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## AN OVERVIEW OF ACUTE RESPIRATORY INFECTION CASES BEFORE AND AFTER EXPOSURE TO VOLCANIC ASH

*Gambaran Kasus Infeksi Saluran Pernafasan Akut Sebelum dan Sesudah Adanya Paparan Abu Vulkanik*

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### ABSTRACT

**Background:** Volcanic ash due to volcanic eruptions has an impact on health. Volcanic ash can cause health problems such as irritation and acute respiratory infections (ARI). **Purpose:** This study aims to know the outlook of ARI cases before and after exposure to volcanic ash. **Methods:** This research is a descriptive observational study with a cross-sectional approach that used secondary data from Kepohbaru Health Centre. The population of this study was ARI patients in Kepohbaru Health Centre in February 2013 and February 2014. The sampling technique used is total sampling. The analysis used is univariate analysis. **Results:** The results of this study indicate that before exposure to volcanic ash, the majority of ARI cases were males (52.01%), age group 5–11 years (16.3%), and with no history of ARI (67, 85%). The majority of ARI patients after exposure to volcanic ash were female (53.67%), age group 5–11 years (15.5%), and with no history of ARI (58.37%). More cases of ARI occurred after rather than before exposure to volcanic ash. **Conclusion:** Before and after exposure, the most common cases of ARI were suffered by respondents in the age group 5–11 years who had no history of respiratory disease. The number of cases of ARI was higher after exposure to volcanic ash. ARI cases happened more on males before exposure, whereas after exposure, it happened more on females.

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### ABSTRAK

**Latar Belakang:** Abu vulkanik akibat erupsi gunung berapi menimbulkan dampak di bidang kesehatan. Abu vulkanik dapat mengakibatkan masalah kesehatan seperti iritasi dan Infeksi Saluran Pernafasan (ISPA). **Tujuan:** Penelitian ini bertujuan untuk mengetahui gambaran kasus ISPA sebelum dan sesudah adanya paparan abu vulkanik. **Metode:** Penelitian ini merupakan penelitian observasional deskriptif dengan pendekatan cross sectional dan menggunakan data sekunder dari Puskesmas Kepohbaru. Populasi penelitian ini adalah pasien ISPA di Puskesmas Kepohbaru pada

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Februari 2013 dan Februari 2014. Teknik pengambilan sampel yang digunakan adalah total sampling. Analisis yang digunakan yaitu analisis univariat. **Hasil** : Hasil penelitian ini menunjukkan bahwa sebelum adanya paparan abu vulkanik, mayoritas kasus ISPA diderita oleh laki-laki (52,01%), kelompok usia 5-11 tahun (16,3%), dan tidak memiliki riwayat penyakit ISPA (67,85%). Mayoritas penderita ISPA setelah adanya paparan abu vulkanik adalah berjenis kelamin perempuan (53,67%), kelompok usia 5-11 tahun (15,5%), dan tidak memiliki riwayat penyakit ISPA (58,37%) . Kasus ISPA lebih banyak terjadi setelah adanya paparan daripada sebelum adanya paparan abu vulkanik. **Kesimpulan**: Sebelum dan sesudah adanya paparan kasus ISPA paling banyak diderita oleh responden dengan kelompok usia 5-11 tahun dan tidak memiliki riwayat penyakit ISPA. Jumlah kasus ISPA lebih banyak setelah adanya paparan abu vulkanik. Kasus ISPA lebih banyak diderita laki-laki sebelum adanya paparan abu vulkanik, sedangkan setelah adanya paparan lebih banyak diderita perempuan.

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## INTRODUCTION

Some regions in Indonesia are prone to disasters. There are 13 types of disasters that occur in Indonesia. These disasters can be in the form of geological, hydro-meteorological, biological, or social disasters. Geological disasters that have recently occurred in Indonesia are volcanic eruptions (Susilo & Rudiarto, 2014). One recent volcanic eruption that occurred in Indonesia was the eruption of Mount Kelud on 14 February 2014. Volcanic ash due to the eruption of Mount Kelud spread to various provinces in Indonesia, namely East Java, Yogyakarta Special Region, Central Java, and several areas in West Java (Suryani, 2014).

