Conference Paper

Indoor PM_{10} Concentration and Respiratory Diseases on Children in Area Around Limestone Combustion

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Abstract

The purpose of this study was to analyze the relationship between indoor PM_{10} concentration and respiratory diseases in infants/young children. The study design was cross-sectional, conducted on 130 infants/young children. PM_{10} and data of other variables collected through measurement, interviews, and observation. The results showed dominant factor causing respiratory diseases in infants/young children was indoor PM_{10} (4.92; 2.25-10.74), after controlled ventilation the house (2.62; 1.18-5.79), type of wall (2.33; 1.10-4.95), humidity (2.35; 1.10-5.04), temperature (2.44; 1.15-5.18), smoking family members (5.40; 1.74-16.75), and maternal education (2.86; 1.16-7.07). Risk analysis showed that at-risk group (indoor PM_{10} concentrations>70 μg/m^3) was 13.42 times to have the risk experiencing respiratory diseases than the non-risk group (indoor PM_{10} concentrations ≤ 70 μg/m^3).

Keywords: respiratory diseases, indoor particulate matter $(PM)_{10}$

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1. Introduction

The WHO Air Quality Guidelines 2005 recommended the limits for the concentration four types of air pollutants, including particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ozone (O_3). Particulate matter is the pollutant emissions which are dispersed solid or liquid derived from various sources of pollutants. Respiratory diseases are one of the leading causes of death in infants/young children with the deaths number of more than 2 million people each year associated with air pollution [1].

Dust as one of the indicators is used to show the level of danger Health and safety against environmental pollution. Particulate matter $(PM)_{10}$ is a fine dust particle with ≤ 10 microns of size, formed from the process of burning fossil fuels and is not easy to settle and survive longer in the air [2]. PM_{10} contains a metal such as lead (Pb), chlorine, calcium, silicon, potassium, and sulfur. PM_{10} indoor and toxicology are chemically more active than the PM_{10} outdoors. There are significant differences between the metal content of cadmium, chromium, arsenic, and lead which are higher in the PM_{10} remaining longer in the room [3]. Human activity plays a role in the spread of asbestos dust-like particles from building materials, dust from steel smelting process, and the smoke from the burning process that is not perfect, especially of coal and limestone. The primary source of the particles is from fuel combustion as well as using industrial activity [4].

Threshold limit values (TLV) PM_{10} required by current WHO is 20 mg/ m^3 for the average annual exposure and 50 ug/m^3 for an average daily exposure for 24 hours [4]. The quality standard of PM_{10} in the ambient air in Indonesia stipulated in the Indonesian Government Regulation No. 41/1999 on air pollution control. Quality standard value PM_{10} 230 ug/m ^{3} for the measurement time 24 hours and 90 ug/m^3 for a measurement time of one year while quality standards PM_{10} is set at 150 mg/m^3 for a 24-hour measurement. Standard quality of PM $_{10}$ in space in Indonesia stipulated in the Regulation of the Minister of Health of the Republic of Indonesia Number 1077/Menkes/Per/V/2011 on the guidelines for restructuring the air in the room of the concentration of PM $_{10}$ required $\leq$ 70 mg/m ^{3} in 24 hours [5].

PM_{10} gets into the body through the respiratory system. The health effects arising are determined by the size, composition, and concentration. Research in America and Europe show a clear correlation between the level of PM $_{10}$ and health effects. Exposure in the long term can lead to cardiovascular disease, pulmonary disease, aggravate *bronchitis,* and asthma [6]. Minor effects of PM $_{10}$ are in respiratory infections such as irritation of the nose and throat, whereas the effects of chronic exposure to PM_{10} increase the risk of lung cancer [7].

PM_{10} at a concentration of 160 μg/m^3 can cause respiratory problems due to lowered lung function in children, especially in infants and toddlers and at a concentration of 355 μ g / m^3, it will increase the severity in patients with *bronchitis.* PM_{10} has a chronic effect on respiratory diseases and lung function in children in areas with high levels of pollution around the highway. Children living in high pollution areas are 2.6 times more likely to suffer respiratory and pulmonary problems than children living in low polluted regions [8]. At a concentration of 140 ug/m ^{3}, it can reduce lung function in children. While at a concentration of 350 ug/m ^{3}, it can aggravate the condition of patients with bronchitis. The toxicity of the inhalable particles depends on the composition [9].

