Concept of Emergency Health Infrastructure Provision in Minimizing the Impact of Earthquakes

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Abstract. Surabaya City has the potential for an earthquake of 6.5 SR. Based on the previous research, the level of emergency health infrastructure readiness in Surabaya City is 0-34%. It was reported that due to the unpreparedness of the health infrastructure during the Lombok Earthquake (2018), 1,477 injured victims did not get proper treatment. Therefore, this research is aimed to formulate the concept of providing emergency health infrastructure to reduce the earthquake risk. This research is qualitative research type with two methods of analysis, particularly content analysis and triangulation. Content analysis was utilized to identify criteria for providing emergency health infrastructure. Meanwhile, triangulation was utilized to formulate the concept of providing emergency health infrastructure. The results of this study are 32 criteria in the provision of emergency health infrastructure. From these criteria, the concept of providing emergency health infrastructure was formed, divided into three disaster phases: 1) Mitigation, 2) Preparedness, and 3) Response. In the mitigation phase, the concept focuses on procuring medical supplies, increasing the competence of health workers, and mapping potential emergency care at the disaster site. In the preparedness phase, the concept focuses on cross-sectoral coordination for activating the emergency care unit in a disaster site, synchronizing the availability of medical equipment, and establishing a health team. Meanwhile, in the emergency response phase, the concept focuses on mobilizing the required medical equipment and health workers, also optimizing health services based on health standards.

1. Introduction
The impact of earthquakes can cause building and infrastructure damages, including health infrastructure. Emergency health infrastructure is needed to accelerate recovery and provide emergency treatment to survivors (Arboleda et al., 2009). The conditions of the victims could worsen due to the limited supply and service of emergency health infrastructure (Pascapurnama, et al., 2018). Based on Aghapour et al (2016), the unprepared emergency health infrastructure provision can make the number of fatalities become higher.

Surabaya City has a potential earthquake with a magnitude of 6.5 (PusGen, 2017). It is due to the activity of Surabaya and Waru Faults (Figure 1). Based on the previous research, the level of all infrastructure readiness in Surabaya City is high for a normal condition: 4,135 out of 5 (Fauzan, 2018). However, the infrastructures could not work effectively during the earthquake emergency response period (Daryono, 2016; Fauzan, 2018). Meanwhile, the level of emergency health infrastructure readiness in Surabaya is still 0-34% (Jannah, 2019). It means that Surabaya City still needs to prepare the emergency health infrastructure from the mitigation phase to the response phase to minimize the impacts of an earthquake event.
During the 2011 Tohoku Earthquake (9 SR), there were lots of hospitals and clinics damaged (Ishigaki et al., 2013). It was also reported that the condition of the victims in the Tohoku Region was getting worse due to the various diseases that appeared in evacuation sites: infectious diseases (influenza, tuberculosis, pneumonia), cardiovascular diseases, diabetes, dialysis, gastrointestinal diseases, respiratory disease, asthma, and deep vein thrombosis (Yamamoto, et al., 2015). Besides, the death rate of the 2010 Haiti Earthquake (SR 7) also increased due to the cholera outbreak that threatened the victims in evacuation sites. Cholera appeared because the clean water and sanitation infrastructure were damaged (Cavallo et al., 2010). Meanwhile, in Lombok 2018 Earthquake (SR 7), there were at least 1,477 people were severely injured during the 5 August earthquake (AHA Centre, 2018). Those injured victims did not get proper treatment due to limited health personnel, medicines, and the lack of availability of emergency care (Amindoni, 2018).

Based on the impacts of previous earthquakes in several areas, the unreadiness of emergency health infrastructure could worsen the condition. Therefore, this paper discusses on concept formulation of emergency health infrastructure after an earthquake event in Surabaya City.