The distribution of volcanic ash due to the eruption of Mount Kelud was quite thick, more than 2 cm. Six international airports had to stop operating. The number of deaths due to the eruption was less than the previous eruption of Mount Kelud in 1919, but the distribution of volcanic ash caused several problems (Suntoro, Widijanto, Sudadi, & Sambodo, 2014). At last eruption, there were four main hazards caused by the eruption of Mount Bromo, namely gas emissions, ballistics, volcanic mud flows, and landslides. The four hazards had a direct impact on the communities around the Mount Bromo area. (Mohamed et al., 2015).

Volcanic ash that spreads in the air at less than 2 micrometres can lead to several health problems. Some of these health problems are skin

irritations, diarrhoea, headache, and acute respiratory infection (ARI). Volcanic ash exposure from the Mount Kelud eruption reportedly resulted in around 78 refugees in Kediri regency suffering hypertension and 364 refugees suffering ARI. When Mount Sinabung erupted in 2014 reportedly around 780 refugees in Karo District suffered from ARI due to volcanic ash exposure (Suryani, 2014).

Based on a risk analysis from Adra Indonesia (2017) after the eruption of Mount Agung in 2017, ARI was ranked as the first disease to occur after the eruption. ARI is a major cause of refugee morbidity and mortality during natural disasters, especially in the age group of less than five years. Access to health services and lack of antibiotics in refugee camps increases the risk of death from ARI. The density of refugee camps, exposure to public kitchen fumes, and poor nutritional intake are also factors in the risk of ARI in refugee camps.

Research on the impact on health due to exposure to volcanic ash has rarely been implemented. Some studies show that exposure to volcanic ash from volcanic eruptions is a risk factor for ARI. The purpose of this research is to determine the description of ARI cases before and after exposure to volcanic ash due to the eruption of Mount Kelud at Kepohbaru Health Centre in Bojonegoro Regency.

## METHODS

This research is a descriptive observational study. The research design used was cross sectional. Secondary data were obtained from Kepohbaru Health Centre, Bojonegoro Regency. The population in this study were all ARI patients who visited Kepohbaru Health Centre in February 2013 and February 2014. This study used total sampling.

The number of ARI cases prior to the exposure of volcanic ash was the number of ARI patient visits at the Kepohbaru Health Centre in February 2013, while the number of ARI cases after the exposure was the number of ARI patient visits in Kepohbaru Health Centre in February 2014. The variables that will be examined in this study include gender, age, and history of ARI. These variables were obtained from sources of ARI case report data published every month in the form of aggregate data. Sex variables were categorized into two, namely men and women. Age variables were categorized into nine, namely ages 0–4 years (toddlers), 5–11 years (children), 12–16 years (early adolescents), 17–25 years (late adolescents), 26–35 years (early adults), 36–45 years (adults), 46–55 years (middle aged), 56–65 years (later middle age), and > 65 years old (elderly). Variable history of ARI disease was categorised into two, namely history of ARI and no history of ARI. The history of ARI is seen based on the patient's medical record. The analysis that will be used is univariate analysis. Univariate analysis is used to look at the distribution of variable frequency, which will be presented in tabular form and narrative. The narrative contains research results that are compared with theory or previous research.

## RESULTS

### Frequency Distribution of ARI Cases Based on Respondent Characteristics before Exposure to Volcanic Ash

Characteristics of respondents surveyed in this study were age, sex, and history of respiratory disease. The majority of ARI cases that occurred before exposure to volcanic ash were suffered by respondents aged 5–11 years (children) for about 73 people (16.29%); males (52.01%) for about 233 people; and with no previous history of ARI for around 304 people (67.85%) (Table 1).

### Frequency Distribution of ARI Cases Based on Respondent Characteristics after Exposure to Volcanic Ash

Most ARI cases occur after exposure to volcanic ash and affect individuals aged 5–11 years (children) for around 76 people (15.5%); females for about 263 people (53.67%); and those without a history of previous ARI disease for about 286 people (58.37%) (Table 2).

