The spatial process of smallpox diffusion at a rural district in early modern Japan — A case study of Nakatsugawa district in the Dewa Province —

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2: The historical sources and study area

3: The human damage caused by smallpox at 1795 and 1796

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◆ Smallpox is one of the viral infection diseases.

◆ After recovery from smallpox, they can acquire lifelong immunity.

◆ We can find numerous descriptions of smallpox from historical sources, because it was easy for people to spot the symptom of smallpox.

◆ Smallpox is one of the most terrible causes of infant mortality in pre-industrial Japan.
<table>
<thead>
<tr>
<th>case</th>
<th>the incubation period</th>
<th>Onset-of-a-disease period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 2 4 6 8 10 12 14 16 18 20 22 24 26 28</td>
<td></td>
</tr>
<tr>
<td>date</td>
<td>0 2 4 6 8 10 12 14 16 18 20 22 24 26 28</td>
<td></td>
</tr>
</tbody>
</table>
The characteristic of smallpox

◆ Smallpox is one of the viral infection diseases.

◆ After recovery from smallpox, they can acquire lifelong immunity.

◆ We can find numerous descriptions of smallpox from historical sources, because it was easy for people to spot the symptom of smallpox.

◆ Smallpox is one of the most terrible causes of infant mortality in pre-industrial Japan.
The picture about the smallpox drawn in the early modern era
◆ Smallpox is one of the viral infection diseases.

◆ After recovery from smallpox, they can acquire lifelong immunity.

◆ We can find numerous descriptions of smallpox from historical sources, because it was easy for people to spot the symptom of smallpox.

◆ Smallpox is one of the most terrible causes of infant mortality in pre-industrial Japan.
People believed that the God of smallpox disliked something of red.
The spread pattern of measles

Short intervals
Densely populated area

Long intervals
Dispersed populated area

Figure 1.8 Conceptual view of measles waves in communities of different population sizes. Bartlett model of measles spread through communities of different population sizes. Source: Cliff and Haggett [1988, Figure 6.5(A), p. 246].
Previous research about smallpox before the diffusion of vaccination

Smallpox mortality and outbreak interval in Gifu (=a mountain district)
90% of cases = children under 10
intervals = ranged from 4 to 7 years
Kawaguchi, H. (2001) in Tama (=a rural area)

The outbreak pattern and the strategies in the Ryukyu island (=remote area)
Patients = included many of adults / intervals= over from 10 to 20 years
Purpose of this study

◆ To describe and analyze the outbreak of smallpox before the diffusion of vaccinations in Japan during the early modern period. (The first mass vaccination in Japan was performed in 1849)

- How outbreaks of smallpox affected the local communities
- How it was transmitted from village to village.
The historical source of smallpox

「疱瘡人改」=
Research report of cases of smallpox

Time: during 1795-1796
Place: Nakatsugawa in Dewa Province, Northeast Japan
The person who reported:
Seizaemon Odagiri (小田切清左衛門)
Head of Nakatsugawa District
He learned the Oriental medicine from the medical specialist.
There was no medical specialist in particular district.
Yonezawa feudal domain

early modern era

10 households, 31 residents

48 households, 223 residents

Fig 1. Nakatsugawa District
Fig. The outline of the historical source reported about the smallpox outbreak.
The characteristic of the source

First research = December 6, 1795

- The number of cases
  - 14 cases

- The number of deaths
  - 1 death

- The number of susceptible
  - 12 susceptible (not including residents who suffered smallpox before)

- The date of onset
  - June 23 (Aug. 7) case and day of onset

Kamiyachi village
The name and age of the susceptible each villages
Second research= March,1796

The number of cases

The number of deaths

The number of the recovered people

The number of susceptible
### December 6, 1795

The prevalence of smallpox in villages on Dec.6, 1795

<table>
<thead>
<tr>
<th>Village</th>
<th>Infected People (人)</th>
<th>The Death (人)</th>
<th>The Susceptible (人)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamiyachi</td>
<td>12</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Shimoyachi</td>
<td>9</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Shirakawa</td>
<td>10</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Kawanaido</td>
<td>12</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Utsusawa</td>
<td>12</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Iwakura</td>
<td>5</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>Kosaka</td>
<td>6</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>Osotani</td>
<td>8</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Uehara</td>
<td>—</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Kazuma</td>
<td>2</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Takazoro</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Sugo</td>
<td>0</td>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td>Hirokawara</td>
<td>0</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Koya</td>
<td>0</td>
<td>0</td>
<td>57</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>76</strong></td>
<td><strong>19</strong></td>
<td><strong>326</strong></td>
</tr>
</tbody>
</table>

### March 9, 1796

The prevalence of smallpox in villages during March.9, 1796

<table>
<thead>
<tr>
<th>Village</th>
<th>Recovered People (人)</th>
<th>The Death (人)</th>
<th>The Susceptible (人)</th>
<th>Infected People (人)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamiyachi</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Shimoyachi</td>
<td>9</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Shirakawa</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Kawanaido</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Utsusawa</td>
<td>23</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Iwakura</td>
<td>15</td>
<td>2</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>Kosaka</td>
<td>27</td>
<td>5</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Osotani</td>
<td>26</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Uehara</td>
<td>5</td>
<td>2</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Kazuma</td>
<td>14</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Takazoro</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Sugo</td>
<td>21</td>
<td>5</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>Hirokawara</td>
<td>25</td>
<td>4</td>
<td>31</td>
<td>1</td>
</tr>
<tr>
<td>Koya</td>
<td>0</td>
<td>0</td>
<td>58</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>199</strong></td>
<td><strong>44</strong></td>
<td><strong>180</strong></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>