2. Methods

Two methods of analysis in this study are content analysis and triangulation. Content analysis was utilized to identify criteria for providing emergency health infrastructure. This analysis was started by conducting in-depth interviews with eight relevant key stakeholders. The stakeholders were selected based on their interests and experiences in health infrastructure provision during the emergency response period. The stakeholders are government agencies (including East Java Provincial Public Health Office and Surabaya City Disaster Management and Community Protection Agency), Civil Society parties (consist of Anesthesiologist and Indonesian National Nurses Association (PPNI)), NGO (The Indonesia City Red Cross (PMI), Muhammadiyah Disaster Management Center (MDMC), and Indonesia's Resilience Society (MTI)), and private sector from various companies (consist of Gudang Garam, Prudential, Indosat Ooredoo, Sido Muncul, INALUM, Pertamina, PT. Kimia Farma, and Amman Mineral). From 8 selected stakeholders, one stakeholder from the private sector could not do an in-depth interview due to the Covid 19 pandemic. Therefore, the data collection from the private sector was conducted through an online system using google search engine with the keywords “Bantuan” (Help), “Ketersediaan rumah sakit lapangan” (Availability of field hospital), “Swasta” (Private Sector), “Gempa Palu 2018” (The 2018 Palu Earthquake). The online information was limited by the case of Palu and Lombok Earthquakes (2018). Meanwhile, the results of the in-depth interviews and online data collection were analyzed through the content analysis technique (Krippendorff, 2004).

Afterward, the triangulation technique was utilized to formulate the concept of health infrastructure provision. Based on Moloeng (2004), triangulation uses a validation process by comparing the result of
criteria health infrastructure with literature reviews, and guidelines or regulations Indonesian and Surabaya context.

To conduct this research, four indicators and twelve variables were formulated from twenty-two literature. The indicator and variables are shown in Table 2.1.

Table 2.1 Indicators and Variables for Emergency Health Infrastructure in An Emergency Response Period.

| Indicators                        | Variables                              | Sources                                                                 |
|-----------------------------------|----------------------------------------|-------------------------------------------------------------------------|
| Availability of Emergency Care    | Availability of Field Hospital          | (Demirkiran, Dikmen, Utku, & Urkmez, 2003);                            |
| Unit                              | Availability of Mobile Clinic           | (Kuwugata, Oda, & Tanaka, 1998);                                       |
|                                   | Availability of General Practitioners   | (Memarzadeh, Loghmani, & Jafari, 2004); (Territorial Army, 2004)      |
|                                   | Availability of Surgeons               | (Bitterman & Zimmer, 2018);                                            |
|                                   | Availability of Anesthetist            | (Cheng, et al., 2015);                                                 |
|                                   |                                        | (Mortier & Coninx, 2007)                                               |
| Availability of Health-Care       | Availability of Nurses                 | (Abbasi & Salehnia, 2013);                                             |
| Workers                           |                                        | (Jennings-Sanders, 2004);                                              |
|                                   | Availability of Midwives               | (Jennings-Sanders, Frisch, & Wing, 2005); (Polivka, et al., 2008);     |
|                                   |                                        | (Vogt & Kulbok, 2008)                                                  |
|                                   | Availability of Midwives               | (Abbasi & Salehnia, 2013);                                             |
|                                   |                                        | (International Confederation of Midwives, 2014)                        |
|                                   | Availability of Medicines              | (Bell & Daniel, 2014)                                                  |
| Availability of Medical Supplies  | Availability of Medical Devices        | (The Sphere Project, 2011)                                             |
|                                   | Availability of Blood Bank             | (Abolghasemi, Radfar, Tabatabaee, Hosseini-Divkolyee, & Burkle, 2008); |
|                                   |                                        | (Zaheer, 2012)                                                        |
| Availability of Ambulance         | Availability of Ambulance              | (Hosseini, Hosseini, & Mansouri, 2008); (Kondo, et al., 2012);         |
| Health Transportation             |                                        | (Pourhosseini, Ardalan, & Mehrolhassani, 2015)                         |
|                                   | Availability of Helicopter             | (Hosseini, Hosseini, & Mansouri, 2008); (Johnsen, Fattah, Solid, & Rehn, 2015); (Li & Zheng, 2014); (Moto}\n|                                   |                                        | (Moto, et al., 2018)                                                  |

3. Results and Discussions

3.1. Criteria and Responses for Emergency Health Infrastructure Provision

3.1.1. Criteria and Responses for Availability of Emergency Care Unit.

An emergency care unit is needed during the emergency response phase as an alternative when the hospitals and clinics were damaged. Based on the previous research, there were more than 50% of hospitals damaged after the 2010 Haiti Earthquake (7 SR). Therefore, the role of the emergency care unit in disaster sites is important as an alternative site to provide health services (Desroches et al., 2011). After conducting an in-depth interview with seven stakeholders and reviewing some literature, there was one additional variable, namely the health post as the first unit for health services before the victims are referred to the field hospital. A health post is built to provide the first emergency care to disaster victims after being evacuated from the disaster site (Departemen Kesehatan RI, 2007).

