

# Analysis on Current Management of Covid-19 Infectious Waste from Self-Isolation Patient towards New Habit Adaptation Era in Indonesia: A Case Study of Sumatera Island

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## Research Article

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# Abstract

In preparation for a new habit adaptation era, Covid-19 infectious waste of self-isolation (SI) patient at home may become a concern in Indonesia. Therefore, the current study evaluates the implementation of the infectious waste management of SI patients (households) in Padang, Medan and Banda Aceh City, Sumatera, through online questionnaires and in-depth interviews. SWOT analysis identifies strengths, weaknesses, opportunities, and threats of the current condition for developing strategies and sustainable programs. Despite the national circular letter instructing the management of the Covid-19 infectious waste from SI patients having been issued, waste management is still not implemented properly. It is likely that most of the Covid-19 infectious wastes from SI patients mix with other household waste and move to the municipal landfill. A lack of concern from the government and society could be the main cause. This creates subsequent problems, such as facility and personnel shortages, lack of coordination, poor campaigns, etc., finally resulting in the low awareness and participation of society. The local government could build partnership with a third-party company and seek assistance of national and international institutions. To ensure sustainability, the Indonesian government must establish an integrated monitoring system to evaluate the program implementation at various levels.

## 1. Introduction

The Coronavirus Disease 2019 (Covid-19) virus may be transmitted through droplets that can be ejected about 1–2 meters, which may possess a transmission potency (*Dokter Jelaskan Penyebab Covid-19 Begitu Cepat Penyebarannya | Republika Online*, n.d.). Due to its high potential for transmission, improvement of the Covid-19 Infectious Hazardous Waste Management is an urgent effort compared to other infectious waste (Nugraha, 2020).

In Indonesia, the first case was announced on March 2, 2020, with two people testing positive (*6 Bulan Berlalu Sejak Jokowi Umumkan Kasus Pertama Corona Di RI*, n.d.). It then increased rapidly to hundreds of thousands of cases. The Professor's Council of The Faculty of Medicine, University of Indonesia, declared that health and quarantine facilities in Indonesia were not ready to handle Covid-19 patients (*Dewan Guru Besar FKUI: Fasilitas Kesehatan Indonesia Belum Siap Tangani Covid-19 Halaman All - Kompas.Com*, n.d.); therefore, this might lead to a greater distribution areas and a higher number of Covid-19 patients, who should isolate themselves independently at home, called self-isolation (SI) patients. Covid-19 infectious waste from SI patients should raise concern since Indonesian society and local governments are not familiar with household hazardous waste (HHW) management. Indonesia has just issued a national regulation for municipal HHW management (PP 27/2020), which rules also municipal infectious waste. It is a follow-up to the Law 18/2008, which should have been published 12 years ago. The late issuance of the HHW regulation also contributes to low readiness of the local government and their community participation in municipal HHW management. It can result in contagious infection in the community in contrast to isolation at referral hospitals or health facilities where the infectious waste is immediately handled by the hazardous waste manager (Nugraha, 2020). The weakness of Covid-19 infectious waste management from SI patients may become a new issue of municipal solid waste management in the Indonesia facing a new habit adaptation era.

According to Ruslinda, et al., the infectious waste generation in Padang is 0.0002 kg/cap/d before the pandemic (Ruslinda et al., 2019). During the pandemic, all daily waste from one SI Patient is considered as infectious waste due to contamination. Current survey and literature estimates the infectious waste generation form SI Patient is 0.226 kg/cap/day (Raharjo et al., 2019), which is around 1,000 times higher than normal condition. During the peak case of Covid-19 in Padang in July 2021, there is a total of 4,700 active cases with 600 new cases daily (*Kasus Covid-19 Di Padang Turun Sejak Awal September | Republika Online*, n.d.). 90% of the patient is self-isolated due to limited health facilities. In addition, widespread location of the SI Patient complicates the infectious waste collection.

The paper evaluates the current situation associated with policy, regulation, and people's habit and participation toward the infectious waste in three capital cities of Sumatera, including Padang, Medan, and Banda Aceh City. Considering the pandemic's rules, the study was conducted by online system. SWOT analysis will develop strategies and programs, including technical and non-technical aspects for improvement of Covid-19 infectious waste management facing the new habit adaptation era. The paper will be advantageous to researchers, environmentalists, administrative authorities, and communities in taking effective action for the control of highly contagious Covid-19.

## 2. Methodology

Data collection focuses on public knowledge and awareness, information and promotion delivery, and technical implementation of the Covid-19 infectious waste management among SI patients. The online questionnaires of 187 respondents, including SI patients and relatives (28 respondents), local community (154 respondents), local government officers (4 respondents), and third-party companies (1

respondent), were conducted in Padang, Medan, and Banda Aceh City. Most of the respondents (65%) were in age range of 21 to 35. and their location are spread evenly in the city. In-depth interviews were also conducted to 10% of SI patients to confirm the questionnaire results. Respondents for in-depth interviews must have basic knowledge about waste management situation to ensure a good discussion.

Data processing and analysis were divided in two, including technical and non-technical aspects. The technical aspect comprises a standard operating procedure (SOP) of Infectious Waste Management of Covid-19 SI patients and its implementation. Any issue about public education and promotion, monitoring and controlling system of the implementation are included in the non-technical aspects. The current implementations were evaluated based on the guidance (Fig. 1), resulting in two categories including not comply and comply.

Furthermore, SWOT analysis divided in terms of strength, weakness, opportunity, and threat, based on internal and external factors that influence the role of government, related agencies, society, and Covid-19 SI patients in implementing the SOP. In this study, local government and community in Padang, Medan, and Banda Aceh are an entity that have main role in conducting The Covid-19 Waste Management. The relationships between internal and external factors were interacted to provide an appropriate strategic analysis. SWOT analysis was carried out by considering responses from experts in solid waste management, other supporting research, and best practices in other countries.

### 3. Results And Discussion

#### 3.1 Management of The Covid-19 Infectious Waste

The first case of Covid-19 in Padang City was confirmed on March 26, 2020, then continued to increase daily. People defined as positive confirmed cases with mild symptoms can conduct self-isolation at home and ask for medical assistance when their condition worsens (Menteri Kesehatan Republik Indonesia, 2020).