**Changes:**

- **+123** in recovered people
- **+25** in the death
- **−146** in the susceptible

### Notes

- In December 6, 1795, the total number of infected people is 326.
- In March 9, 1796, the total number of infected people is 13.
- The increase in recovered people is 123.
- The increase in the death is 25.
- The decrease in the susceptible is 146.
A number of cases

Fig 2. The age structure of the persons infected during Dec 6, 1795 ~ Jan 19, 1796
A number of the susceptible

Fig 3. The age structure of the susceptible in 10 villages (Dec 6.1795)
A number of cases

- December 6, 1795
- March 9, 1796

New cases after first census

The end of outbreak

The middle of outbreak

The beginning of outbreak

Fig. The change of the number of infected persons (Dec 6, 1975 and May 9, 1796)
The prevalence and case fatality rate from smallpox in 4 villages, where infection had finished (May.9, 1796)

<table>
<thead>
<tr>
<th>Village</th>
<th>Score (cases/susceptible)</th>
<th>Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamiyachi</td>
<td>92.86</td>
<td>7.14</td>
</tr>
<tr>
<td>Shimoyachi</td>
<td>77.78</td>
<td>26.32</td>
</tr>
<tr>
<td>Shirakawa</td>
<td>86.67</td>
<td>18.75</td>
</tr>
<tr>
<td>Kawanaido</td>
<td>86.67</td>
<td>7.14</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>85.99</strong></td>
<td><strong>14.84</strong></td>
</tr>
</tbody>
</table>

Percentage of susceptible infected

Finished outbreak villages

Wide range
Fig. Presumed infection route of smallpox in Nakatsugawa district
Fig5. The relation between distance from Kamiyachi village and the date of the onset of smallpox outbreak

- Distance from Kamiyachi village (km)
- Kosaka Village

R = 0.74
(if the Kosaka village is excluded, R = 0.9)

X: a number of days between the date of the onset of smallpox in Kamiyachi and one of each villages.
Fig6. The relation between the time lag of the onset of smallpox outbreaks and the distance between the presumed source and infected villages.

X: a number of days between the date of the onset of smallpox between the presumed source and infected villages.

Y: the distance between the presumed source and infected villages (km).

These villages contracted an outbreak after November 11, 1795.
Snowy days and the maximum depth of snow cover by months, 1958–1968

<table>
<thead>
<tr>
<th></th>
<th>Nov</th>
<th>Dem</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowy days</td>
<td>5</td>
<td>24</td>
<td>31</td>
<td>28</td>
<td>29</td>
</tr>
<tr>
<td>New snowy days</td>
<td>6</td>
<td>20</td>
<td>27</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>The maximum depth of snow (cm)</td>
<td>12</td>
<td>80</td>
<td>174</td>
<td>224</td>
<td>181</td>
</tr>
</tbody>
</table>

The knitted footwear made of straw

The average temperature by months, 1958-1968
Fig 7. The date of the onset of smallpox and the age of infected persons (Sugo village and Hirokawara village)
The sketch about children in a Japanese rural area which the foreign traveler drew at 1877-78

By Bird, I.L. (English traveler)

By Morse, E.S (American zoologist)
During early modern period, this kind of playmate group might have been usual and formed a unit of transmission of smallpox.

This transmission pattern reflects high morbidity rate in a household.

**Benin** 31%  
(located West Africa: Republic of Benin)  (refer to Henderson, R.D., and Yekpe, M. 1969)

**Nakatsugawa** 76% (Sugo village)  
82% (Hirokawara village)
Conclusion

◆ the majority of the infected = children under the age of 10
  ↑ this pattern is observed widely among smallpox epidemics in early modern Japan

◆ 86% of the susceptible were infected in this outbreak.
  ↑ This point is vital to consider when thinking about the durability of a community under repeated outbreaks.

◆ Children’s mobility was so low that it took 1 month to transmit the disease between adjacent villages on average.
  ↑ The spread of smallpox was much slower than would be normally expected.

◆ The spread pattern was reflected by the behavior of children
  ↑ Therefore they were infected at the same time.
  ↑ The infected rate in Nakatsugawa was higher than Benin.
Fig. 5. The relation between the duration of transmission and morbidity of smallpox.
Fig 10. Probable course of smallpox transmission in Hirokawara village, 1795–1796
The morbidity

<table>
<thead>
<tr>
<th>Village</th>
<th>① using the population data of 1786</th>
<th>② using the population data of 1805</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamiyachi</td>
<td>41.94</td>
<td>24.53</td>
</tr>
<tr>
<td>Shimoyachi</td>
<td>17.28</td>
<td>22.58</td>
</tr>
<tr>
<td>Shirakawa</td>
<td>15.85</td>
<td>15.85</td>
</tr>
<tr>
<td>Kawanaido</td>
<td>29.55</td>
<td>35.14</td>
</tr>
<tr>
<td>Kosaka</td>
<td>24.24</td>
<td>24.81</td>
</tr>
<tr>
<td>Osotani</td>
<td>25.00</td>
<td>21.48</td>
</tr>
<tr>
<td>Average</td>
<td>25.64</td>
<td>24.06</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>8.648</td>
<td>5.768</td>
</tr>
</tbody>
</table>