In-door factors and its status related to pneumonia risk in children under five years

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Abstract. Children under five years spend most of their time indoors, which means that their primary exposure to air pollution may come from home. Pneumonia has been one of the serious problems for children under five in Indonesia. In this study, we aim to analyze pneumonia risk factors including environmental risk factors at home and the host factors. We conducted a case-control study. Cases were children aged 12 to 59 months with pneumonia based on medical records of Sememi Primary health center in Surabaya and controls were those with non-pneumonia who live surrounding. We administered structures questionnaires to mothers to obtain data on in-door exposure (ETS, coil mosquito smoke, and aerosol mosquito) and the host factors (birth weight and exclusive breastfeeding). Housing environment (humidity, temperature, natural light, ventilation, and child bedroom’s densities) were measured using appropriate tools. Data were analyzed using binary logistic regression; the significance level was set at 0.05. The results showed that humidity, natural light, and exclusive breastfeeding were related to pneumonia. Although the in-door exposure was not. Children under five bedrooms should be designed comfortably and have good indoor air quality. Exclusive breastfeeding could be a protective risk factor to pneumonia in children under five.

1. Introduction

Pneumonia in children under five is one of the health problems. Pneumonia is an acute respiratory infection that affects the lungs. When someone has pneumonia, the alveoli are filled with pus and fluid, which makes breathing painful and limits oxygen intake. Pneumonia is the largest infectious disease, cause of death in children worldwide, besides diarrhea and malaria. The main killers of children under five in 2016 included pneumonia (16%), diarrhea (8%) and malaria (5%)[1]. Indonesia is still facing these problems. The mortality rate of pneumonia in children under five is still high in Indonesia. In 2016, 363,565 children under five were suffering from pneumonia, with mortality rate was 0.13%[2]. The number of cases of pneumonia in children under five throughout Surabaya, one of the big city in Indonesia, reached 3,925 cases, and the biggest number of cases was recorded in Sememi primary health center, counting for 281 cases in 2016[3].

Childhood pneumonia is caused by exposure to risk factors related to host, environment and infectious agent. The infectious agent’s causes of pneumonia are including viruses, bacteria, and fungi, but the data on the specific pathogen are limited. The most common are bacterial pathogen called Streptococcus pneumoniae and Haemophilus influenzae type b (Hib). Other pathogens include respiratory syncytial viruses is the most common viral cause of pneumonia. Most healthy children can fight the infection with their natural defenses. However, children whose immune systems are
compromised have a higher risk of developing pneumonia. Children immune system may be weakened by undernourishment or malnutrition, particularly those who are not exclusively breastfed. Children with pneumonia and moderate or severe malnutrition are at higher risk of death. Environmental factors, such as living in crowded homes and exposure to environmental tobacco smoke or indoor air pollution, may also have a role to play in increasing children’s susceptibility to pneumonia[4,5,6,7].

This study was conducted to identify the host risk factors and the environmental factors; to analyze the association of risk factors with pneumonia in children under five years.

2. Methods
This was a case-control study design. The study was conducted in urban area in Benowo subdistrict of Surabaya in East Java Province, Indonesia. Cases were children aged 12 to 59 months with pneumonia based on medical records of Sememi primary health center, Benowo from May to July 2018 and controls were those with non-pneumonia who live surrounding, without pneumonia symptom. We used simple random sampling method and sample size formula for case-control study. Minimum sample requirements were 35 for each group.

Data collected in this study were housing environmental factors, exposure to indoor air pollution and host factors. Housing environmental factors such as humidity, temperature, natural lighting, ventilation, and densities of child’s bedroom. Humidity and temperature were measured with thermo hygrometer, natural lighting was measured with luxmeter. Ventilation was assessed after obtaining information about floor area in square meter and also the ventilation area, measured with roll meter. Humidity is good if the value 40% - 60% RH, temperature is good if the value 18°C – 30°C, lighting is good if the value ≥ 60 lux. Ventilation is good if the size of ventilation area ≥ 10% from floor area, and densities of child’s bedroom is overcrowded if the area of bedroom is < 8 m² with maximum occupancy were 2 adult and 1 child under five[8]. We administered structures questionnaires to mothers of under five children to obtain data on indoor exposure to children such as exposure from environmental tobacco smoke (ETS), coil mosquito smoke, and aerosol mosquito. The host factors were also asked, such as birth weight, and exclusive breastfeeding. Children who were breastfed only for 6 months categorized as exclusive breastfeeding[9]. Low birth weight infants were the body weight of a baby at its birth less than 2500 gram[10]. This study was started after the approval of by the Health Research Ethics Committee Faculty of Public Health Universitas Airlangga.