"It has not reached the field hospital yet. So, there is still a health post where the minimum needs are available. It can provide further services after the emergency condition ..." (MTI, January 22nd, 2020, translated)
In this indicator, there are 16 criteria for the availability of an emergency care unit. In formulating the criteria for availability of emergency care unit needs to consider the location, the need of health workers, and the health service capability. As an example, for this indicator will be explained some criteria for the availability of field hospital variables.

Provision of the field hospital is important in the disaster site. It is mentioned that the field hospital is even more important in the case of an earthquake because of the damage of the normal health infrastructure (Finestone et al., 2001). When building a field hospital, it is necessary to pay attention to the appropriate location criteria. Tim Penilaian Cepat (Rapid Health Assessment (RHA) Team) will go to the disaster site to identify the location of the field hospital establishment and determine other health needs. The assessment by the RHA Team is important to ensure that the field hospital is based on the needs. Based on the stakeholder from MDMC, the location to build a field hospital must consider proximity to the main hospital that is not damaged. Vafaei & Oztaysi (2014) states that the proximity of field hospitals to the existing hospitals can speed up the referral process when the victims need further medical actions. Besides, proximity to public hospitals will make it easier to get medical aid and available medical equipment.

"... And usually the field hospital is set up close to the main hospital. In the area or near the main hospital. " (MDMC, February 7th, 2020, translated)

Besides, the field hospital must also have easy access. Based on the stakeholder from PPNI, to build a field hospital, it must consider proximity to the arterial road and be in a safe area. The field hospitals must be built close to the transportation access, especially arterial roads, for a minimum of 100 - 500 meters (Vafaei & Oztaysi, 2014). The proximity of the field hospital to the arterial road will make it easier to receive and distribute health assistance and evacuate the disaster victims.

"... yes, a field hospital must be built near the arterial road so that transportation for that can be easy." (PPNI, February 3rd, 2020, translated)

Responses for the availability of emergency care unit consider the results of the criteria. In preparing the location to build an emergency care unit, the response needed is to make a map of potential locations for health posts and field hospitals based on the results of the criteria. Mapping the prospective locations to build an emergency care unit is needed to ensure security in providing health services for the victims (Basu et al., 2017). The result of field hospital mapping can be used as a guide to accelerate the establishment of the field hospital in the disaster site. In terms of ensuring the need for the establishment of the field hospital, it is necessary to conduct cross-sectoral coordination to activate the establishment of the field hospital in the disaster site during an emergency (Peraturan Menteri Kesehatan No 75 Tahun 2019). Based on Merin et al (2010), activation of field hospitals must be done quickly so that more victims can be handled.

More detailed information about criteria and responses for the availability of emergency care unit is shown in Table 3.1.

| Variables | Criteria | Responses |
|-----------|----------|-----------|
| Availability of Health Post | Close to the evacuation sites | 1.1 Mapping prospective locations for health posts |
| | The location has an area of at least 73 m² | 1.2 Mapping prospective locations for field hospital |
| | At least 1 health team consists of 1 doctor, 1 nurse, and 1 midwife | 1.3 Cross-sectoral coordination to activate |
| | Able to provide basic health services of at least 100 people per day |           |
| | Health services are carried out 24 hours, divided into 3 shifts |           |


### Availability of Field Hospital

1. Close to arterial roads at least 100 - 500 m
2. Close to the existing hospital which is still operational
3. Close to the water and electricity sources
4. Health-care workers needed, at least including:
   - Surgeon
   - Anesthesiologist
   - Intensive Care Specialist
   - Pediatrician
   - Obstetricians and gynecologists
   - Nurses
   - 1 Pharmacist
   - 1 Radiologist
   - 1 Laboratory technician
5. Able to provide outpatient services to at least 100 people per day
6. Able to provide inpatient services to at least 20 people per day
7. Able to provide minor surgical services at least 15 times per day
8. Able to provide major surgical services at least 7 times per day
9. Provide health service of at least 50 people per day
10. The duration of health service is at least 8 hours per day

