Vulnerability assessment of public rental housing (Rusunawa) residents in facing the risk of COVID-19 transmission (Case study of Surabaya)

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Abstract. This study focused on assessing the vulnerability of public rental housing (Rusunawa) residents facing the risk of COVID-19 transmission. The level of vulnerability was measured through a Weighted Scoring Method (WSM), which considered various aspects that set Rusunawa apart, such as elderly population, occupancy rate, overcrowding, the number of confirmed positive cases in an area, access to clean water service and jobs vulnerable to the spread of the SARS-CoV-2 virus. Results showed that each of the Rusunawa had different levels of vulnerability, which was categorized into 4 clusters: Most Vulnerable (Dupak Bangunrejo and Siwalankerto), Vulnerable (Wonorejo, Pesapen, Jambangan and Dukuh Menanggal), Slightly Vulnerable (Penjaringansari, Keputih and Bandarejo) and Least Vulnerable (Romokalisari, Gununganyar and Tambak Wedi). Dupak Bangunrejo Rusunawa was identified to be one of the most vulnerable Rusunawa towards COVID-19 transmission in comparison to other Rusunawa due to a high amount of older people, high occupancy rate and population density. In contrast, Siwalankerto Rusunawa was caused due to a higher amount older people in conjunction with its residents working in job sectors vulnerable to the virus and the number of confirmed COVID-19 positive case in its area.

1. Introduction

Coronavirus Disease (COVID-19) had spread at an alarming rate in Indonesia. Based on the data issued by the Indonesia National Board for Disaster Management (BNPB) on December 8, 2020, this infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) had reached all provinces and 508 municipalities/regencies¹. It managed to infect 556,000 people, with 18,000 amongst them succumbing to the virus. As per the global tendency, most confirmed cases of COVID-19 originates from the urban area [1]. In Indonesia, Surabaya became one of the greater urban areas with the most confirmed case. Real-time data released by the Province of East Java depicted that per December 8, 2020, the total amount of confirmed cases of COVID-19 in Surabaya had reached 17,189 people, with a higher fatality rate than that of the national average².

In order to face the number of confirmed cases of COVID-19, proper housing and environment become two of the most prioritized prerequisites for people to cope with the transmission rate of the

¹ https://covid19.go.id/peta-sebaran-covid19, accessed on December 9, 2020
² https://infocovid19.jatimprov.go.id, accessed on December 9, 2020
virus. Housing areas must fulfill adequacy in terms of spatial availability, building and environment. It is imperative that basic infrastructures, such as sanitation and clean water, be well provided to increase obedience towards the health protocol and ultimately combat the spread of the virus. Not all housing conditions in Surabaya are classified as habitable. One of the most vulnerable housing types that became hotspots of COVID-19 transmission is public rental housing, generally referred to as Rusunawa. Among the factors which contributed to the vulnerability of Rusunawa in Surabaya include high density, improper environmental quality, and the lack of essential services [2] [3] [4]. Furthermore, the number of Rusunawa residents working under informal sectors added another worrying concern to the increase of COVID-19 transmission risk because those residents were obliged to work outside their compound, leading to increased human-to-human contact frequency to potentially infected people.

This study aims to measure the vulnerability level of each Rusunawa in facing the risk of COVID-19. A deep understanding of vulnerability assessment is highly required by the local government to efficiently and effectively allocate resources to tackle prevention, mitigation, treatment, and recovery. In light of lacking current resources, information regarding the vulnerability levels of each Rusunawa could also aid the local government in establishing a priority scale in response to the COVID-19 pandemic.

