Information of bed occupancy was available only from December 15, 2020 to June 30, 2021. Nagasaki city underwent four waves of a COVID-19 pandemic since April, 2020. The peak of the pandemic in the nursing facility population coincides with the peak of the pandemic in the general population.
Abbreviations: COVID-19, coronavirus disease 2019; HCWs, healthcare workers.

**Table 1**
IRRs of COVID-19 and its death in Nagasaki city by different age groups and status of the nursing facility use.

| | Population (no.) | COVID-19 cases (no.) | Incidence rate (/100,000 person-year) | IRR (vs community-dwelling) (95%CI) |
|---|---|---|---|---|
| Total population | 406,313 | 1527 | 311.0 | 1.17 (1.05–1.32) |
| ≤ 64 years | 267,204 | 1096 | 339.5 | 1.28 (1.14–1.45) |
| ≥ 65 years | 132,441 | 429 | 268.1 | 1.01 (0.88–1.17) |
| Nursing facility users | 20,668 | 71 | 284.3 | 1.07 (0.82–1.39) |
| Community-dwelling older adults | 111,773 | 358 | 265.1 | 1 |

| | Population (no.) | COVID-19 deaths (no.) | Incidence rate (/100,000 person-year) | IRR (vs community-dwelling) (95%CI) |
|---|---|---|---|---|
| Total population | 406,313 | 46 | 9.37 | 0.38 (0.24–0.62) |
| ≤ 64 years | 267,204 | 1 | 0.31 | 0.01 (0.0003–0.08) |
| ≥ 65 years | 132,441 | 45 | 28.1 | 1.15 (0.72–1.86) |
| Nursing facility users | 20,668 | 12 | 48.1 | 1.97 (0.92–3.91) |
| Community-dwelling older adults | 111,773 | 33 | 24.4 | 1 |

The population data is based on Japan national census data as of October 1, 2020.
Age data of 6668 people in Nagasaki city and 2 COVID-19 cases are missing.
The follow-up period from April 15, 2020 to June 30, 2021 (14.5 months) was used to calculate the incidence rate.
Abbreviations: IRR, incidence rate ratio; COVID-19, coronavirus disease 2019; CI, confidence interval.

on the limitations in their ADLs. They can receive different types of care services at various nursing facilities under the long-term care insurance.

The term "older adults" refers to those who are ages 65 or above. The term "community-dwelling older adults" indicates people who are ages 65 or above and do not rely on care services.

The term "cluster" refers to two or more COVID-19 cases that are epidemiologically linked. For instance, if a HCW or a user visits several facilities and introduces COVID-19 to the facilities, we count the sum of all COVID-19 cases in the facilities as one cluster.

### 2.4. Data collection and sources

We included data from the first case of COVID-19 in a nursing facility in Nagasaki city on July 15, 2020 onward to June 30, 2021. We collected information of age, sex, comorbidities, number of close contacts, date of symptom onset, date of diagnosis, cycle threshold value in real-time RT-PCR, status of hospital admission, duration of hospital stay, and the outcome of death for each individual from the epidemiological survey, which was performed by the Nagasaki city public health center under the Infectious Disease Control Law. We obtained the information on the number of positive cases in Nagasaki city and Nagasaki prefecture, their population by age groups, and the number of nursing facilities in Nagasaki city from the website of Nagasaki city and Nagasaki prefecture, which are publicly available. The information on the bed occupancy of medical facilities in Nagasaki city, the past outbreak of infections in the nursing facilities, the number of people who receive care services under the long-term care insurance, the vaccine status of the older adults in Nagasaki city, and the details of the COVID-19 outbreak investigation at nursing facilities were obtained from the records of the Nagasaki city public health center.

### 2.5. Statistical analysis

We estimated incidence rate ratios (IRRs) of COVID-19 cases and deaths in the nursing facility users compared with those in the community-dwelling older adults who were ages 65 or above. We used Fisher's exact test to compare the proportions of COVID-19 occurrence in each facility type (LTCFs, day care services, home care services, and short-stay services). We used Kruskal-Wallis H test to compare the median numbers of COVID-19 cases in each facility type ($\alpha = 0.05$). All statistical analyses were conducted using STATA ver. 16.1 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC.).

### 2.6. Ethics statement

The data collection and analysis were conducted under the Infectious Diseases Control Law in Japan. The ethical review board of the Institute of Tropical Medicine, Nagasaki University waived the need for informed consent based on the condition that the anonymities of each individual and the facility were assured. Publishing this study was approved by the ethical committee of the Institute of Tropical Medicine, Nagasaki University (No. 210603261).