The concentration of indoor PM_{10} is affected by the concentration of PM_{10} outside, the physical environment (type of housing, type of walls, type of flooring, ventilation and the kind of ceiling), housing conditions (occupancy density and humidity, temperature), the source of pollutants (usage mosquito repellent, smoking habit in family members, cooking fuel). One of the non-formal industries that is one of the activities in the countryside that contributes to air pollution that is quite large is especially PM_{10} in the limestone industry. Emissions of limestone burning process include gas - gas NO_2, SO_2 and CO and particles that add to air pollution [10].

Factors that cause respiratory disease due to dust may be affected by dust characteristics, individual factors that include pulmonary defense mechanisms, anatomy and airway physiology, and individual immunological factors. Exposure to humans also can affect and receive attention among other sources of exposure, type of industry, duration of exposure, and exposure from other sources. Patterns of daily activity and potential comorbid factors are such as age, sex, ethnicity, smoking habits and allergen factors [11]. Inadequate house ventilation and indoor furnace smoke will ease the occurrence of respiratory disease in children [12]. The concentration of PM_{10} in European countries such as Spain showed a high rate by a margin of 47.7 ug/m^3, influenced by the intensity of dust from the Sahara. An increase in mortality was due to the increasing concentration of PM10, reaching per 10 ug/m^3. The concentration of PM_{10} in Korea showed an average of 55.3 µg/m^3, and there was a significant relationship between the concentration of PM_{10} and impaired lung function in children. There were 259/10000 cases of respiratory diseases change in concentration of PM_{10} that was high, exceeded TLV. The symptoms include a chronic cough, sputum, wheezing, and shortness of breath [13].

The decrease in the mean annual concentration at 40 µg/m^3 can prevent and reduce as many as 7 cases of postneonatal mortality. The reduction in the level of 20 µg / m3 will prevent and cut as many as 21 postneonatal cases. Decrease short term PM_{10} concentration 20 ug/m ^{3} will prevent 186 people to have a case of respiratory diseases [14]. A weinmayr study in 2010 showed deaths from respiratory disease increased by 5.3% -10% along with an increase in PM_{10} concentration per day by 38.7 µg/m^3. There was a significant relationship between PM_{10} and the occurrence of episodes of asthma symptoms, in which PM_{10} levels that exceeded the threshold increased the risk of recurrence of static and nonatopic asthma by 1.5 times compared to PM_{10} concentrations below the limit [13].

There are 103 of limestone burning companies in Pangkalan sub-district: 85 (82.52%) in Tamansari Village and 18 (17.48%) in Tamanmekar village. Some residents diseases around the limestone combustion are related to environmental conditions and lousy health behavior. Based on the monthly report respiratory disease Base Health Center in January to September 2012, in Tamansari village had a population of 6.215 peoples with a population of infants and toddlers age as much as 621. Data of ARI disease in infants and toddlers were 319 cases (51%).

The region of limestone burning village of Castle District of Pangkalan Karawang is a densely populated region that could lead to the entry of pollutants PM $_{10}$ into homes as a result of combustion activities ranging from the production process in the area to the vehicle. State houses poor sanitation also influence the high concentration of PM $_{10}$ in the homes. Increasing concentrations of PM_{10} will increase the risk of respiratory problems especially in infants and toddlers because it is a vulnerable group. Thus, it is necessary to picture to analyze concentrations of PM_{10} in the house and respiratory problems in infants and toddlers who live around burning limestone in Karawang.

2. Methods

The research design used in this study was a *cross-sectional* design. The population was all infant and toddlers who lived around the limestone combustion of Tamansari Village, Pangkalan Sub-district, Karawang regency. Samples were 130 of infants and toddlers, aged 0-59 months.

The research variables included PM_{10} as the primary independent variable, and the incidence of respiratory diseases in infants and toddlers is the primary dependent variable. Other variables studied were the type of walls, type of flooring, ventilation, humidity, temperature, density, location of the kitchen, use of insect repellent, smoking habits of family members, cooking fuel, people with respiratory problems at home a confounding variable and characteristic of infants and toddlers (nutritional status, immunization history, gender, age, and maternal education) whose role was to modify the relationship between risk factors and disease. Data on the parameter of PM_{10} temperature and humidity were measured directly in each house surveyed in toddlers sleeping room by using Haz-Dust EPAM 5000, thermometer and hygrometer.