2. Methods

2.1. Selecting variables
This study observed several factors and variables to assess the vulnerability of residents in each Rusunawa in facing the risk of COVID-19 transmission. Most of the said factors and variables were derived from various social vulnerability indices towards natural disasters aligned with the main pandemic issues of COVID-19 and public rental housing. Several of those factors alongside its specific variables were as follows:

2.1.1. Demography.
Demographic factors became one of the considered items in measuring the vulnerability level in response to the rate of transmission being directly influenced by the demographic condition of the society [5]. There were two variables used; elderly population and morbidity. Population density was chosen to measure the vulnerability level based upon earlier investigations identifying a link between density and the number of infectious disease transmission impact, including COVID-19 [5] [6] [7] [8] [9] [10]. In contrast, the elderly population was chosen due to the sheer number of fatal cases due to the coronavirus (SARS-CoV-2) showing a higher tendency towards elders. Furthermore, inherently morbidity-related diseases supported the notion that people with underlying diseases, such as hypertension, cardiovascular disease, diabetes, chronic respiratory disease and chronic kidney disease, possess a greater mortality rate, especially when coupled with old age [11].

2.1.2. Housing environment and basic infrastructure condition.
Housing environment and primary infrastructure conditions played a vital role in assessing the vulnerability of residents facing COVID-19 infection. Several variables influence this factor: occupancy rate, overcrowding, number of confirmed positive cases and access to clean water service. Occupancy rate was chosen because this factor is essential in consideration of the study’s context, which is public rental housing in Indonesia. The low levels of occupancy rate may provide an opportunity for residents to utilize vacant areas and units for COVID-19 treatment use, such as independent isolation rooms, whereas overcrowding within the Rusunawa complex was chosen due to several studies having successfully proven the correlation of overcrowding towards the intensity of infectious disease transmission, including COVID-19 [12] [13] [14] [15] [16]. The number of confirmed positive cases was used as a variable to show the amount of infection risk in a single region. As a supplementary variable to basic infrastructure, access to clean water service towards residents became a means of increasing hygiene to prevent coronavirus transmission [17] [18].
2.1.3. Socio-economy.
In the context of COVID-19, socio-economic factors became one of the most important indicators to measure the vulnerability level of public rental housing residents towards COVID-19. This factor was ideally not restricted to the vulnerability of residents towards the risk of infection and the impact of crisis due to the COVID-19 pandemic [19]. However, this study would only touch upon the measurement of vulnerability level from the risk of infection. This factor could be analyzed from the number of residents working in non-home-based occupations that require extensive face-to-face interactions. Several examples of said occupation types are doctors, nurses and medical staffs. Apart from that, occupations in informal sectors, possessing low pay and less secure characteristics, are also part of non-home-based-works [19] [20].

Table 1. Formulation of factors and variables in measuring vulnerability level.

| Factors                               | Variables                        | Descriptions                                                                 |
|---------------------------------------|----------------------------------|------------------------------------------------------------------------------|
| Demography                            | Elderly population               | The ratio between the number of residents aged above 46 years old and the total number of residents |
|                                       | Morbidity                        | The ratio between the number of residents with inherent morbidity-related diseases and the total number of residents |
| Housing environment and essential infrastructure condition | Occupancy rate | The ratio between the number of occupied units and the total unit number of the Rusunawa |
|                                       | Overcrowding                     | The average ratio between the number of occupants per unit and the total unit number of the Rusunawa (persons-per-room (PPR)) |
|                                       | Number of confirmed positive cases in an area | The average ratio between the floor area per unit and the number of occupants per unit (average floor area per person (m²)) |
|                                       | Access to clean water service    | The number of confirmed COVID-19 positive cases within an area (district/kecamatan) in which the Rusunawa resides |
|                                       | Vulnerable jobs                  | The ratio between residents provided with clean water service and the total number of residents |

2.2. Collecting data
The data used to measure the vulnerability level of residents in each Rusunawa in Surabaya were obtained from the Building and Land Management Services (DPBT) of Surabaya. The data originated from DPBT data collection concerning the development of residents and Rusunawa condition in 2019-2020. However, due to the unfortunate restriction of data completeness, this study only analyzed vulnerability levels from 12 out of 20 Rusunawa in Surabaya. In addition, not all of the variables were able to be analyzed, such as morbidity.