### Availability of Mobile Clinic

11. Health team consists of at least 2 nurses who can provide emergency health services
12. Optimization of basic health services for victims in and around the evacuation sites
13. Optimization of referral patient services
14. Optimization of integrated mobile health services
15. Providing emergency health training for the health-care workers
16. Cross-sectoral coordination to ensure the availability of the health-care workers
17. Establishing a health team
18. Mobilization of the need for health-care workers based on rapid health assessment

### 3.1.2. Criteria and Responses for Availability of Medical Supplies.

Medical supplies have a vital role to accelerate the health services for the victims. Thirteen criteria for the availability of medical supplies are formulated to meet the needs of medical supplies in every health unit (health posts and field hospital). The following paragraphs discuss the example on criteria and response formulation.

Based on stakeholders from MDMC, the provision of medical devices in the field hospital should have minimum medical devices standard like in a normal hospital. A field hospital in disaster condition acts as a referral health facility when the victims in the health posts need more adequate surgical treatment. MDMC suggests that minimum medical devices in the field hospital include minor surgical equipment sets (sewing needles and anesthetic drugs), radiographs, and mobile X-rays. During the Turkish earthquake in 1999, four main medical devices were needed in the field hospital that are: surgical equipment, radiology equipment, laboratory supporting equipment, and blood supply equipment (Finestone, et al., 2001). Online news also mentioned that the private sector (PT Sido Muncul) provided medical assistance in the form of medical devices, including surgical equipment, surgical gowns, wheelchairs, medicines, and implants for the victims in Lombok (2018).

“If there is a field hospital, it should be on normal hospital standard. There will be a set of minor surgical tools, including surgical scissors, surgical needles, and anesthetic medicine, all of these have to be available. If we want to establish a field hospital, it should be equipped with radiographs, as well as mobile X-rays.” (MDMC, February 7th, 2020, translated)

“...Sido Muncul had already given help for the victims in Lombok. Sido Muncul gave them medical devices, such as disposable surgical gowns, the implant that would be put inside the body of the victims who had fractures and other medical devices” (PRIVAT, June 17th, 2020, https://sains.kompas.com/read/2018/08/12/222220728/sido-muncul-beri-bantuan-bagi-korban-gempa-lombok, translated)

Meanwhile, five main responses should be done to provide medical supplies meeting the selected criteria. The first response is to conduct procurement of medicine buffer stock in every hospital. In the United States, it has medicine stock called 12-hour Push Package that has to be distributed within 12
hours after the disaster attacked (Bell & Daniel, 2014). Based on (Kepmenkes No 59 Tahun 2011, 2011), it is necessary to procure a supply of medicine and medical supplies as a buffer in the event of a disaster. The buffer must be available from the city level, provincial level, to the central level (Kepmenkes No 59 Tahun 2011). The amount of medicine buffer stock that can be carried out by pharmacy warehouse both at the hospital and at the City Health Office: 10-20% of the available medicines (Kementerian Kesehatan RI, 2019). The second response is to do inventory on medical devices. Inventory activities include identification of the number of medical devices, the condition of the devices, and the storage location (Perka BNPB No 11 Tahun 2011). It is important to do procurement of medicine and inventory of medical devices to ensure the availability of it when a disaster occurs. The third response is to mobilize the needs of medical supplies from medicines, medical devices, and blood-based on rapid health assessment in the disaster site (Kementerian Kesehatan RI, Pusat Krisis Kesehatan, 2016). The fourth response is to conduct coordination to synchronize the availability of medical supplies. Meanwhile, the fifth response is to do coordination between the Blood Transfusion Unit or The Indonesia Red Cross and Hospital Blood Bank with the health units (health posts and field hospitals) in the disaster site. The coordination is to ensure that the blood has already been tested and confirmed the blood type (A, B, O) and the rhesus blood. Table 3.2 summarizes all responses to meet the criteria for the availability of medical supplies.