## 3. Results

### 3.1. Overview of COVID-19 cases in Nagasaki city

From April 15, 2020 to June 30, 2021, Nagasaki city underwent four waves of a COVID-19 pandemic (Fig. 1). During that period, Nagasaki city had 1527 COVID-19 cases (48% of the 3197 cases in Nagasaki prefecture), and 160 cases of those originated in nursing facilities [24, 25]. Fig. 1 demonstrates that the peaks of the pandemic within the general population and in the nursing facilities occurred almost simultaneously. The incidence rates of COVID-19 and death in Nagasaki city were 311/100,000 person-year and 9.4/100,000 person-year (Table 1). The number of COVID-19 cases was 429 for older adults (28% of the overall cases, 429/1527), 358 for the community-dwelling older adults (23% of the overall cases, 358/1527), and 71 for the nursing facility users (4.6% of the overall cases, 71/1527). The IRRs of COVID-19 and its deaths among the nursing facility users was 1.07 (95% confidence interval (CI), 0.82–1.39) and 1.97 (95%CI, 0.92–3.91) compared with the community-dwelling older adults.

### 3.2. Overview of COVID-19 cases in the nursing facilities in Nagasaki city

Since the first case of COVID-19 in a nursing facility on July 15, 2020, 160 COVID-19 cases were identified that were either of the users (n = 71), the HCWs (n = 38), or their family members (n = 51). They accounted for 10% of the overall cases in Nagasaki city (160/1527), 16% of all hospitalized cases (101/629), and 28% of COVID-19 deaths (13/46). The average days of hospital stay was 16.6 days for the nursing facility users, while they were 14.5 days for the overall older adults in Nagasaki city. No positive case had a previous administration of a COVID-19 vaccine. The proportions of hospital admission and the case fatality of the users were 100% and 17% (Table 2). There was no occasion in which the users could not be admitted to a hospital due to a high bed occupancy.

**Table 2**
Demographics and clinical outcomes of COVID-19 cases among the users of nursing facilities from July 15, 2020 to June 30, 2021.

| | Users (n = 71) |
|---|---|
| Age - median (IQR), years | 86 (81–90) |
| Female - no. (%) | 52 (73.2) |
| Comorbidities - no. (%) | |
| Dementia | 23 (32.4) |
| Hypertension | 36 (50.7) |
| Diabetes mellitus | 16 (22.5) |
| Cardiac disease | 22 (31.0) |
| Cerebrovascular disease | 25 (35.2) |
| Malignancy | 12 (16.9) |
| Renal disease | 2 (2.8) |
| Pulmonary disease | 5 (7.0) |
| Hospitalized - no. (%) | 71 (100.0) |
| Admission days - no. (%) | |
| ≤ 10 days | 13 (18.3) |
| 11– - 30 days | 46 (64.8) |
| ≥ 31 days | 10 (14.1) |
| Unknown | 2 (2.8) |
| Death - no. (%) | 12 (16.9) |

Data presented in median (interquartile range) and no. (%).
Abbreviations: COVID-19, coronavirus disease 2019; IQR, interquartile range.

Table 3 shows the transmission characteristics of SARS-CoV-2 among the users and the HCWs in the nursing facilities. The number of identified close contacts from one COVID-19 case was one (range 0–32) when the COVID-19 case was a user, and three (range 0–32) when the COVID-19 case was a HCW. However, 82% (58/71) of users and 82% (31/38) of HCWs were not previously recognized as the close contact of another COVID-19 case before testing positive for SARS-CoV-2. The users were asymptomatic in 23 of 71 cases (32.4%) when diagnosed with COVID-19.

There were 43 nursing facilities, which had more than one COVID-19 case during the study period. Of the 43 facilities, 17 were LTCFs (40%), 14 were day care services (33%), 6 were home care services (14%), 3 were short-stay services (7%), and 3 were monasteries (7%). Out of 277 LTCFs, 257 day care services, 173 home care services, and 94 short-stay services in Nagasaki city, COVID-19 occurred in 6% of LTCFs (17/277), 5% of day care services (14/257), 3% of home care services (6/173) and 3% of short-stay services (3/94) [26,27]. There was no statistical difference among the four proportions (p-value = 0.56). The number of COVID-19 cases among the HCWs and the users in each facility is shown in Fig. 2. Out of 43 facilities, 23 facilities (53%) had no secondary transmission of SARS-CoV-2 within their facilities (Supplementary Table S1). The median numbers of COVID-19 cases per facility were 2 (interquartile range (IQR) 1–3) for LTCFs, 1 (IQR 1–3) for day care services, 1.5 (IQR 1–2) for home care services, 4 (IQR 3–14) for short-stay services, and 1 (IQR 1–4) for monasteries. There was no statistical difference among the median numbers of COVID-19 cases in each facility type (p-value = 0.22).