### Overview of ARI Cases before and after Exposure to Volcanic Ash

ARI cases occur more after exposure to volcanic ash than before exposure to volcanic ash. The number of ARI cases before exposure to volcanic ash was recorded for about 448 cases, while after exposure to volcanic ash was about 490 cases. The number of ARI cases after exposure to volcanic ash was more frequent in the early adult, adult, and middle aged groups (26–35 years), while in other age groups the number of cases was smaller (See Table 1 and 2).

## DISCUSSION

### Overview of ARI Cases Based on Respondent Characteristics before Exposure to Volcanic Ash

The majority of ARI cases that occurred before exposure to volcanic ash were suffered by children in the age group 5–11. This study is in accordance with the study by Mohamed et al (2015), which showed that cases of ARI were more common among adults and children aged between 5 and 14 years. ARI cases in individuals aged 5 to 14 years are four times more frequent than individuals over the age of 25 years

The results of this study differ from the results of Fibrila (2015) which showed that ARI cases were more prone to the high-risk age group, which is between the age of one and four years (toddlers). Research by Sari & Ardianti (2014) also showed that ARI is more likely to occur to individuals aged between 2 and 3 years. Toddlers in the 2–3 year age range are 1.39 times more likely to suffer from ARI.

A close relationship between age and the incidence of ARI can occur because of the influence of each individual mindset. Age increase in individuals can lead to an increase in mindset, so that the level of knowledge also increases. Increasing individual knowledge can cause these individuals to receive health information more easily. This will cause individuals to be more

vigilant in order to avoid disease risk factors (Sari & Ardianti, 2014).

**Table 1**

Frequency Distribution of ARI Cases Based on Respondent Characteristics before Exposure to Volcanic Ash

Variable	Frequency (n)	Percentage (%)
<b>Age (Years Old)</b>		
0-4	56	12,50
5-11	73	16,29
12-16	60	13,39
17-25	65	14,51
26-35	35	7,81
36-45	48	10,71
46-55	31	6,92
56-65	55	12,28
> 65	25	5,58
<b>Sex</b>		
Male	233	52,01
Female	215	47,99
<b>History of ARI</b>		
No History	304	67,85
Has a history	144	32,15
Total	448	100,00

**Table 2**

Frequency Distribution Based on Respondent Characteristics after Exposure to Volcanic Ash

Variable	Frequency (n)	Percentage (%)
<b>Age (Years Old)</b>		
0-4	31	6,33
5-11	76	15,51
12-16	61	12,45
17-25	66	13,47
26-35	58	11,84
36-45	62	12,65
46-55	59	12,04
56-65	53	10,82
> 65	24	4,90
<b>Sex</b>		
Male	227	46,33
Female	263	53,67
<b>History of ARI</b>		
No History	286	58,37
Has a history	204	41,63
Total	490	100,00

ARI cases that occur before exposure to volcanic ash were more common among males than females. This is consistent with research by Iskandar, Tanuwijaya, & Yuniarti (2015), which showed that the proportion of male ARI patients

was 58%. In the study, it was also found that there was a significant relationship between gender and the incidence of ARI. Males are 1.84 times more at risk of suffering ARI than are women.

Males, especially male children, are more at risk of developing acute respiratory infection, because male children tend to be more active than female children. Hormonal factors are also very influential. Testosterone in men has less influence in hindering expenditure of inflammatory mediators such as TNF, which can hinder inflammation response during an infection.  $17\beta$ -oestradiol hormones in women will enhance immunity by removing inflammatory mediators during an infection (Iskandar, Tanuwijaya, & Yuniarti, 2015)

Based on the history of ARI and the characteristics of patient respondents before exposure to volcanic ash, ARI is mostly suffered by individuals who have never before suffered ARI. This was different from Casadevall & Pirofski (2018), which proved that each individual's immunity was different. This was related to the history of infection with microbes. The immunity of individuals who have been infected by microbes can be directly damaged, so these individuals are more susceptible to further infections with different organisms.