To deal with the infectious Covid-19 waste from SI Patients (Households), Indonesian Minister of Environmental and Forestry released Standard Operating Procedure (SOP) in a circular letter SE.2/MENLHK/PSLB.3/3/2020 on March 24, 2020 (*Surat Edaran Menteri Lingkungan Hidup Dan Kehutanan Nomor SE.2/MENLHK/PSLB3/PLB.3/3/2020 Tahun 2020 - Covid-19 Hukumonline.Com, n.d.*). Responding the circular letter, the Governor of West Sumatera issued formal letters 369/377/BPBD-2020 and 360/021/COVID-19/IV-2020 about infectious waste management of Covid-19 and infectious waste management in quarantine locations for people under monitoring and positive people with mild symptoms, respectively (*Masuk Limbah B3, Sampah Medis Covid-19 Mesti Dikelola Khusus, n.d.*) (Tata Cara Penanganan Limbah B3 Infeksius Covid-19 Di Fasilitas Karantina (Lampiran II Surat Gubernur Sumatera Barat Nomor 360/021/COVID-19-SBR/IV-2020 Perihal Pengelolaan Limbah B3 Infeksius Di Tempat Karantina ODP Dan Covid Positif Ringan), 2020). The circular letters instruct all regents and mayors in The Province to implement the national circular letter. The Governor appointed a cement company as a Covid-19 waste processor through Decree 660-285-2020 (Standar Operating Prosedur (SOP) Pengelolaan Limbah Infeksius Dari Fasyankes Dan ODP Dan Sampah Sejenis Rumah Tangga Dari Penanganan Covid-19 Bekerjasama Dengan PT. Semen Padang (Lampiran Keputusan Gubernur Sumatera Barat Nomor 660-285-2020 Tentang Penunjang, 2020). Figure 1 displays the schematic of Covid-19 waste management from households (SI patients) in West Sumatera Province (*Surat Edaran Menteri Lingkungan Hidup Dan Kehutanan Nomor SE.2/MENLHK/PSLB3/PLB.3/3/2020 Tahun 2020 - Covid-19 Hukumonline.Com, n.d.*) (*Masuk Limbah B3, Sampah Medis Covid-19 Mesti Dikelola Khusus, n.d.*) (Tata Cara Penanganan Limbah B3 Infeksius Covid-19 Di Fasilitas Karantina (Lampiran II Surat Gubernur Sumatera Barat Nomor 360/021/COVID-19-SBR/IV-2020 Perihal Pengelolaan Limbah B3 Infeksius Di Tempat Karantina ODP Dan Covid Positif Ringan), 2020) (Standar Operating Prosedur (SOP) Pengelolaan Limbah Infeksius Dari Fasyankes Dan ODP Dan Sampah Sejenis Rumah Tangga Dari Penanganan Covid-19 Bekerjasama Dengan PT. Semen Padang (Lampiran Keputusan Gubernur Sumatera Barat Nomor 660-285-2020 Tentang Penunjang, 2020). Covid-19 infectious waste such as masks, gloves, tissue papers, protective clothes, and all daily wastes from Covid-19 patients, should be separated from domestic waste, and wrapped by using impermeable yellow plastic containers. The plastic container should be labeled as infectious waste. Daily waste which is composed of organic biodegradable (kitchen waste), cannot be stored more than two days. Therefore, the SOP instructs the infectious waste must be collected no more than two days. Collection and transportation are carried out by special operators wearing personal protective equipment (PPE), using closed vehicles, and recording the amount of Covid-19 waste collected and transported. The infectious waste is transported to a cement company for final destruction.

The first national circular letter needs immediate and real implementation from the local government. Interviews with some government officials suggested that not all local governments took actions on the national circular letter. Compared to West Sumatera, Aceh and North Sumatera Province did not follow up the national circular letter. It is caused by low awareness of government officers, limited budgets, and facility shortages. Therefore, Banda Aceh and Medan do not have local regulations for handling the Covid-19 infectious waste from

SI patients. It is indicating that the local governments may not be ready to implement the Covid-19 waste management from SI Patients (Households). Furthermore, this may contribute to the lack of public awareness about the dangers of Covid-19 infectious waste and its handling procedures.

## 3.2 Questionnaire and Interview Results

### 3.2.1 Local Community and SI Patient

#### Public knowledge and awareness:

Around 85% of the local community in Padang, Medan and Aceh have enough knowledge that Covid-19 waste from SI patients is classified as infectious waste and needs to be managed specifically.

In Padang City, SI patients' neighbors (69% of respondents) stated that they did not know if local government had conducted a special management of Covid-19 SI patient waste. Most respondents (77%) did not know when collection and transportation were conducted, or whether it complies with the regulation or not.

In Medan and Banda Aceh City, as much as 87% of the community did not know about the presence of special officers who will collect the infectious waste from the homes of SI patients. The community also did not know whether the officer who collected the waste was wearing a complete PPE or not.

The questionnaire results suggest that even the local communities have enough knowledge on the infectious waste, they do not know how to manage the infectious waste according to the regulation.

#### Information and promotion delivery:

In general, the local community obtained the SOP Management of Covid-19 waste from various online media sources, including social media as affording the greatest provision of information (58%), online news (31%), government website (9%), and book/journal (2%). However, online digital tracing only found general information related to Covid-19 health procedures instead of SOP management of Covid-19 waste. The respondents may have misunderstood to distinguish between general information and specific SOP management of Covid-19 infectious waste. Banda Aceh and Medan City have a similar condition indicating that the community received limited information, resulting in a lack of community understanding regarding infectious waste information and how to handle it. This may be due to the authorities not adopting the circular letter from the national government. The local government does not seem to have any special attention concern for the management of infectious waste from SI patients.

The dissemination effort of information about Covid-19 waste management by the responsible institution, including hospitals, environmental offices, and public health centers, is of a low percentage, with only 15% of SI Patient respondents stating they had received information directly from the above-mentioned institutions. However, 54% of them obtained the general information themselves from various media, including social media, online news, television, a government website, and related books/journals. Social media and online news have an important role to disseminate Covid-19 information to the local community. In-depth interviews stated that the SI Patients did not receive any instruction from hospital, public health center, or environmental office on how to handle the infectious waste in the home when first confirmed positive Covid-19.

#### Technical Implementation:

Questionnaires to SI patients in Padang City gave worse results in respecting the guidance; 63% of respondents did not have an idea about the containerization of Covid-19 SI waste, while only 21% of respondents implemented containerization based on regulations. The high percentage of disposing of Covid-19 waste to the common bin (73%), leading to the unpredictable wide spread of Covid-19.