Data were coded and analyzed using the statistic program. Categorical data were presented as number and percentage. Binary logistic regression was used to find association between variables and calculated odds ratio to determine the probability of the exposure is related to the disease. The significance level was set at 0.05.

3. Results

3.1. Housing environment
The children’s bedroom has average humidity were 60.08% RH, 31.27°C of temperature, and 23.50 lux of natural light. Majority 58.6% of children’s bedroom had inadequately humidity, 77.1% had a temperature above 30°C, 85.7% had poor natural light, and 51.4% had insufficient ventilation. Children’s bedroom with inadequate humidity confers a 5.063-fold greater chance to get pneumonia ($p= 0.002; \ OR= 5.063; \ CI_{95\%} 1.791$ to $14.310$), while poor natural light present 9.000-fold greater chance ($p= 0.037; \ OR= 9.000; \ CI_{95\%} 1.140$ to $71.038$). Only 31.4% densities of child’s bedroom were overcrowded. There was no significant relation with the variables children’s bedroom temperature, ventilation, and children’s bedroom densities (Table 1).

Out of total household, 17.7% of children have exposure to cigarette smoke. Although some family member was a smoker, they didn’t smoke near the children and smoking outside the house. There were 58.6% household used mosquito coil, 21.4% used mosquito spray, and 20.3% used mosquito electric disperser and mosquito net. Only 15% household applied the mosquito coil or mosquito spray when their
child inside the bedroom. There was no significant relation with the variables indoor air pollution caused by environmental tobacco smoke, coil mosquito smoke, and aerosol mosquito (Table 1).

Table 1. Distribution of the pneumonia housing environment risk factors

| Children’s bedroom | Pneumonia n (%) | Non-pneumonia n (%) | Total n (%) | OR (95% CI) | p-value |
|-------------------|-----------------|---------------------|-------------|-------------|---------|
| Humidity          |                 |                     |             |             |         |
| < 40 - > 60 % RH  | 27(77.1)        | 14(40.0)            | 41(58.6)    | 5.063       | 0.002   |
| 40 - 60 % RH      | 8(22.9)         | 21(60.0)            | 29(41.4)    | (1.791 to 14.310) |         |
| Temperature       |                 |                     |             |             |         |
| <18 – >30°C       | 26(74.3)        | 28(80.0)            | 54(77.1)    | 0.722       | 0.57    |
| 18 – 30°C         | 9(25.7)         | 7(20.0)             | 16(22.9)    | (0.235 to 2.220) |         |
| Natural light     |                 |                     |             |             |         |
| < 60 lux          | 34(97.1)        | 26(74.3)            | 60(85.7)    | 9.000       | 0.037   |
| ≥ 60 lux          | 1(2.9)          | 9(25.7)             | 10(14.3)    | (1.140 to 71.038) |         |
| Ventilation       |                 |                     |             |             |         |
| < 10% from floor area | 22(62.9)    | 14(40.0)            | 36(51.4)    | 2.538       | 0.058   |
| ≥ 10% from floor area | 13(37.1)    | 21(60.0)            | 34(48.6)    | (0.969 to 6.650) |         |
| Densities         |                 |                     |             |             |         |
| Overcrowded       | 13(37.1)        | 9(25.7)             | 22(31.4)    | 1.707       | 0.305   |
| Not overcrowded   | 22(62.9)        | 26(74.3)            | 48(68.6)    | (0.614 to 4.744) |         |
| ETS exposure      |                 |                     |             |             |         |
| Yes               | 7(20.0)         | 5(14.3)             | 12(17.1)    | 0.667       | 0.528   |
| No                | 28(80.0)        | 30(85.7)            | 58(82.9)    | (0.190 to 2.345) |         |
| Mosquito coil smoke or aerosol mosquito exposure | | | | | |
| Yes               | 6(17.1)         | 5(14.3)             | 11(15.7)    | 0.806       | 0.743   |
| No                | 29(82.9)        | 30(85.7)            | 59(84.3)    | (0.221 to 2.932) |         |

3.2. Host Factors

Majority i.e 90.0% of the children had normal birth weight, but only 48.6% were exclusively breastfeeding (EBF) until six months of age. Children’s with exclusively breastfeeding confers a 4.182-fold greater chance to get pneumonia (p= 0.005; OR= 4.182; CI= 1.541 to 11.347). There was no significant relation to the variables birth weight (Table 2).