Nutritional state measured anthropometric indexes based on weight(kg) / age (months) according to the WHO-NCHS standards categorized men of malnutrition and nutrition so good. Immunization history is the history of immunization of BCG, DPT, Polio, and Measles obtained by infants and toddlers according to the age of infants and toddlers. It can be seen on Healthy Towards Card or visit cards to other health facilities categorized into incomplete (less one of BCG, DPT, Polio Or Measles) and complete (BCG, DPT, Polio, and Measles). Other variables were observation and questionnaires. The study conducted in March-April 2013. The analysis performed with Chi-square test and logistic regression.

3. Results

Respiratory diseases were used as a dependent variable, consisting of two categories, respiratory problems, and no respiratory diseases. The concentration of PM_{10} consists of the groups that did not meet the requirements and qualify. It's said "not eligible" if the frequency of PM_{10} in the home was > 70 ugs/m^3 and train of the concentration of PM_{10} in the house was $\leq$ 70 ug/m^3. Results of analysis of the relationship between the concentration of PM_{10} in the incidence of respiratory diseases in infants and toddlers showed that there were 65 (79.3%) infants and toddlers whose concentration indoor PM_{10} did not qualify experiencing respiratory diseases incident. Whereas among infants and toddlers with levels PM_{10} indoor that was restricted, there were 21 (43.8%) who had respiratory problems.

The results of the analysis of PM_{10} concentration relationship with respiratory diseases obtained p = 0.000 and OR value of 4.92 (95% CI: 2.25 to 10.74), concluded that the infant/toddler who lived in the house with the concentration of PM_{10} did not qualify to have the opportunity that was 4.92 times to experience respiratory problems than those who lived in homes with high levels of PM_{10} are eligible (Table 1).

Table 1: PM 10 concentrations, Physical Environment Houses, Source Pollutants and characteristics with Respiratory Events in Infants and Toddlers.

Variable	**The occurrence of respiratory diseases**				**Total**		**The value of p**	**OR**	**CI 95%**
	There is		There is no						
	n	%	N	%	n	%			
PM_{10}									
Not eligible	65	79.3	17	20.7	82	100	**0.000**	4.92	2.25-10.74
eligible	21	43.8	27	56.3	48	100			
Ventilation									

Variable	The occurrence of respiratory diseases				Total		The value of p	OR	CI 95%
Not eligible	68	72.3	26	27.7	94	100	**0.028**	2.62	1.18-5.79
eligible	18	50.0	18	50.0	36	100			
Type of floor									
Not eligible	41	69.5	18	30.5	59	100	0.584	1.32	0.63-2.75
eligible	45	63.4	26	36.6	71	100			
Wall type									
Not eligible	47	75.8	15	24.2	62	100	**0.042**	2.33	1.10-4.95
eligible	39	57.4	29	42.6	68	100			
Humidity									
Not eligible	45	76.3	14	23.7	59	100	**0.042**	2.35	1.10-5.04
eligible	41	57.7	30	42.3	71	100			
Temperature									
Not eligible	61	73.5	22	26.5	83	100	**0.031**	2.44	1.15-5.18
Qualify	25	53.2	22	46.8	47	100			
Dwelling density									
Not eligible	42	72.4	16	27.6	58	100	0.243	1.67	0.79-3.52
eligible	44	61.1	28	38.9	72	100			
The location of the kitchen									
Not separate	36	61.0	23	39.0	59	100	0.346	0.66	0.32-1.37
Separate	50	70.4	21	29.6	71	100			
Use of Mosquito repellent									
Use	64	68.1	30	31.9	94	100	0.586	1.36	0.61-3.01
Do not use	22	61.1	14	38.9	36	100			
Smoking habit									
Smoke	81	71.1	33	28.9	114	100	**0.002**	5.40	1.74-16.75
Do not smoke	5	31.3	11	68.8	16	100			
Cooking fuel									
Not good	19	65.5	10	34.5	29	100	1.000	0.96	0.40-2.30
Good	67	66.3	34	33.7	101	100			
ARI sufferer at home									
There is	40	72.7	15	27.3	55	100	0.242	1.68	0.79-3.57
There is no	46	61.3	29	38.7	75	100			
Gender									
Women Man	53 33	68.8 62.3	24 20	31.2 37.7	77 53	100 100	0.556	1.34	0.64-2.79