### Table 3.2 Criteria and Actions for Availability of Medical Supplies.

| Sub Variables                              | Criteria                                                                 | Responses                        |
|--------------------------------------------|------------------------------------------------------------------------|----------------------------------|
| Availability of Medicine in Health Post    | 1. At least there are symptomatic drugs, certain antibiotics, and injectable drugs in limited quantities | 2.1 Procurement of emergency medicine buffer stock 10-20% |
| Availability of Medicine in Field Hospital | 2. At least have all medicine in the National Essential Medicine List (Kepmenkes No 312 Tahun 2013, 2013) | 2.2 Inventory on medical devices |
| Availability of Medical Devices in Health Post | 3. There is at least airway equipment                                  | 2.3 Cross-sectoral coordination to synchronize the availability of medical supplies |
| Availability of Medical Devices in Field Hospital | 4. There is at least cardiac resuscitation equipment                   | 2.4 Mobilization of the need for medical supplies based on rapid health assessment |
| Availability of Blood Bank                 | 5. There is at least wound care equipment                               | 2.5 Coordination between the health units in the disaster site and the Blood Supplier (The Indonesia Red Cross and the Hospital Blood Bank) to provide and distribute blood |
|                                            | 6. There is at least pneumatic / electric equipment                     |                                  |
|                                            | 7. There is at least surgical equipment                                 |                                  |
|                                            | 8. There is at least radiology equipment                                |                                  |
|                                            | 9. There is at least laboratory supporting equipment                    |                                  |
|                                            | 10. There is at least blood supply equipment                            |                                  |
|                                            | 11. There is a cooperation between the health units at the disaster area with the Blood Transfusion Unit or The Indonesia Red Cross and the Hospital Blood Bank |                                  |
|                                            | 12. Blood distribution is carried out by a closed system and cold chain method |                                  |
|                                            | 13. The Blood must be tested and confirmed the blood type (A, B, O) and Rhesus blood groups |                                  |

### 3.1.3. Criteria and Responses for Availability of Health Transportation.

Health transportation is crucial to mobilize the victims to the health units to get proper treatment. Eight criteria for the availability of health transportation indicators are defined. The following paragraphs discuss the example on criteria and response formulation.

In an emergency due to an earthquake, the availability of an ambulance is urgently dispatched to a disaster site. The ambulances are used to transfer severely injured victims to the nearest health facility to get immediate treatment (Pourhosseini et al., 2015). Two types of ambulances are transportation
ambulance to transport victims with light injuries and emergency ambulance to give basic emergency services (Kepmenkes No 143/Menkes-Kesos/SK/II/2001).

“... an ambulance can be used to pick up the victims, it is called transportation ambulance which can carry the victims to the referral health facility. For example, if the victim living far away from the health unit so the victim will be picked up by an ambulance. Meanwhile, there is an emergency ambulance for the victims who need emergency treatment, it is equipped with enough medical devices...” (PPNI, February 3rd, 2020, translated)

In transporting the victims to the health facility, the emergency ambulance is equipped with medical equipment. Husna et al. (2018) states that the emergency ambulance has medical equipment consisting of minor surgical equipment, airway equipment, cardiac resuscitation equipment, and emergency medicines. It is also mentioned by the stakeholder from PPNI that emergency ambulances can give minor surgical to the victims. Yet, the emergency ambulance only can accommodate a maximum of 2 stretchers (Kepmenkes No 143 / Menkes-Kesos / SK / II / 2001). Besides that, the medical staff needed to give health services in an emergency ambulance are at least 1 doctor and 1 nurse who can provide emergency health services.

"An emergency ambulance can provide minor surgical, so it is equipped with minor surgical equipment" (PPNI, February 3rd, 2020, translated)

“There are at least 1 doctor and 1 nurse in an emergency ambulance to provide pre-hospital services to the victims” (PPNI, February 3rd, 2020, translated)

To prepare the criteria for availability of health transportation, there are five responses formulated. The key to providing good health services during a disaster is to meet medical supplies needs and ensure their availability before a disaster event (Pourhosseini et.al., 2015). This can be done through the concept of an inventory. It is also mentioned on Syahrir et al. (2015) that inventory of availability for medical needs can be applied in responding to natural disasters. Besides, it is also important to hold emergency training for the health-care workers. The trained health-care workers are the key to the success of health services during a disaster emergency response period (Berhanu et al., 2016). This training will increase the competence of health workers. As a result, they will be well prepared and understand dealing with disaster victims. The last response is mobilizing the need for ambulances to the disaster victim based on the rapid health assessment. The detailed information about criteria and responses for the availability of health transportation can be seen in Table 3.3.