In-depth interviews suggest that they did separation and packaging of the infectious waste using tied up plastic garbage bags on their own initiative. Unfortunately, the infectious waste was picked up by a regular operator. Upon testing positive, there was no address collection requested by the environmental office as a responsible institution for the infectious waste collection. Therefore, it is likely that most of the Covid-19 infectious wastes from SI patients mix with other household wastes, move to common temporary collection points, and go to the municipal landfill or other dumpsites.

Table 1 compares practices on Covid-19 waste management based on questionnaire and in-depth interview results. Both methods give conclusion that Covid-19 waste management in Padang, Medan, and Banda Aceh has yet to be implemented at household level.

Table 1  
Summary of Practices on Covid-19 Waste Management in Padang, Medan, and Banda Aceh.

Section	Questionnaire Results	In-depth interview results
Separation and containerization	Around 63% of SI Patient respondents do not know about separation and containerization	They did separation and packaging using common plastic bag on their own initiative, because they do not know if there is a specific rule.
Collection	Around 73% of SI Patient respondents put the infectious waste in common bin, it means the infectious waste will be picked up by regular operator, mix with other wastes, and sent to municipal landfill.	The separated infectious waste is picked up by regular operator, mixed with other wastes, and sent to municipal landfill.
SI Patient data for the infectious waste collection system	--	There is no SI Patient data collection for conducting the infectious waste collection from households.

### 3.2.2 Local Government

The Environmental Office of West Sumatra has provided guidance, monitoring, and evaluation of the Covid-19 Infectious Waste management. They provide a solution for any obstacle in the related waste management, including the unavailability of vehicles according to the technical specifications for hazardous waste. Based on information from the Environmental Office of Padang City, SI patients sorting related waste is not carried out correctly. The operators collect the infectious waste not only from SI patients, but also from small health and local quarantine facilities. Padang City Environmental Office operates only one qualified vehicle with a capacity of 6.4 m<sup>3</sup>. However, questionnaires and interviews suggest that most of the Covid-19 infectious waste from SI patients (households) in Padang City is not collected by the special operators. This is probably caused by the lack of operators and transportation facilities, while the spread of Covid-19 infectious waste from SI patients (households) is very wide.

Interviews with the environmental offices of Aceh Province and Banda Aceh City suggest that Covid-19 patients will be treated in hospitals, and garbage is the responsibility of the hospital, which refers to the Minister of Health's Regulation on Hazardous and Infectious Wastes. It is likely that the local government is not ready to manage the Covid-19 waste from SI patients at home.

### 3.2.3 Private Sector

As previously explained, a cement company with adequate processing technology accepts the Covid-19 infectious waste from all districts and cities in West Sumatera. However, in-depth interviews with some SI patients suggest that the Covid-19 infectious waste transferred to the cement company mostly comes from small health and local quarantine facilities.

## 3.3 Evaluation of Covid-19 Infectious Hazardous Waste Management

Table 2 evaluates the implementation of Covid-19 infectious waste in Sumatera (Padang, Medan, and Banda Aceh City). All the technical evaluation regarding to the role of local government in the three cities (e.g., environmental office) and community (SI patients) is not complying. This may be associated with the lack of operators and transportation facilities provided by the local government in Padang City. Meanwhile, the two other cities are in a worse condition because the provincial governments have not followed up the national circular letter about Covid-19 infectious waste handling from SI patients (households). The role of a cement company in Padang City in conducting final processing of the infectious waste is categorized as comply. The company is ready to accept all Covid-19 infectious waste from small health facilities, local quarantines, and SI patients (households) in West Sumatera Province. In contrast, the two other cities do not specify their final processor for treating the Covid-19 infectious waste in their territory. Therefore, the other two cities do not handle the generated Covid-19 infectious waste from SI Patients (households). Yu et al. suggested that the local city may install temporary incinerators to treat tremendous increase of the infectious waste (Yu et al., 2020).

Table 2  
Evaluation of Covid-19 Infectious Waste Management Implementation

No	Aspect	Existing Conditions	Related Regulation	Compliance Category	Recommendation
<b>Technical Aspect</b>					
1.	<b>Sorting from other household wastes</b>	More than half of SI patients do not conduct separation.	Circular Letter of Indonesian Minister of Environmental and Forestry No. SE.2/MENLHK/PSLB.3/3/2020 explains to sort and package Covid-19 waste specifically.	Not comply	Intensify dissemination.
2.	<b>Containerization</b>				
	a.Provision of the yellow plastic bags with hazardous labeling.	No special plastic bags provided by the local government. Half of SI patients package the infectious waste with tied up general plastic bags.	Circular Letter of Governor of West Sumatera No. 369/377/BPBD in 2020 appeals city government to ensure the right containerization management of Covid-19 waste.	Not comply	The government should provide hazardous waste labeling for special yellow plastic bags, if possible.
	b.Cardboard packaging with hazardous labeling.	No SI patients put the packaged plastic waste into the cardboard.	Circular Letter of Governor of West Sumatera No. 369/377/BPBD in 2020 appeals city government to ensure the right containerization management of Covid-19 waste.	Not comply	Cardboard packaging is not necessary because there is no sharps waste.
3.	<b>Self-Storage</b>	Covid-19 waste is stored for 3–4 days to a week. This is an offence against the regulation that rules storage time is maximum two days.	Circular Letter of Governor of West Sumatera No. 369/377/BPBD in 2020 appeal that the maximum storage time is two days since waste generated.	Not comply	Environmental office of local government has to increase the frequency of collection.
4.	<b>Collection and Transfer</b>				
	a.Using vehicle with closed container	Environmental office operates only 1 qualified vehicle with a capacity of 6.4 m <sup>3</sup> . The collection route does not reach SI patients (households).	Circular Letter of Governor of West Sumatera No. 369/377/BPBD in 2020 appeals to collect and transport Covid-19 waste by using closed container vehicles.	Not comply	Environmental office must increase the capacity of collection.