COVID-19 cases of the HCWs and the users are grouped into clusters based on the epidemiological links among the cases (Table 4). The index case was a user for 5 of 12 clusters (42%), a HCW for 5 of 12 clusters (42%), and a family member for 2 of 12 clusters (17%). The cross-facility movement of HCW or user was observed in 6 of 12 clusters (50%) (Supplementary Fig. S1). A single large cluster involved 28 HCWs and users (28/109, 26%) deriving from 7 different facilities (2 short-stay services, 2 day care services 2 LTCFs, and 1 home care service) (Supplementary Fig. S2). Four clusters (A-D), which had more than ten positive cases, composed 60% (65/109) of all COVID-19 cases among the HCWs and the users.

## 4. Discussion

We described the epidemiology of COVID-19 in 43 nursing facilities in Nagasaki city. COVID-19 cases in the nursing facilities composed 10% of all positive cases, and 28% of COVID-19 deaths in Nagasaki city, which were comparable with global epidemiological data [1]. The incidence rates of COVID-19 were similar between the nursing facility users and the community-dwelling older adults (Table 1). However, the incidence rate of COVID-19 deaths in the nursing facility users was two times higher than deaths in the community-dwelling older adults. The use of the nursing facility may not increase the chance of contracting COVID-19, but the prognosis of the disease may be more severe among nursing facility users than community-dwelling older adults [28].

The fluctuations of COVID-19 cases in the nursing facilities coincided with the community prevalence of COVID-19 (Fig. 1); and the peaks of the COVID-19 cases in the nursing facilities and overall cases were almost simultaneous. The high community prevalence of COVID-19 influenced the number of cases in the nursing facilities by increasing the chance that the HCWs or the users would be infected with COVID-19 in the community and then introduce the infection into the facilities [29]. The COVID-19 cases among the nursing facility users also had long average duration of the hospital stay (16.6 days) and high proportions of hospitalization (100%), which resulted in high bed occupancy and straining of the local health system (Fig. 1).

The results from Table 3 indicate the difficulty of applying manual contact tracing to identify close contact (high-risk contact) in the nursing facilities and the limited capability of symptom-based screening. More than 80% of COVID-19 cases by users or HCWs were not recognized as the close contacts of another COVID-19 case before their diagnosis of COVID-19. The manual contact tracing based on the memory of users and HCWs may be insufficient to promptly and correctly identify close contacts in the nursing facilities [30]. The congregate nature of the nursing facilities makes it difficult to recall individual encounters, and some users may have memory impairment to recall their close contacts. Table 3 shows that 32.4% of users were asymptomatic when diagnosed with COVID-19. Asymptomatic transmission is a known contributor of COVID-19 transmission especially in the nursing facilities [31]. Considering the limitations of manual contact tracing and symptom-based screening, mass screening of users and HCWs is needed to detect asymptomatic cases and prevent further spread of COVID-19 [32].

We observed that various types of facilities were affected by COVID-19 (Fig. 2). We expected community-based services (short-stay, home care, and day care services) to have higher proportions of COVID-19

**Table 3**
Transmission characteristics of SARS-CoV-2 among the users and the HCWs of nursing facilities from July 15, 2020 to June 30, 2021.

| | Users (n = 71) | HCWs (n = 38) |
|---|---|---|
| The number of identified close contacts from one COVID-19 case - median (range) | 1 (0–32) | 3 (0–32) |
| The number of COVID-19 cases among close contacts- median (range) | 0 (0–11) | 0 (0–2) |
| Asymptomatic when diagnosed with COVID-19 - no. (%) | 23 (32.4) | 5 (13.2) |
| Asymptomatic throughout the observation period - no. (%) [a] | 4 (7.1) | 0 (0.0) |

Data presented in median (range) and no. (%).
For "asymptomatic throughout the observation period", the number of cases and percentages were calculated irrespective of missing data.
Abbreviations: SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; HCWs, healthcare workers; COVID-19, coronavirus disease 2019.
[a] The data of 15 users and 3 HCWs were missing for "asymptomatic throughout the observation period."