Table 2. Tabulation of vulnerability assessment factors and variables.

| Rusunawa     | Elderly population (%) | Occupancy rate (%) | Overcrowding (persons-per-room) | Overcrowding (average floor area per person) | Number of confirmed positive cases in the area around Rusunawa site (people) | Access to clean water service | Vulnerable jobs (%) |
|--------------|------------------------|--------------------|---------------------------------|-----------------------------------------------|----------------------------------------------------------------------------|----------------------------|---------------------|
| Dupak Bangunrejo | 61.33                | 99.33             | 3.4                             | 6.86                                          | 12                                                                       | Accessible                | 65.10              |
| Keputih      | 48.09                 | 70.70             | 3.36                            | 14.64                                         | 11                                                                       | Inaccessible              | 82.32              |
| Tambak Wedi  | 55.71                 | 100.00            | 2.94                            | 18.04                                         | 6                                                                        | Accessible                | 71.43              |
| Rusunawa | Elderly population (%) | Occupancy rate (%) | Overcrowding (persons-per-room) | Overcrowding (average floor area per person) | Number of confirmed positive cases in the area around Rusunawa site (people) | Access to clean water service | Vulnerable jobs (%) |
|----------|------------------------|--------------------|---------------------------------|-----------------------------------------------|-------------------------------------------------|-------------------------|--------------------|
| Jambangan | 56.58                  | 96.20              | 3.33                            | 8.37                                         | 24                                               | Accessible             | 72.37              |
| Siwalankerto | 68.69                | 60.74              | 3.33                            | 9.22                                         | 27                                               | Accessible             | 75.76              |
| Bandarejo | 36.08                  | 97.98              | 3.28                            | 9.62                                         | 16                                               | Accessible             | 73.20              |
| Dukuh Menanggal | 56.70                | 84.21              | 3.94                            | 7.24                                         | 1                                                | Accessible             | 81.25              |
| Pesapen   | 85.71                  | 100.00             | 3.29                            | 10.24                                        | 22                                               | Accessible             | 34.69              |
| Gununganyar | 57.38                | 96.97              | 2.67                            | 12.57                                        | 3                                                | Accessible             | 81.25              |
| Romokalisari | 56.28                | 89.29              | 2.89                            | 11.92                                        | 1                                                | Slightly inaccessible  | 75.34              |
| Wonorejo  | 48.08                  | 99.65              | 3.45                            | 7.56                                         | 16                                               | Accessible             | 69.34              |
| Penjaringansari | 48.49              | 90.16              | 3.21                            | 8.77                                         | 15                                               | Accessible             | 82.83              |

* Access to clean water service variable is explained and quantified as follows:
  Accessible (1) = The municipal water network (PDAM) fully provides clean water to the Rusunawa
  Slightly accessible (2) = The municipal water network (PDAM) partially provides clean water to the Rusunawa
  Inaccessible (3) = The municipal water network (PDAM) does not provide clean water to the Rusunawa

Figure 1. Map of the number of confirmed positive COVID-19 cases within the area in which each Rusunawa resides.

2.3. Measuring the vulnerability level in Rusunawa

A Weighted Scoring Method (WSM) was employed to measure the vulnerability level of residents in each Rusunawa in Surabaya facing COVID-19. Generally, scoring methods are used to assess the overall numerical value after weights have been assigned. WSM has been applied in numerous occasions of quantitative parametric analysis [21]. Coupled with the Analytic Hierarchy Process (AHP), weighted-based analysis helps find more precise computation means based on real-world priority. However, in response to the usage of weight, equal-weighted schemes are also robust in its results [22] [23] [24] [25]. Thus, all of the aforementioned factors would be regarded as equally important and weighted towards vulnerability in this study.
 Firstly, 12 Rusunawa datasets corresponding to 7 variables (elderly population, occupancy rate, overcrowding, number of confirmed positive cases in an area, access to clean water service and vulnerable jobs) were arranged in the order of least to most. Secondly, the order was imposed with a quartile method computed with the following formula\(^3\):

\[
Q_n = \frac{n}{4} \cdot (N + 1)
\]

Thirdly, as the Rusunawa have been ordered and clusters have been assigned, the Rusunawa were given scorings based on their standings of the cluster. Fourthly, the score-assigned variables of each Rusunawa were summed to obtain the final score out of 100 points.