Table 2. Distribution of the pneumonia host risk factors

| Host factors                | Pneumonia n (%) | Non-pneumonia n (%) | Total n (%) | OR (95% CI) | p-value |
|-----------------------------|-----------------|---------------------|-------------|-------------|---------|
| Birth weight                |                 |                     |             |             |         |
| < 2500 gr                   | 5(14.3)         | 2(5.7)              | 7(10.0)     | 0.364       | 0.247   |
| ≥ 2500 gr                   | 30(85.7)        | 33(94.3)            | 63(90.0)    | (0.066 to 2.016) |         |
| History of breastfeeding    |                 |                     |             |             |         |
| Non-exclusive               | 24(68.6)        | 12(34.3)            | 36(51.4)    | 4.182       | 0.005   |
| Exclusive                   | 11(31.4)        | 23(65.7)            | 34(48.6)    | (1.541 to 11.347) |         |
4. Discussion

4.1. Housing environment

Housing is one of the issues in public health. Housing conditions are some of the risk factors associated with respiratory infection such as pneumonia[11]. In the current study, 58.6% of children’s bedroom had inadequately humidity, and 77.1% had a temperature above 30°C. It is widely believed that pathogens causing pneumonia may be spread through contaminated air droplets[4]. Temperature and relative humidity may affect the airborne survival of viruses, bacteria and fungi[12]. For examples the survival of Chlamydia pneumoniae, ones of pneumonia agent, the in aerosols was optimal at 15 to 25°C and the humidity is high. However, other variables as UV radiation and temperature should also be taken in to account. This condition makes the transmission of C. pneumoniae via aerosols more possible[13]. In contrary, room temperatures more than 30°C at relatively high humidity (greater than 50% RH) may reduce the survival of airborne influenza virus, the tolerance of children in such conditions will also need to be considered[12]. The influence of humidity on the abundance of pathogens suggests that indoor humidity levels should be considered as a factor of indoor air quality, and it should be maintained at levels between 40 and 60%[14].

In the current study, 85.7% had poor natural light and 51.4% had insufficient ventilation in children’s bedroom. Designing home which allowing increased exposure to sunlight and outdoor air may prevent survival and spread of pathogen with concomitantly health benefits for occupants[15]. Overcrowding and inadequate ventilation increases indoor moisture and provide an enriched environment for respiratory viruses. It is well known that they all play role in respiratory disease pathogenesis[11]. Although, we did not observe any association of children’s bedroom densities with pneumonia. Various studies have indicated overcrowding as a significant risk factor for infectious airborne diseases[7,16]. Temperature, humidity (RH), air exchange rate and occupant density are minimum requirement for assessing properties of indoor airborne bacteria [17]. On the other hand, when bedroom air quality has ideal humidity, temperature, and density, it will improve the occupant’s sleep quality[18]. Sleep has strong regulator of immunological processes[19]. If the child has good sleep quality, hopefully it will reduce the possibility of children to get pneumonia. The physical environment of a child’s bedroom indirectly influences health for occupants[14].

In the present study, reported only 17.1% and 15.7% children had exposed to ETS and coil mosquito smoke or mosquito aerosol and there was no significant effect found between ETS and coil mosquito smoke or mosquito aerosol and pneumonia. Other studies, exposures to environmental tobacco smoke (ETS) have reported the association, home environmental tobacco smoke (ETS) was positively associated with pneumonia (1.25, 1.07 to 1.45) in preschool children in Urumqi [20]. Burning mosquito coils indoors generates smoke, this practice was used in some households in the current study. However, the smoke may contain pollutants of health concern. Exposure to the smoke of mosquito coils can pose significant acute and chronic health risks [21].

Malnutrition children (weight–for–age z<–2), low birth weight (≤2500 g), non–exclusive breastfeeding (in the first 4 months), solid fuel use (“yes”) and crowding (7 or more persons sharing the same household) were identified as the most important factors for childhood pneumonia [5,22]. Yet only about one-third of infants in the developing world are exclusively breastfed for the first six months of life[4]. Prevalence of exclusive breastfeeding in the first 6 months in the current study was found 48.6%, while reports based on Indonesia Demographic Health Survey 2012 have shown the prevalence of 40-42%[23,24,4]. It has been shown that exclusive breastfeeding was associated with pneumonia in the current study (p< 0.05). Exclusive breastfeeding during the first six months of age and continued breastfeeding for 18 months plays an essential role in the prevention of pneumonia-specific and all-cause morbidity and mortality[25]. Breastmilk contains the nutrients, antioxidants, hormones and antibodies needed by the child to survive and develop. This is an important factor in reducing infant and childhood morbidity and mortality. Breastmilk makes the child’s immune system to function properly[4].
5. Recommendation
The is a need to create awareness regarding healthy house environment especially on making the child’s bedroom designed comfortably and have good air quality, and giving exclusive breastfeeding in the first 6 months of age.

6. Conclusion
Humidity and natural light in the children’s bedroom and also exclusive breastfeeding in the first 6 months of age was associated with pneumonia in children under five years.

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