No	Aspect	Existing Conditions	Related Regulation	Compliance Category	Recommendation	
		b.Collection and Transfer Process	Most SI patients testify no collection from special operators. The separated infectious waste was collected by regular operators.	Circular Letter of Governor of West Sumatera No. 369/377/BPBD in 2020 appeal city government to conduct collection and transport for all Covid-19 SI waste	Not comply	Environmental office must increase their capacity in collection and transfer of the infectious waste from SI patients.  Cooperation with private sector could be an option.
<b>5.</b>	<b>Final Processing (In Padang City)</b>					
	a. Final Processing of Covid-19 infectious waste	A cement company has been processing the infectious waste mostly from small health facilities and local quarantines, probably with a very small numbers of SI patients.	Formal Letter of Governor of Sumatera Barat No, 660-285-2020.	Comply		
	b.The third parties of processing Covid- 19 waste and residue	A cement company has been processing the infectious waste.		Comply		
<b>Non-Technical Aspects</b>						
<b>1.</b>	<b>Regulation</b>	Of the three cities studied, only one followed up the national circular letter.	Circular Letter of Indonesian Minister of Environmental and Forestry No. SE.2/MENLHK/PSLB.3/3/2020	Not comply	The local government must ensure the implementation of issued regulations related to Covid-19 waste.	
<b>2.</b>	<b>Socialization and Campaign</b>	The SOP is scarcely found in social media, online news, etc. SI patients testify that they did not receive any information on the SOP from hospital, public health center, or environmental office.	-	Not comply	Environmental office must do socialization and campaigns through hospitals, public health centers, and various online media.	

No	Aspect	Existing Conditions	Related Regulation	Compliance Category	Recommendation
3.		<b>Data Sharing</b>	It is likely that hospitals and public health centers do not share the SI patient data to the environmental office. Therefore, the office cannot locate the SI patients for the infectious waste collection.	-	Not comply Sharing data between hospitals, public health centers and environmental office must be established
4.		<b>Monitoring and Evaluation</b>	Implementation of monitoring and evaluation has been carried out, but it has not reached all related stakeholders	Circular Letter of Governor of West Sumatera No. 369/377/BPBD in 2020 appeals city government to supervise the Covid-19 waste management.	Not comply The environmental office must establish coordination until village level.

All the non-technical aspects, as displayed in Table 2, are not complying. Provincial and local (city and district) government have not responded to the national circular letter in following technical rules and with real implementation. A lack of concern from the government could be the main cause. This creates subsequent problems such as facility and personnel shortages, lack of coordination, poor campaign, data collection, monitoring, and evaluation. The low level of information to the public causes results in a low public understanding of the Covid-19 infectious waste handling from SI patients.

### 3.4 SWOT analysis

Table 3 displays SWOT matrix. It is assessed by representative respondents as indicated in Fig. 2. Figure 3, 4, 5, and 6 display responses from respondents, which are mostly agree with internal and external factors in this study. Internal strength comes from the existence of national policy and regulations, institutional support, and good coordination between provincial and city/district government as well as private companies. Additionally, most people understand that Covid-19 infectious waste needs special attention. The existence of these strengths indicates that the local government and citizens should be ready to implement the Covid-19 infectious waste handling from SI patients. However, the implementation of Covid-19 infectious waste faces some weaknesses, including facility and personnel shortages. According to Muhadjir, limited budget for improving infrastructure of medical waste management is a common obstacle in Indonesia, and lack of coordination between implementing agencies such as environmental office of city/district with hospitals and public health centers (*Soroti Penanganan Limbah Medis Yang Meningkat Selama Covid-19 | Kementerian Koordinator Bidang Pembangunan Manusia Dan Kebudayaan*, n.d.). Kushwaha also found that lack of coordination in various department contributes to the weakness of Indian government in combating Covid-19 (Kushwaha, 2021). Because of the lack of socialization, most people do not understand how to manage the Covid-19 infectious waste according to the standard operating procedure (SOP).

Table 3  
Matrix SWOT of the Infectious Covid-19 Waste from SI patients.

INTERNAL FACTORS			
		STRENGTHS (S)	WEAKNESSES (W)
		<ol style="list-style-type: none"> <li>1. Existence of environmental office of local government for Covid-19 Waste Management and Supervision.</li> <li>2. Existence of policy, regulation, and circular letter from the national and provincial government.</li> <li>3. Good cooperation between the local government and private company, e.g., a cement company.</li> <li>4. Good coordination between provincial and city government.</li> <li>5. Most people understand that Covid-19 waste from SI patients is infectious and requiring special handling.</li> </ol>	<ol style="list-style-type: none"> <li>1. City/district government encounter facilities and personnel shortages.</li> <li>2. Lack of coordination between environmental office of city/district with hospitals and public health centers.</li> <li>3. Lack of community knowledge on Covid-19 Infectious Waste Management of SI patients.</li> </ol>
EXTERNAL FACTORS	OPPORTUNITIES (O)	Strategy: S ↔ O	Strategy: W ↔ O
	<ol style="list-style-type: none"> <li>1. Existence of certified cement industry capable of treating infectious and hazardous waste.</li> <li>2. The ease of disseminating information through social media.</li> <li>3. Local, national, and international pressure on outbreaks prevention.</li> </ol>	<ol style="list-style-type: none"> <li>1. <i>Provincial and city/district government must do monitoring and evaluation to improve the service quality.</i></li> <li>2. <i>City/district government must establish a strong information network between environmental offices and health institutions especially on SI patient data.</i></li> <li>3. <i>Environmental office of city/district government must intensively provide SOP information of Covid-19 Infectious Waste Management for SI patients through hospitals, public health centers, and various media.</i></li> </ol>	
	THREATS (T)	Strategy: S ↔ T	Strategy: W ↔ T
	<ol style="list-style-type: none"> <li>1. Circulating hoax information regarding the pandemic.</li> <li>2. Some people do not believe the existence of Covid-19.</li> </ol>	<ol style="list-style-type: none"> <li>1. <i>Public health office of city/district government must intensively provide correct information on the pandemic through various media and institutions.</i></li> </ol> <p><i>regarding transmission potential of the virus.</i></p>	

External factors consist of opportunities and threats. Provincial, city or district government may build partnership with a third-party company that can treat infectious and hazardous waste in their territory. Other opportunities include ease and cheapness in disseminating information through social media and global pressure on outbreak prevention. Kushwaha also considered the use of social media for communication is an advantage in combating Covid-19 in India (Kushwaha, 2021). It may afford opportunities for the local government to seek funding and technical guidance from national or international institutions. As a negative impact of ease of news circulation, hoax information regarding the pandemic may be accepted by the citizens. This may result in the worst impact, such as some people do not believe the existence of Covid-19.