Variable	The occurrence of respiratory diseases				Total		The value of p	OR	CI 95%
Age									
0-12 months	16	55.2	13	44.8	29	100	0.232	0.55	0.23-1.27
13-59 months	70	69.3	31	30.7	101	100			
Education mother									
Low education	75	70.8	31	29.2	106	100	**0.037**	2.86	1.16-7.07
Higher education	11	45.8	13	54.2	24	100			
Nutritional status									
Malnutrition	26	74.3	9	25.7	35	100	0.234	1.69	0.71-4.00
Good nutrition	60	63.2	35	36.8	95	100			
Immunization status									
Incomplete	32	72.7	12	27.3	44	100	0.349	1.58	0.71-3.50
Complete	54	62.8	32	37.2	86	100			

The results of the analysis of the physical environment of the house acquired a significant relationship among the variables of ventilation OR of 2.62 (95% CI: 1.18 to 5.79), the type of wall OR of 2.33 (95% CI: 1.10 to 4.95), moisture OR of 2.35 (95% CI: 1.10 to 5.04), and the temperature OR of 2.44 (95% CI: 1.15 to 5.18) and the incidence of respiratory diseases in infants and toddlers. Based on the sources of pollutants variable, smoking habits in family members had a significant relationship with the impact of the respiratory illness in infants and toddlers with OR = 5.40 (95% CI: 1.74 to 16.75). Variable characteristics of infants and toddlers who have a significant relationship with the of respiratory diseases in infants and toddlers the educational status of the mother with an OR of 2.86 (95% CI: 1.16 to 7.07).

3.1. Dominant factors associated with respiratory diseases in infants and toddlers

Based on the results of the multivariate analysis of the variables, it's obtained OR 6.37 PM_{10} which meant that the babies/ toddlers in the house with PM_{10} concentration were 6.37 times not eligible (PM_{10} > 70 ug/m $^{3)}$ to risk of incidence of respiratory diseases, compared to 6.37 times with infant / toddler who lived in the house with the levels of PM_{10} which were eligible ($PM_{10} \leq$ 70 mg / m $^{3)}$ after controlled variables as smoking, ventilation, and the type of wall (Table 2).

4. Discussion

There may be information bias on the measurement, interview, and observation of the respondents resulting in irregularities in the research results obtained. Despite these limitations, cross-sectional design is most likely to be done for this study to see the magnitude of health problems when data are collected at the same time either to see whether or not PM_{10} exposure is present or to notice the presence or absence of respiratory

Table 2: Final Model of Multivariate Analysis of Logistic Regression between Candidate Variables of Respiratory Diseases in Children.

Variable	B	P wald	OR	CI95%
Indoor PM_{10} concentration	1.851	0.000	6.37	2.59-15.70
Smoking habit	1.796	0.005	6.02	1.70-21.32
Ventilation	1.141	0.015	3.13	1.24-7.88
Wall type	0.938	0.041	2.56	1.04-6.28
Constant	-2.579	0.000	0.08	
-2Log Likelihood = 128.824 G = 37.579 p = 0.000				

diseases in infants and toddlers. This research method is relatively easier to implement, relatively inexpensive, yields the number of health problems and can observe many variables related to PM_{10} concentration and respiratory diseases in infants and toddlers.

One of the producers of PM $_{10}$ is the limestone burning process. Based on the results of chemical analysis laboratory Research and Technological Development Center for Mineral and Coal Energy, limestone contains chemical elements such as CaO, SiO_2, MgO and other items. Lime processing before used, it must go through combustion. In the process, it also produces PM_{10}which became one of the risk factors for respiratory diseases. Lime dust is thought to be a risk factor for respiratory disease and chronic obstructive pulmonary diseases such as chronic bronchitis and emphysema resulting in inflammation of the respiratory tract wall resulting in slimy respiratory tract and narrowing and affecting the rate of air exchange [16].