| Sub Variables               | Criteria                                                                 | Responses                                                                 |
|-----------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Availability of transportation ambulance | 1. There is at least 1 nurse with emergency care capability             | 3.1 Providing emergency health training for health-care workers          |
|                             | 2. The maximum service capacity is 1 stretcher                          |                                                                          |
|                             | 3. Minimum required medical equipment:                                   |                                                                          |
|                             | • Airway equipment                                                       | 3.2 Ensure the availability of health-care workers                       |
|                             | • Cardiac resuscitation equipment                                       |                                                                          |
|                             | 4. Equipped with emergency medicines                                    | 3.3 Inventory on medical supplies                                       |
|                             | 5. There are at least 1 doctor and 1 nurse with emergency care capability|                                                                          |
|                             | 6. The maximum service capacity is 2 stretchers                         | 3.4 Ensure the completeness of medical equipment and medicine in every ambulance |
| Availability of emergency ambulance | 7. Minimum required medical equipment:                                   | 3.5 Mobilize the needs of ambulances based on rapid health assessment    |
|                             | • Minor surgical equipment                                               |                                                                          |
|                             | • Airway equipment                                                       |                                                                          |
|                             | • Cardiac resuscitation equipment                                       |                                                                          |
|                             | 8. Equipped with emergency medicines                                    |                                                                          |
3.2. Concept of Emergency Health Infrastructure Provision

The concept of emergency health infrastructure provision is needed to be a guideline for the government in preparing the emergency health infrastructure during the earthquake emergency response period. This concept integrates all the responses to meet all the criteria discussed above in accordance with the Disaster Risk Management (DRM) cycle. For the emergency health infrastructure provision, three main stages of DRM are relevant including mitigation, preparedness, and response. Those three stages of involvement ensure that the emergency health infrastructure will not be also provided only during the emergency after the earthquake but also prepared before the earthquake event. This approach will also make all the emergency health infrastructures mainly prepared before the earthquake.

Formulating the concept of emergency health infrastructure provision was conducted through the triangulation technique. The following paragraph discusses the example of the concept of emergency health infrastructure formulation.

A mobile clinic is necessary to be done to make it easier to reach the victims in evacuation sites. A mobile clinic is also can be an alternative to accelerate health services in the areas that have minimum access (Khanna & Naula, 2017). Based on criteria for availability of mobile clinic, the capacity of health services per day that can be provided by a mobile clinic is as many as 50 people with a service duration of 8 hours. It is mentioned on Peraturan Menteri Kesehatan No 75 Tahun 2019 that during the emergency response period, it is important to improve health services in accordance with health standards. The concept of improving health services can be carried out by providing an integrated mobile clinic to each evacuation tent. In the Bantul earthquake (2006), the provision of an integrated mobile clinic was effective in accelerating the health services and monitoring the health conditions of the victims in evacuation sites (Donna, 2007).

Detailed information about the concept of emergency health infrastructure in each disaster management cycle is shown in Figure 2.
Figure 2. Concept of Emergency Health Infrastructure from Mitigation, Preparedness, and Response.

4. Conclusion

Emergency health infrastructure has 32 criteria in minimizing the impact of earthquakes. Criteria for the availability of emergency care units focus on the location, the availability of the health-care workers, and the service capability. Criteria for the availability of medical supplies focus on the need for medicine and medical devices in each health unit as well as the process of blood distribution to the disaster site. Meanwhile, criteria for availability of health transportation focus on the completeness of medicine,
medical devices, and health-care workers that are needed in each ambulance. There are 20 key responses that should be taken to meet the criteria. From those responses generated the concept of health infrastructure provision that is classified into three-phase of disaster management cycle: Mitigation, Preparedness Phase, and Response. In the mitigation phase, the concept focuses on preparing the needs of medical supplies, the competence of the health-care workers, and mapping the potential area to build health units. In the preparedness phase, the concept more focuses on cross-sectoral coordination to ensure the activation of health units in the disaster site and the availability of medical supplies as well as health-care workers. Meanwhile, in the emergency response phase, the concept focuses on mobilizing the required medical supplies and health-care workers and optimizing health services based on the health standards.

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