### Overview of ARI Cases Based on Characteristics of Respondents after Exposure to Volcanic Ash

The majority of ARI cases that occurred after exposure to volcanic ash were suffered by the age group 5–11 years. Children were more prone to suffer from ARI due to several factors, such as poor nutritional status, weak immune system, and slow cognitive development. Environmental cleanliness can also affect the incidence of ARI. Environmental cleanliness also needs to be considered because contamination in food, drinks, and children's toys can trigger ARI (Yaya & Bishwajit, 2019). Asih's (2014) research showed that individuals with poor nutritional status were 6.96 times more likely to suffer from ARI compared to individuals with good nutritional status. The susceptibility of children, especially infants, to ARI, is triggered because in the early phases of life the individual's immunological system is still very susceptible, especially to the developing lungs. Alveolar macrophages (AM) are the most common leukocytes in a child's lungs. Lack of cytokinin production and the ability of alveolar macrophages phagocytes make children

more susceptible to infection compared with adults (Lambert & Culley, 2017).

Research conducted by Mahendrayasa & Farapti (2018) showed that the physical condition of houses such as lighting, kitchen smoke holes, roofs, smoking behaviour of family members, and air ventilation were also risk factors for the cause of ARI disease in infants. Individuals who live in houses with inadequate lighting were at risk 3.35 times more likely to suffer from ARI. Bacteria, viruses, and parasites will develop well in houses with poor lighting, which can lead to health problems. Residents of houses with fewer kitchen smoke holes were 4.05 times more likely to suffer from ARI.

ARI cases that occurred after exposure to volcanic ash were mostly suffered by females. This was in accordance with the research of Umar, Sutriningsih, & Warsono (2017), which showed that all female respondents suffered from ARI after exposure to volcanic ash from the eruption of Mount Dukono. The same results were also obtained in the research of Ijana, Eka, & Lasri (2017), which showed that ARI cases in children under five mostly involved female children.

Natural disasters have different effects on males and females, especially on elderly females. Older refugee women will be more susceptible to problems both physically and psychologically (Hanani, 2016). Handling the problems of elderly women including susceptible groups at the time of natural disasters is regulated in Government Regulation Number 21 of 2008. The regulation describes the priority of protection for susceptible groups and the provision of needs such as sanitation, clean water, temporary shelter, clothing, health services, psychosocial services, and food services (President of RI, 2008).

Steroid hormones greatly influence differences in the individual responses of men and women to infection and vaccination. The immune and endocrine systems will change as they age. This results in the body's susceptibility to disease. Increasing age decreases antibody response, especially to new antigens, both in men and women. Women who have entered the postmenopausal phase experience a decrease in the number of lymphocytes, especially type B lymphocytes (Giefing-kro, Berger, & Grubeck-loebenstein, 2015).

The majority of ARI cases that occur after exposure to volcanic ash are suffered by individuals who have never previously had ARI. There are several risk factors that can cause a person to suffer from ARI, namely smoking habits

in family, the use of mosquito coils, and air humidity (Sofia, 2017). Research by Suparto & Sukarman (2015) showed that there were heavy metal elements such as Fe, Pb, Ag, As, Ni, and Cd in volcanic ash. Based on research conducted by Wani, Ara, & Usmani (2015), Pb exposure can occur in several ways, including through the digestive tract, respiratory tract, or through the skin gap. Pb levels that can be inhaled through the respiratory tract are 35–40% and 95% of them will enter the lungs. The entry of organic Pb compounds through the respiratory tract and skin gap is very easy to occur and takes place quickly. Organic Pb exposure is rare, because organic Pb compounds are rarely found, but these compounds can affect the central nervous system.

### **Overview of ARI Cases Before and after Exposure to Volcanic Ash**

The number of ARI cases appears to be higher after exposure to volcanic ash than before. The results of this study were in accordance with the research of Umar, Sutriningsih, & Warsono (2017), which showed that there was a significant relationship between exposure to volcanic ash from the eruption of Mount Dukono and the incidence of ARI. The number of ARI cases in the early adult age group, 26–35 years, was higher after exposure to volcanic ash. The majority of ARI sufferers after the eruption of Mount Sinabung aged 46–55 years belong to the middle adulthood group. Age factors play an important role in pulmonary disorders. Along with the increasing age of the individual, the quality of the lungs will also decrease when suffering from ARI.