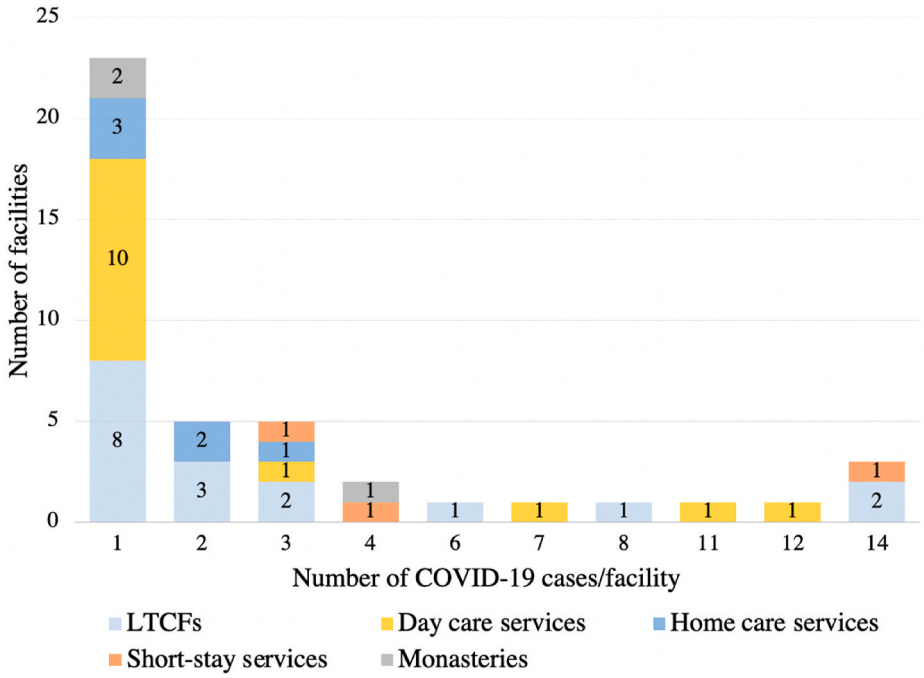


**Fig. 2.** Number of COVID-19 cases per facility according to facility type among 43 nursing facilities. The graph shows the number of COVID-19 cases per facility according to their facility types. The COVID-19 cases include the users and the HCWs. Twenty-three facilities (53%, 23/43) had only one COVID-19 case within their facilities. Two LTCFs and one short-stay service had 14 cases in each of their facilities, that marked the highest number of COVID-19 cases per facility.
Abbreviations: COVID-19, coronavirus disease 2019; HCWs, healthcare workers; LTCFs, long-term care facilities.

**Table 4**
The number of COVID-19 cases and deaths among users and HCWs, index case, presence of cross-facility movement, number of facilities and types of facilities in each cluster.

| Cluster | Number of COVID-19 cases | Users | HCWs | Deaths | Index case[a] | Cross-facility movement (HCW/User) | Number of facilities | Types of facilities[b] (Number of cases within the facility) |
|---|---|---|---|---|---|---|---|---|
| A | 28 | 19 | 9 | 7 | User | Yes (HCW/User) | 7 | LTCF(14), LTCF(1), SS(14), SS(4), DC(11), DC(1), HC(2) |
| B | 14 | 12 | 2 | 2 | HCW | Yes (HCW) | 2 | LTCF(14), LTCF(1) |
| C | 12 | 7 | 5 | 0 | HCW | Yes (User) | 2 | DC(12), DC(1) |
| D | 11 | 8 | 3 | 1 | HCW | Yes (HCW) | 6 | LTCF(8), LTCF(2), MO(4), MO(1), MO(1), HC(3) |
| E | 9 | 7 | 2 | 0 | User | Yes (User) | 5 | DC(7), DC(1), DC(1), DC(1), HC(2) |
| F | 6 | 2 | 4 | 0 | HCW | No | 1 | LTCF(6) |
| G | 4 | 4 | 0 | 1 | Family | Yes (User) | 2 | DC(3), LTCF(2) |
| H | 3 | 2 | 1 | 1 | User | No | 1 | SS(3) |
| I | 3 | 1 | 2 | 0 | Family | No | 1 | LTCF(3) |
| J | 3 | 1 | 2 | 0 | HCW | No | 1 | LTCF(3) |
| K | 2 | 1 | 1 | 0 | User | No | 2 | DC(1), HC(1) |
| L | 2 | 2 | 0 | 0 | User | No | 1 | LTCF(2) |
| Non | 1 | 1 | 0 | 0 | User | No | 1 | LTCF(1) |
| Non | 1 | 1 | 0 | 0 | User | No | 1 | DC(1) |
| Non | 1 | 0 | 1 | 0 | HCW | No | 1 | HC(1) |
| Non | 1 | 0 | 1 | 0 | HCW | No | 1 | HC(1) |
| Non | 1 | 0 | 1 | 0 | HCW | No | 1 | LTCF(1) |
| Non | 1 | 1 | 0 | 0 | Family | No | 1 | DC(1) |
| Non | 1 | 0 | 1 | 0 | HCW | No | 1 | LTCF(1) |
| Non | 1 | 1 | 0 | 0 | User | No | 1 | DC(1) |
| Non | 1 | 0 | 1 | 0 | Family | No | 1 | LTCF(1) |
| Non | 1 | 0 | 1 | 0 | HCW | No | 1 | LTCF(1) |
| Non | 1 | 0 | 1 | 0 | Family | No | 1 | LTCF(1) |
| Non | 1 | 1 | 0 | 0 | User | No | 1 | DC(1) |
| Total | 109 | 71 | 38 | 12 | | | 43 | |