SWOT matrix suggested that some strategies may be adopted as follows:

1. Strengths-Opportunities Strategies:

a. *National, provincial and city/district government must do monitoring and evaluation to improve the service quality.*

Global pressure and national policy must be translated into real practices. However, it is very often not implemented. Therefore, the higher level must do monitoring and evaluation to the lower level. The Indonesian government must establish an integrated monitoring system to evaluate the program implementation at various levels. **Table 2** indicates that the implementation of monitoring and evaluation has been carried out, but it has not reached all related stakeholders. Therefore, the environmental office must establish coordination until village level. According to IGES study on some developing countries including Indonesia, Health Care Waste Management (HCWM) facilities should be developed and equipped with integrated monitoring system ("Waste Manag. Dur. COVID-19 Pandemic," 2020).

## 2. Strengths-Threats Strategies:

a. *Public health office of city/district government must intensively provide correct information on the pandemic through various media and institutions.*

False information circulated in a society may develop a distrust of government programs. As indicated in **Table 3**, some people may not believe the existence of Covid-19 due to hoax information about the pandemic. Therefore, the local government will encounter difficulties in implementing the programs. The government must combat the false information with correct information. SI patients testify that they did not receive any information on the SOP from hospital, public health center, or environmental office. Therefore, the public offices and environmental offices must undertake socialization and campaigns through hospitals, public health centers, and various online media.

As also suggested by Panjaitan, the Indonesian Government should deploy village officials to educate communities until household association level through regular meetings (Indonesia & Panjaitan, 2021).

## 3. Weaknesses-Opportunities Strategies:

- a. *Provincial and city/district government must actively seek funding and partnership to the national government, private sectors, and international agencies to improve their facilities and personnel.*
- b. *City/district government must establish a strong information network between environmental offices and health institutions especially on SI patients*
- c. *City/district government must intensively provide SOP information of Covid-19 Infectious Waste Management for SI patients through hospitals, public health centers, and various media.*

The most important parts of Covid-19 infectious waste management are separation, collection, and transportation. As evaluated in **Table 2**, these aspects do not comply with the guidance. The collection route does not reach SI patients (households). Therefore, the separated infectious waste done by some SI patients is collected by regular operators and transported to the municipal landfill. The local government could establish a partnership with the private sector and seek funding through cooperation with domestic and foreign institutions to resolve the problems. According to IGES (2020), encourage multisectoral cooperation at all levels is one of a key consideration for making contingency plans. Inviting third party operators for collection of the infectious waste in specific containers from scattered locations can be considered ("Waste Manag. Dur. COVID-19 Pandemic," 2020). With such cooperation, city/district government may also establish a strong information network to manage SI patient data, distribute the infectious waste guidance, and manage their infectious waste. IGES suggests that map out sources generating potentially COVID-19-contaminated waste and healthcare waste from homes with self-isolated patients is very important during the pandemic. Development of media such as website, social media platform, for provision of SOP information of Covid-19 Infectious Waste Management are also encouraged ("Waste Manag. Dur. COVID-19 Pandemic," 2020).

## 4. Weaknesses- Threats Strategies:

a. *Public health offices and environmental offices of city/district government must establish a strong coordination with various institutions to provide correct information regarding transmission potential of the virus.*

The false information (hoax) causes people to mis respond to the spread of the virus. Implementation of the Covid-19 infectious waste from SI patients requires full participation of the community itself. The government must combat the hoax by providing correct information to a substantial degree. Since the outbreak of the delta variant, many mass media have reported the weakness of health facilities in Indonesia, which is partly intended to incite. This results in public distrust of hospitals. People with mild and moderate symptoms choose not to go to the hospital, which has resulted in many patients not being registered as active positive, making it difficult to handle their waste.

## 4. Conclusion

The Indonesian Minister of Environmental and Forestry issued a circular letter providing a Standard Operating Procedure (SOP) to manage Covid-19 infectious waste from health facilities and households and instructing all governors to implement it in their territory. However, of the three cities sampled, only Padang City has taken actions. However, the management of the Covid-19 infectious waste from SI patients in Padang City has not been completely implemented. Therefore, the Covid-19 infectious wastes from SI patients have been contaminating other household wastes and ending up in municipal landfill or other dumping sites. The bad history of municipal HHW management in Indonesia suggests that the lack of concern from the government and society could be the main cause.

The implementation of Covid-19 infectious waste faces some weaknesses, including facility and personnel shortages, lack of coordination between implementing agencies, poor socialization and campaigns, weak database, and lack of monitoring and evaluation. The national and local government are not ready to implement the SOP. Furthermore, it may contribute to the lack of public awareness about the dangers of Covid-19 infectious waste and its handling procedures. Provincial, city or district government may build a partnership with third party institutions at national and international level that can help in the infectious waste management. To combat the hoaxes, the public offices and environmental offices must campaign the correct information through hospitals, public health centers, and various online media. Finally, to ensure sustainability, the Indonesian government must establish an integrated monitoring system to evaluate the program implementation at various levels.

## Declarations

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**Conflict of interest** All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

**Ethics approval** Not applicable

**Consent to participate** Not applicable

**Consent for publication** Not applicable

**Availability of data and material** Not applicable

**Code availability** Not applicable

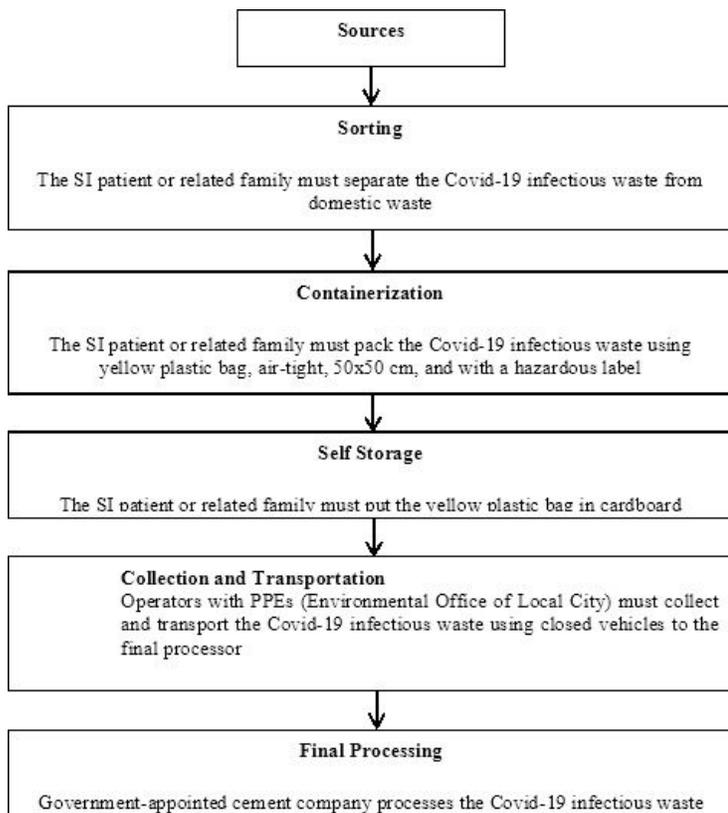
**Authors' contributions** All authors contributed to online data collection. All authors read and approved the final manuscript.