3. Results and Discussion

The study results showed that among the 12 Rusunawa analyzed, residents of Dupak Bangunrejo and Siwalankerto Rusunawa were classified as the most vulnerable in facing COVID-19 risks, obtaining a vulnerability assessment of 67.90. Both outcomes depict different outlooks on their underlying explanations and reasons. On the one hand, the vulnerability in Dupak Bangunrejo Rusunawa is mainly caused by a high occupancy rate, coupled with cramped and overcrowded units in which almost two-thirds of the residents are the elderly. On the other hand, Siwalankerto Rusunawa’s elderly residents are exposed to more risk of COVID-19 transmission from its observed positive case and occupations being mostly non-home-based-work.

In contrast, Tambak Wedi, Gununganyar and Romokalisari Rusunawa are classified as the least vulnerable in facing COVID-19 risks, obtaining an equal vulnerability assessment of 46.48. Several factors play significant roles, with several of them being spacious room units and an objectively lower elderly population compared to the higher half. Despite the three of the Rusunawa having high occupancy rates with most people working from their respective venues, the amount of confirmed positive case and its room units compensate for its pitfalls. Considering Tambak Wedi Rusunawa was established in 2017, both of the factors answer a reassuring question that the provision of public rental housing, in this case, has succeeded in providing a better housing quality within the normal financial limitation. The overall results of the vulnerability assessment in each Rusunawa can be seen in detail in Table 4 and Table 5.

| Table 3. Quartile method computation. |
|---------------------------------------|
| n | Least Vulnerable | Slightly Vulnerable | Vulnerable | Most Vulnerable |
|---|------------------|---------------------|------------|-----------------|
|   | n\(^{th}\) position | n\(^{th}\) position | n\(^{th}\) position | n\(^{th}\) position |
|   | 1\(^{st}\) - 3.25\(^{th}\) | 4\(^{th}\) - 6.5\(^{th}\) | 7\(^{th}\) - 9.75\(^{th}\) | 10\(^{th}\) - 13\(^{th}\) |
| Score | 3.58 | 7.15 | 10.72 | 14.29 |
| 100 points divided into 7 variables = maximum point of 14.29 |

| Table 4. Categorization of Rusunawa based on factors and variables. |
|---------------------------------------------------------------|
| (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|
| Bandarejo | 36.08 | Siwalankerto | 60.74 | Gununganyar | 2.67 | Tambak Wedi | 18.04 |
| Wonorejo | 48.08 | Keputih | 70.70 | Romokalisari | 2.89 | Keputih | 14.64 |
| Keputih | 48.09 | Dukuh Menanggal | 84.21 | Tambak Wedi | 2.94 | Gununganyar | 12.57 |
| Penjaringansari | 48.49 | Romokalisari | 89.29 | Penjaringansari | 3.21 | Romokalisari | 11.92 |
| Tambak Wedi | 55.71 | Penjaringansari | 90.16 | Bandarejo | 3.28 | Pesapen | 10.24 |
| Romokalisari | 56.28 | Jambangan | 96.20 | Pesapen | 3.29 | Bandarejo | 9.62 |
| Jambangan | 56.58 | Gununganyar | 96.97 | Jambangan | 3.33 | Siwalankerto | 9.22 |

\(^3\) [https://www.educba.com/quartile-formula/](https://www.educba.com/quartile-formula/), accessed on December 10, 2020
## Table 5. Weighted sum of vulnerability assessment.