Abbreviations: COVID-19, coronavirus disease 2019; HCWs, healthcare workers; LTCF, long-term care facility; SS, short-stay service; DC, day care service; HC, home care service; MO, monastery.

[a] Index case was defined as the first person who was tested positive for SARS-CoV-2 within the facility. If there was more than one person who was tested positive on the same date, the person who first showed symptoms was identified as the index case.

[b] For facilities that had cross-facility movement, the person (HCW or user) who belonged to two or more facilities was counted separately in each facility.

than LTCFs under the lockdown (specifically, restrictions of visitors and activities outside of the facility); and LTCFs could have links to the community only through HCWs or newly admitted cases. However, the proportions in all facility types were similar. We should be mindful of numerous interactions with the community that persist even after the implementation of lockdown [33,34].

The LTCFs and short-stay services, which were residential facilities, had higher median numbers of cases per facility than day care services and home care services, which are outpatient-based. Although there was no statistical significance, the median numbers of cases per facility were higher in the residential facilities because the containment of infection may be easier to implement in outpatient-based services than the residential facilities (Fig. 2). In outpatient-based services, it is possible to isolate the close contacts or the positive cases in each of their homes; and their services can be temporarily closed down or be substituted in the case of a COVID-19 event. However, in the residential facilities, the close contacts and the positive cases remain within the facility, and they sometimes have difficulty complying with the infection control measures.

Four large clusters of COVID-19 had a large impact on the local health system (Table 4, Supplementary Fig. S2). Clusters (A-D), which had more than 10 positive cases, involved 17 different facilities, 19 HCWs and 46 users, and accounted for 60% (65/109) of the overall cases of the HCWs and the users. Due to the limited sample size, this study could not identify the factors that triggered the secondary transmissions of SARS-CoV-2 within and out of the nursing facilities. However, we observed a higher percentage of symptomatic index cases (57.9% vs. 34.8%) in the facilities that had secondary transmissions (Supplementary Table S1). Symptomatic index cases could cause higher secondary attack rates than asymptomatic index cases [35,36]. Cross-facility movement provoked a spread of SARS-CoV-2 beyond one facility, and was observed in 50% of the COVID-19 clusters (Table 4). Further research is required to examine the benefits of avoiding cross-facility movement, which should outweigh the disadvantages of limiting the access of users to various care services [37].

There are three main limitations to our study. Firstly, our sample size was limited for adequate comparison of the characteristics of each facility type and individuals. Secondly, our calculation of the incidence rate of COVID-19 did not take into account the possible asymptomatic cases among the community-dwelling people who were not tested. We could have underestimated the incidence rate of COVID-19 in the community. Third is the difference in the virus lineage of the fourth pandemic wave, which was mainly due to the alpha variant known for its high lethality and infectivity compared to the pre-existing lineages [38]. This difference could have influenced the transmission pattern between each individual and transmission into the nursing facility.

## 5. Conclusion

We described the magnitude of the COVID-19 pandemic in Nagasaki city nursing facilities and the impact of their clusters. The nursing facility users had more severe outcomes of COVID-19 than the community-dwelling older adults. Prevention of COVID-19 clusters is crucial to reduce the number of COVID-19 cases and deaths within nursing facilities and to sustain the local health system.

## Author contributions

Koki Shimizu (KS) and Konosuke Morimoto (KoM) proposed the study idea. Haruka Maeda (HM), Eiichiro Sando (ES), KoM, and Katsuaki Motomura supervised the research. KS performed the analysis. KS, HM, ES, and KoM interpreted the findings. KS drafted the first report. All authors contributed to the writing of the final report. All authors have approved the final version to be submitted.

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We did not receive any fund for the research.

## Declaration of competing interest

The authors declare no conflicts of interest. This article has not been published previously nor is not being considered for publication in other journals.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jiac.2022.04.010.

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