## References

1. *Bulan Berlalu Sejak Jokowi Umumkan Kasus Pertama Corona di RI*. (n.d.). Retrieved September 9, 2021, from <https://news.detik.com/berita/d-5156069/6-bulan-berlalu-sejak-jokowi-umumkan-kasus-pertama-corona-di-ri>
2. *Dewan Guru Besar FKUI: Fasilitas Kesehatan Indonesia Belum Siap Tangani Covid-19 Halaman all - Kompas.com*. (n.d.). Retrieved September 9, 2021, from <https://nasional.kompas.com/read/2020/03/27/10403401/dewan-guru-besar-fkui-fasilitas-kesehatan-indonesia-belum-siap-tangani-covid?page=all>
3. *Dokter Jelaskan Penyebab Covid-19 Begitu Cepat Penyebarannya | Republika Online*. (n.d.). Retrieved September 9, 2021, from <https://republika.co.id/berita/q7cn9i414/dokter-jelaskan-penyebab-covid19-begitu-cepat-penyebarannya>
4. Standar Operating Prosedur (SOP) Pengelolaan Limbah Infeksius dari Fasyankes dan ODP dan Sampah Sejenis Rumah Tangga dari Penanganan Covid-19 Bekerjasama dengan PT. Semen Padang (Lampiran Keputusan Gubernur Sumatera Barat Nomor 660-285-2020 tentang Penunj, Pub. L. No. 660-285-2020 (2020).
5. Tata Cara Penanganan Limbah B3 Infeksius Covid-19 di Fasilitas Karantina (Lampiran II Surat Gubernur Sumatera Barat Nomor 360/021/COVID-19-SBR/IV-2020 Perihal Pengelolaan Limbah B3 Infeksius di Tempat Karantina ODP dan Covid Positif Ringan), Pub. L. No. 360/021/COVID-19-SBR/IV-2020 (2020).
6. Indonesia, C.-D. I., & Panjaitan, V. E. (2021). *Jurnal Tata Sejuta*. 7(2), 1–23.
7. *Kasus Covid-19 di Padang Turun Sejak Awal September | Republika Online*. (n.d.). Retrieved December 30, 2021, from <https://www.republika.co.id/berita/qzgzc4366/kasus-covid-19-di-padang-turun-sejak-awal-september>

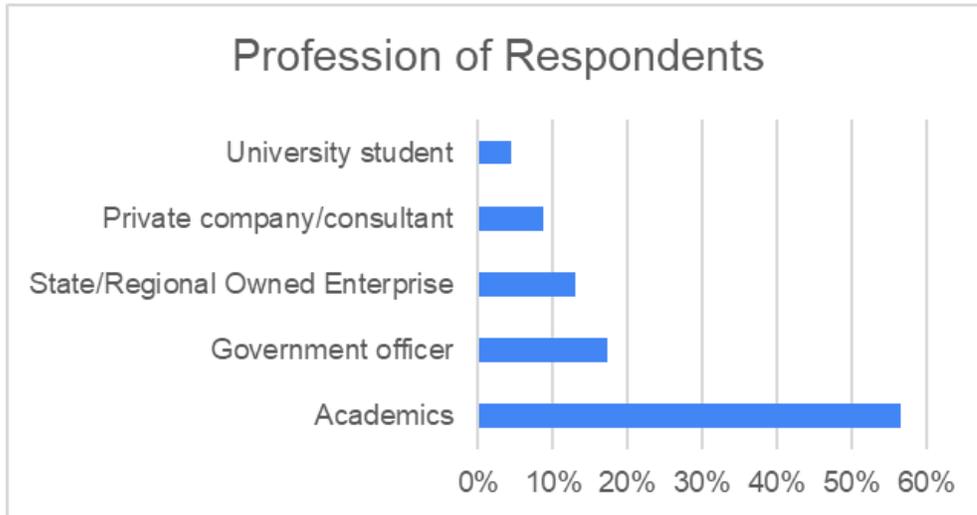
8. Kushwaha, A. (2021). *SWOT analysis paper. February.*
9. Masuk Limbah B3, *Sampah Medis Covid-19 Mesti Dikelola Khusus.* (n.d.). Retrieved September 9, 2021, from <https://padangkita.com/masuk-limbah-b3-sampah-medis-covid-19-mesti-dikelola-khusus/>
10. Menteri Kesehatan Republik Indonesia. (2020). *Keputusan Menteri Kesehatan Republik Indonesia Nomor HK.01.07/MENKES/413/2020 tentang Pedoman Pencegahan dan Pengendalian Coronavirus Disease 2019 (Covid-19).* Republik Indonesia.
11. Nugraha, C. (2020). Tinjauan Kebijakan Pengelolaan Limbah Medis Infeksius Penanganan Corona Virus Disease 2019 (Covid-19). *Jurnal Karya Ilmiah Teknik Lingkungan ITENAS.*
12. Raharjo, S., Bachtiar, V. S., Ruslinda, Y., Matsumoto, T., & Rachman, I. (2019). Improvement of recycling-based municipal solid waste management in Padang City, West Sumatera, INDONESIA. *IOP Conference Series: Earth and Environmental Science, 245(1).* <https://doi.org/10.1088/1755-1315/245/1/012007>
13. Ruslinda, Y., Raharjo, S., Dewilda, Y., Hidayatullah, & Aziz, R. (2019). Minimization of household hazardous solid waste (HHSW) with 4R concepts (reduce, reuse, recycle and recovery) in Padang City, Indonesia. *IOP Conference Series: Materials Science and Engineering, 602(1).* <https://doi.org/10.1088/1757-899X/602/1/012055>
14. *Soroti Penanganan Limbah Medis yang Meningkatkan Selama Covid-19 | Kementerian Koordinator Bidang Pembangunan Manusia dan Kebudayaan.* (n.d.). Retrieved December 30, 2021, from <https://www.kemenkopmk.go.id/soroti-penanganan-limbah-medis-yang-meningkat-selama-covid-19>
15. *Surat Edaran Menteri Lingkungan Hidup Dan Kehutanan Nomor SE.2/MENLHK/PSLB3/PLB.3/3/2020 Tahun 2020 - Covid-19* *Hukumonline.com.* (n.d.). Retrieved July 18, 2021, from <https://covid19.hukumonline.com/2020/03/24/surat-edaran-menteri-lingkungan-hidup-dan-kehutanan-nomor-se-2-menlhk-pslb3-plb-3-3-2020-tahun-2020/>
16. Waste Management during the COVID-19 Pandemic. (2020). In *Waste Management during the COVID-19 Pandemic.* <https://doi.org/10.18356/abfaaadd-en>
17. Yu, H., Sun, X., Solvang, W. D., & Zhao, X. (2020). Reverse Logistics Network Design for Effective Management of Medical Waste in Epidemic Outbreak: Insights from the Coronavirus Disease 2019 (COVID-19) in Wuhan. *SSRN Electronic Journal.* <https://doi.org/10.2139/ssrn.3538063>