There was a significant relationship between work and the incidence of ARI. People who work as farmers are more susceptible to ARI because they spend more time outside the house. People who work as farmers rarely use personal protective equipment such as masks when working, so that volcanic ash, which is very small, can be inhaled and enter the lungs. Therefore the use of masks when doing activities outside the house is important to reduce the risk of developing ARI (Marianta, Chahaya, & Marsaulina, 2015) Research conducted by Pujiani & Siwiendrayanti (2017) showed a significant relationship between the use of masks and ARI incidence.

The use of masks is very important, especially for adults who are more active outside the house during a volcanic eruption. Poor air quality when an eruption occurs can cause ciliary, whereby the fine hairs in the nasal cavity move more slowly. This can cause coarse dust particles to not filter

properly. Production of mucus in the nasal cavity will also increase due to the slow movement of the cilia, which can result in narrowing of the respiratory tract. Narrowing of the respiratory tract will result in individuals having difficulty breathing and make it difficult to excrete inhaled dust particles and bacteria from the respiratory tract (Mukono, 2008).

The number of ARI cases in the 0–4, 5–11, 12–16, 17–25, 56–65, and > 65 years age group did not increase. This showed that the protection of susceptible groups had gone well. Priority of rescue and evacuation in susceptible groups during disasters is regulated in Government Regulation number 21 of 2008, especially in article 51. Susceptible groups such as infants, toddlers, children, pregnant or lactating mothers, people with disabilities, and the elderly are a priority with natural disasters emergency assistance. Health care during a volcano eruption involves nurses making evacuation and treatment efforts by prioritising susceptible groups. Priority for susceptible groups needs to occur because these groups are more susceptible to illness and death (Martono, Ratnawati, & Setyoadi, 2014; President of RI, 2008)

In general, volcanic eruptions will produce very fine volcanic ash particles. Exposure to volcanic ash with high frequency can cause tightness in the chest, coughing, and irritation. The severity depends on the size of the volcanic ash that is inhaled and enters the respiratory tract. Volcanic ash with a size of more than 10–100 micrometres will settle in the upper respiratory tract. In volcanic ash with a size of 4–10 micrometres it will settle in the trachea and bronchial tubes. Volcanic ash with a diameter of less than four micrometres will enter the alveola (VAIWG, 2015).

The main substance in volcanic ash that can cause lung diseases such as fibrosis and cancer is crystalline silica, although not all volcanic eruptions produce volcanic ash containing crystalline silica (Damby et al., 2017). Exposure to volcanic ash containing crystalline silica can worsen a person's condition with opportunistic infections (Damby, Murphy, Horwell, Raftis, & Donaldson, 2016).

Research conducted by Poinen-Rughooputh, Rughooputh, Guo, Rong, & Chen (2016) showed a relationship between crystalline silica exposure and the incidence of lung cancer. The tiny crystalline silica granules have high levels in the air when volcanic eruptions occur and high levels of crystalline silica have the potential to cause

chronic lung disease. Crystalline silica that enters the lungs where it can cause tissue damage and damage lung function (VAIWG, 2015). There is a significant relationship between exposure to crystalline silica and workers with restrictive pulmonary disease (Tavakol et al., 2017).

### Research Limitation

The limitation in the preparation of this article was the lack of information related to the characteristics of respondents because the data obtained were aggregate data.

### CONCLUSION

Before and after exposure to volcanic ash, ARI cases are mostly suffered by children aged 5–11 years and by individuals who have no history of ARI. ARI cases are suffered more by males before exposure to volcanic ash, and more by females after exposure to volcanic ash. The number of ARI cases was higher after exposure to volcanic ash than before. After exposure to volcanic ash, the number of ARI cases in the age group 26–35 years was higher, while in the other age groups the number was lower.

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