Respiratory illness or respiration transmitted through particles present within the house (Waterborne particle), droplets, or direct contact / physical relationship. The airborne particles that irritate lead to the occurrence of respiratory diseases. Such as influenza and pneumonia are often secondary infections of the development of an irritant. The shows that the quality of air in the house that does not meet the health requirements that are very instrumental in the occurrence of respiratory problems. The health effects of exposure to PM_{10} in a short time can affect lung inflammation, respiratory infection and symptoms in the respiratory tract, increasing impact on the cardiovascular system [11].

Children, especially infants and toddlers, are particularly vulnerable to airborne disguises. A cough, sore throat, acute and chronic bronchitis, asthma, pneumonia, pulmonary emphysema, lung cancer are manifestations of respiratory diseases caused by prolonged exposure to air pollution such as dust particles

Based on the measurement of PM10 air quality parameters, it could say that air quality in people's homes in Tamansari Village was still weak, knowing evident from the average concentration of PM_{10} (84 µg/m^3) was above the 70 µg/m^3 and in some residential houses were (78.3%), while the highest PM_{10} concentration was 233 µg/m^3, far from the 70 µg/m^3 threshold and close to the PM_{10} threshold value that was in 251 µg/m3 ambient air.

The high concentration of PM $_{10}$ was possible due to the location of its research to be around burning limestone Tamansari village. The burning of limestone was scattered and mixed with the settlement of citizens. The process of burning lime in one period lasted for three days for 24 hours. This process continuously produced smoke and dust resulting in high concentrations of PM_{10} in the ambient air. Because the burning of limestone did not have a chimney, the smoke and dust from burning in the residential area can cause high concentrations of PM_{10} in the house.

From 4 variables of pollutant source in house studied, it was found that the significant relation with respiratory disturbance occurrence in toddler was variable of cigarette smoke while other variables such as the use of mosquito coils, the use of cooking fuel, and the presence of patients with domestic respiratory diseases, did not show a meaningful relationship.

Children who lived at home with family members of smokers group of potentially exposed to cigarette smoke [17]. The could be explained through the classification of tobacco smoke that formed the mainstream smoke and sidestream. Although the proportions were smaller than in mainstream smoke, in sidestream smoke, there were also particulates that could inhale to the lungs. For children, smoke sidestream was more critical than mainstream smoke because smoke sidestream was a smoke inhaled by the passive smokers are people who did not smoke but inhaling cigarette smoke from other smokers. All air polluters that caused the most adverse health effected for children are parents who smoke. Limited space made children more exposed to cigarette smoke compared to school-aged children [10]. Another characteristic variable associated with the immune system of children was the history of immunization. Immunization is one of the most effective and efficient ways to prevent serious infectious diseases. Inadequate Immunization is a risk factor increasing incidence (morbidity) and mortality due to ARI, especially pneumonia [4].

Children who received immunization on time (immunization obtained children at appropriate age range) included in the category of complete immunization status. In contrast, children who not immunized on time (vaccinations received by children outside the appropriate age range) fall into the category of incomplete immunization status. The results indicated that the percentage of infants and children who are fully immunized by 66.2% was still below the national immunization coverage target of 80%.

The results of the analysis showed no significant relationship between immunization status and the occurrence of respiratory diseases. However, the possibility of children with immunization status incomplete to experience greater respiratory infections than children with complete immunization status could see from the proportion of children whose history of immunization is incomplete and respiratory diseases (72.7%) was higher than that of children with complete immunization history and respiratory infections (62.8%)

Another variable studied is a good education, showing a significant relationship to respiratory diseases. Training is related to the mother's knowledge and behavior in child care. It's found that there are 81.5% of children with low education that is not finished primary/primary school and junior high while the results of the analysis showed a significant relationship between maternal education with respiratory diseases in children in which infants and toddlers with low-educated mothers are at risk of respiratory illnesses 2.8 times compared with children with well-educated mothers.