## Figures



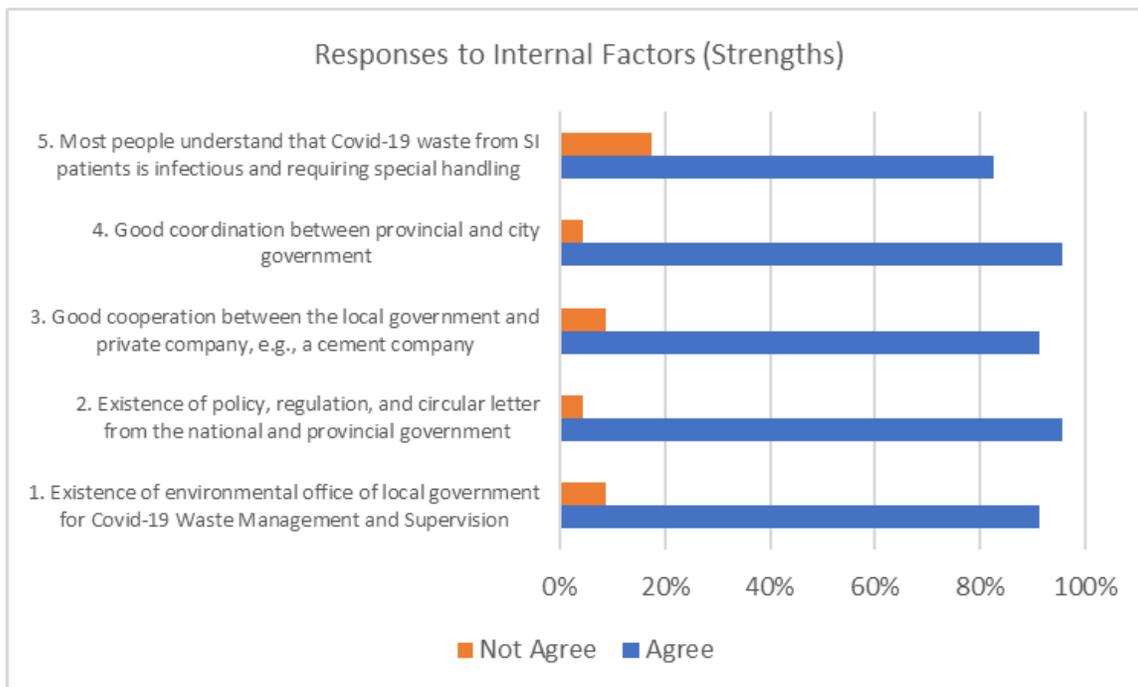
**Figure 1**

Schematic of Covid-19 Infectious Waste Management in West Sumatera (*Surat Edaran Menteri Lingkungan Hidup Dan Kehutanan Nomor SE.2/MENLHK/PSLB3/PLB.3/3/2020 Tahun 2020 - Covid-19 Hukumonline.Com, n.d.*) (*Masuk Limbah B3, Sampah Medis Covid-19 Mesti Dikelola Khusus, n.d.*) (*Tata Cara Penanganan Limbah B3 Infeksius Covid-19 Di Fasilitas Karantina (Lampiran II Surat Gubernur Sumatera Barat Nomor 360/021/COVID-19-SBR/IV-2020 Perihal Pengelolaan Limbah B3 Infeksius Di Tempat Karantina ODP Dan Covid Positif Ringan), 2020*) (*Standar Operating Prosedur (SOP) Pengelolaan Limbah Infeksius Dari Fasyankes Dan ODP Dan Sampah Sejenis Rumah Tangga Dari Penanganan Covid-19 Bekerjasama Dengan PT. Semen Padang (Lampiran Keputusan Gubernur Sumatera Barat Nomor 660-285-2020 Tentang Penunj, 2020).*