| Rusunawa          | (a) | (b) | (c) | (d) | (e) | (f) | (g) | Total | Status          |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-------|----------------|
| Dupak Bangunrejo  | 14.29 | 10.72 | 14.29 | 14.29 | 7.15 | 3.58 | 3.58 | 67.90 | Most vulnerable |
| Keputih           | 3.58 | 3.58 | 10.72 | 3.58 | 7.15 | 14.29 | 14.29 | 57.19 | Slightly vulnerable |
| Tambak Wedi       | 7.15 | 14.29 | 3.58 | 3.58 | 3.58 | 7.15 | 14.29 | 46.48 | Least vulnerable |
| Jambangan         | 10.72 | 7.15 | 10.72 | 10.72 | 14.29 | 3.58 | 7.15 | 64.33 | Vulnerable |
| Siwalankerto      | 14.29 | 3.58 | 10.72 | 10.72 | 14.29 | 3.58 | 10.72 | 67.90 | Most vulnerable |
| Bandarejo         | 3.58 | 10.72 | 7.15 | 7.15 | 10.72 | 3.58 | 7.15 | 50.05 | Slightly vulnerable |
| Dukuh Menanggal   | 10.72 | 3.58 | 14.29 | 14.29 | 3.58 | 3.58 | 14.29 | 64.33 | Vulnerable |
| Pesapen           | 14.29 | 14.29 | 7.15 | 7.15 | 14.29 | 3.58 | 3.58 | 64.33 | Vulnerable |
| Gununganyar       | 10.72 | 10.72 | 3.58 | 3.58 | 3.58 | 10.72 | 10.72 | 46.48 | Least vulnerable |
| Romokalisari      | 14.29 | 7.15 | 14.29 | 3.58 | 7.15 | 14.29 | 3.58 | 46.48 | Least vulnerable |
| Jambangan         | 10.72 | 7.15 | 10.72 | 10.72 | 14.29 | 3.58 | 7.15 | 64.33 | Vulnerable |
| Penjaringansari   | 7.15 | 7.15 | 10.72 | 10.72 | 14.29 | 3.58 | 14.29 | 60.76 | Slightly vulnerable |

**Notes:**
- (a) Elderly population
- (b) Occupancy rate
- (c) Persons-per-room
- (d) Average floor area per person
- (e) Number of confirmed positive cases in an area
- (f) Access to clean water service
- (g) Vulnerable jobs

*The scores represent the weighted sum of vulnerability assessment for each Rusunawa.*
Of all the variables tested, the occupancy rate was the variable with the most significant influence on the vulnerability assessment of Rusunawa in Surabaya. The average occupancy rate was 90.44%, signifying the majority of the units are fully occupied. 2 out of 12 Rusunawa, namely Pesapen and Tambak Wedi, were fully occupied (100%), meaning that there is an increased chance of human-to-human contact, possibly leading to transmission. Furthermore, not a single vacant unit remains, which can be used to meet the needs for COVID-19 handling space, such as an independent isolation room.

On the other hand, the variable of access to clean water service contributed little to the vulnerability of the Rusunawa because the majority of Rusunawa residents had ample access to clean water service, which could be used to implement health protocols, especially for washing hands. Only 2 out of 12 Rusunawa were not fully connected to the municipal clean water provision service (PDAM).

4. Conclusion
This study found the vulnerability levels of Rusunawa residents based upon demographic, housing environment and essential infrastructure condition, and socio-economic factors. The level of vulnerability was divided into four clusters as follows: most vulnerable, vulnerable, slightly vulnerable, least vulnerable. Dupak Bangunrejo and Siwalankerto Rusunawa residents were classified as the most vulnerable in facing COVID-19, whereas Wonorejo, Pesapen, Jambangan and Dukuh Menanggal Rusunawa residents were classified as vulnerable. Penjaringansari, Keputih and Bandarejo Rusunawa were classified into the slightly vulnerable, while the least vulnerable cluster towards the transmission risks of COVID-19 was comprised of Romokalisari, Gununganyar and Tambak Wedi Rusunawa.

Amongst the variables tested to assess how vulnerable the Rusunawa were, the occupancy rate variable contributed the highest to the vulnerability level. This was caused by the absence of usable vacant units for COVID-19 treatment priority.

The results of this study still have shortcomings due to the exclusion of several other important variables in determining the vulnerability level of residents to the risks of COVID-19 caused by restrictions. Some of these variables include epidemiology, health insurance, behavioural patterns of resident and the capacity of COVID-19 referral hospitals. In addition, the level of vulnerability should not only be measured in terms of the risk of transmission but also from the impact of the crisis due to COVID-19. This is socio-economically important because the residents of Rusunawa are dominated by poor or low-income people. In this situation, they are certainly the most affected group by COVID-19 and require significantly higher efforts to survive this pandemic. Nevertheless, the results of this study can still be used by the local government as preliminary information in pandemic management, especially for public rental housing, which can become hotspots for COVID-19 transmission.

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