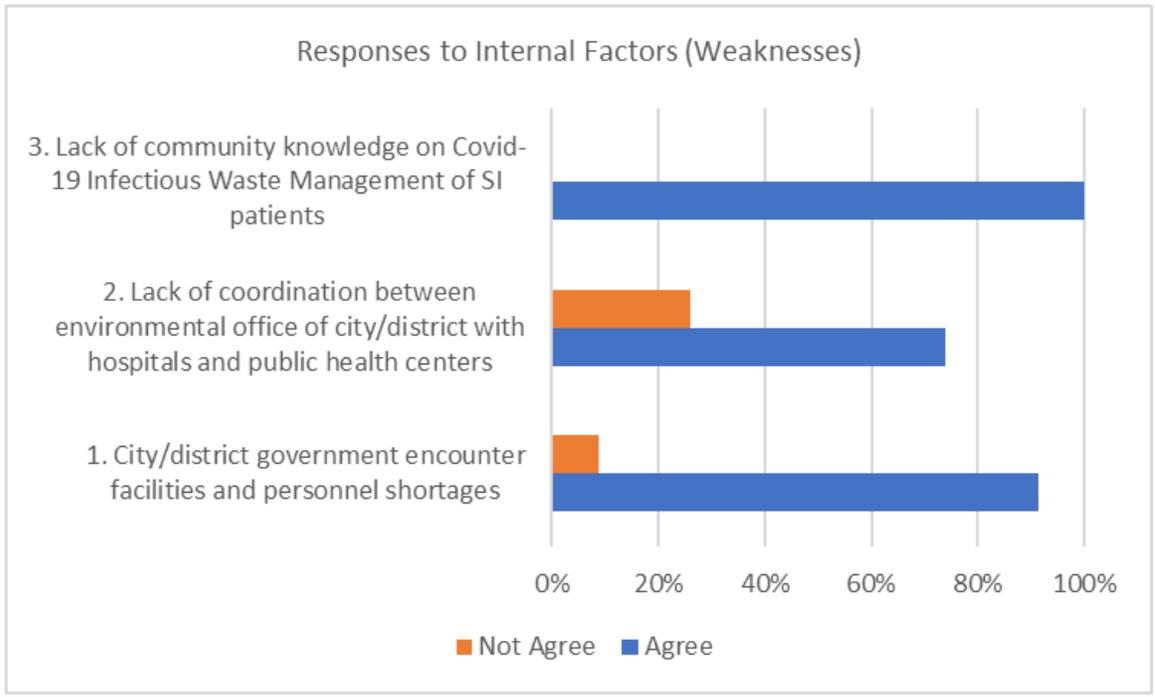
**Figure 2**

Profession of respondents.



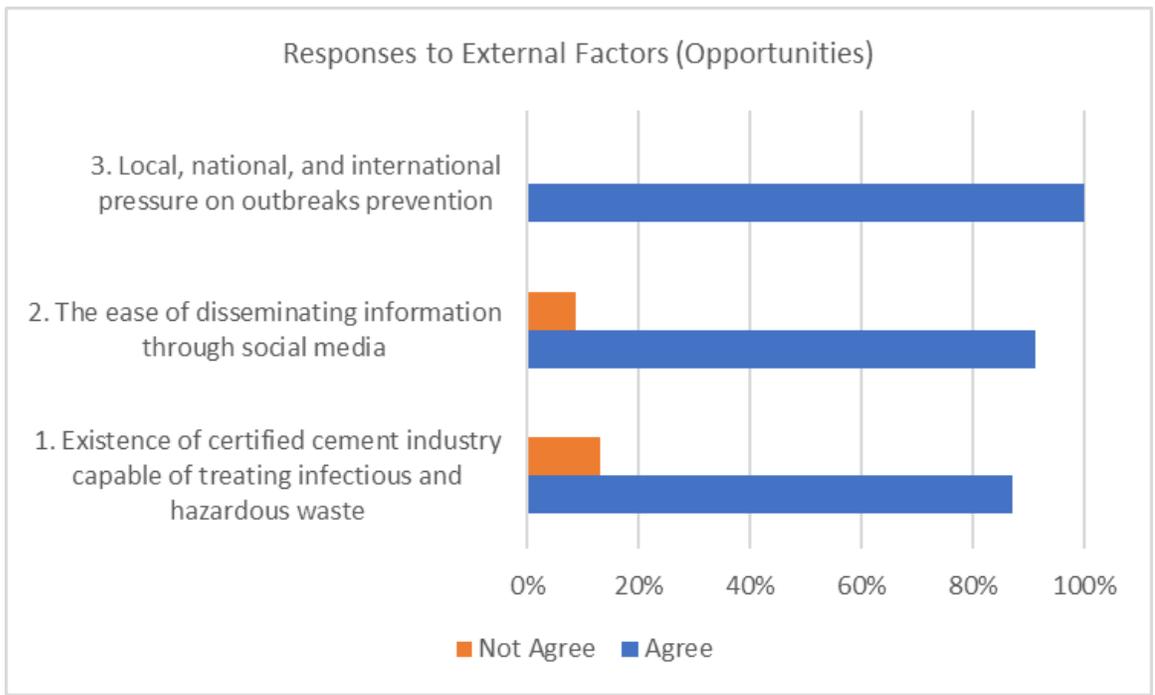
**Figure 3**

Responses to internal factors (strengths)



**Figure 4**

Responses to internal factors (weaknesses)



**Figure 5**

Responses to external factors (opportunities)

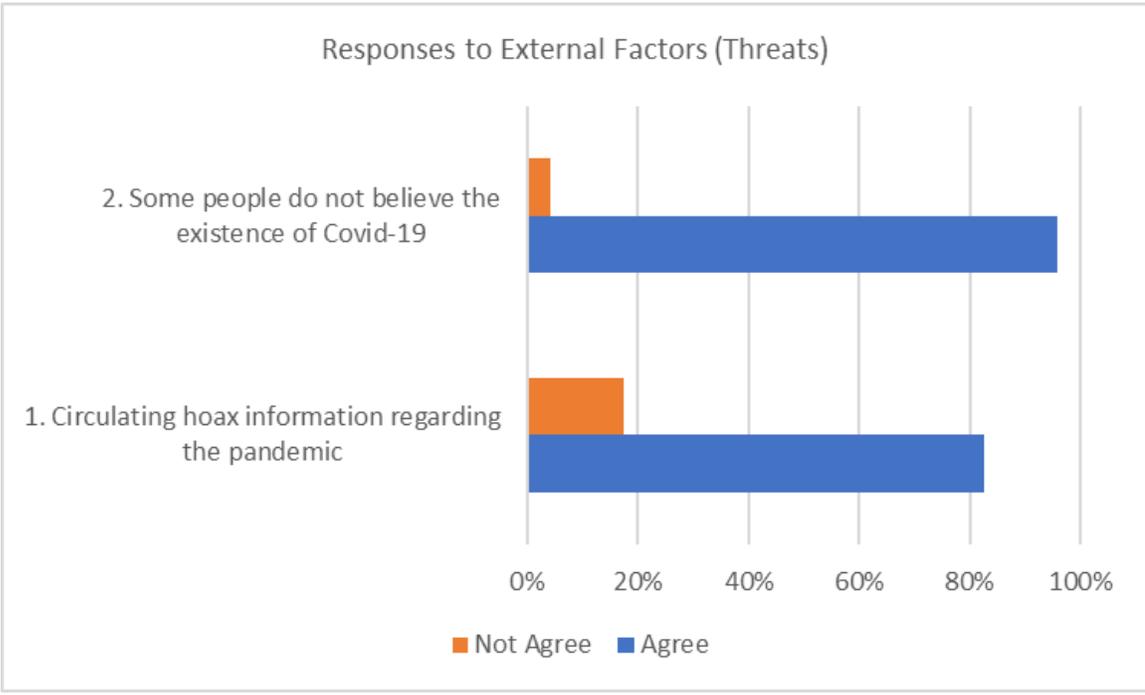


Figure 6

Responses to external factors (threats)