The results of Chen's (2002) showed that low maternal education level was also a risk factor that could increase the mortality rate of ARI, especially pneumonia. The level of maternal education would affect protective care measures for children with ARDs. If the mother's knowledge to tackle pneumonia not appropriate, infant or toddler suffering from pneumonia would die from pneumonia risk by 4.9 times when compared with mothers who had the right expertise [18].

Pramudiyani's (2011) study showed the extent of ventilation had a significant relationship with the incidence of respiratory tract infections in infants. Ventilation one of the factors that affect the humidity level. Less ventilation could cause moisture to increase. Humidity outside the home naturally could affect the moisture in the house. Moist space allowed the growth of pathogenic microorganisms of microorganisms that caused respiratory infections [19].

Ventilation is a means of air circulation in which clean air from outside the room/room pumped into the chamber, and bad breath will remove. For good air circulation, it requires room ventilation at least 20% floor area. If the ventilation area of the room <20% of floor space, the process of air circulation in the place will run abnormally and increase the air temperature in the house exacerbated again. If the room is crowded (overcrowded), it will cause a lack of oxygen in the room [5].

The high percentage of unqualified ventilation in the settlement around the limestone burning of Tamansari Village is probably because some of the respondents who have ventilation area are eligible to permanently close the ventilation of their houses to prevent smoke from burning limestone from entering the house. Partial house windows are also closed every day to prevent the entry of dust from burning lime into the house

Type of wall can affect the air quality in the home. Walls that are not water-resistant cause the humidity of the room to be high and can increase the concentration of dust particles. Cigarette smoke and other pollutant fumes (mosquito coils, used cooking fuels) in the house can partly absorb into the surface of the walls of the house, and after some time the components of cigarette smoke and pollutant fumes such as CO and CO_2 and particulates Irritant to the respiratory tract may be released into the air. The contaminant component can be released into the atmosphere and blends with the particles in the air, increasing the concentration of particles in the air.

It found that as many as 45.4% of infants and toddlers staying at home whose moisture did not meet the requirements of more than 60% moisture showed a significant relationship between humidity and respiratory disturbances in children. Children living in households with moisture that was not eligible at risk for respiratory diseases had 2.35 times compared to children living at home with eligible humidity.

Multivariate analysis with logistic regression analysis obtained from 11 variables that entered the multivariate modeling showed the four variables which were a statistically significant relationship with the incidence of respiratory diseases in children ($p < 0.05$) of variable concentrations of PM_{10}, smoking habits, ventilation and wall type of house. The final results showed that the risk of incidence of respiratory diseases in children with concentrations of PM_{10} in the home that was not qualified such as there was smoke in some spaces, ventilation was not eligible and had ineligible wall types, had 13.42 times to have risk to respiratory diseases compared to children with concentrations of PM_{10} found in suitable homes with no smoking occupants and had eligible ventilation and eligible wall types.

The result of multivariate analysis with logistic regression test obtained from 11 variables that entered multivariate modeling. It's found four variables that showed a statistically significant relationship with respiratory disturbances in infants and toddlers ($p < 0.05$) of variable concentrations of $PM_{10,}$ smoke/smoking, ventilation and type of house wall. These four variables were factors whichwere significantly associated with respiratory diseases in infants and toddlers. From the four variables, variable concentrations of PM_{10} in the home became the most dominant variable.

The final results showed that the risk of incidence of respiratory diseases in infants and toddlers with concentrations of PM_{10} smoke in some spaces, ventilation that was not eligible and ineligible wall types.

Based on the results of the bivariate analysis of variable concentrations of PM_{10} in the house, no smoking occupants, ventilation, and wall type significantly associated with the incidence of respiratory diseases in infants and toddlers. In multivariate analysis, it found that PM10 concentration was the dominant factor in respiratory illnesses in infants and toddlers. If variable concentrations of PM_{10} in the house such as no smoking occupants, ventilation, and the type of wall in a state were not qualified, it would increase to 13.42 times the risk of infant and toddlers to experience respiratory diseases

5. Conclusions

The children who lived in the house with the concentration of PM_{10} that was not eligible had 6.37 times of the opportunity to suffer respiratory problems after being controlled by the variable no residents smoke, ventilation and type of wall. The risk of occurrence of respiratory diseases in infants and toddlers with concentrations of PM_{10} in the home that not qualified were: space of smoke, ineligible ventilation, and type of wall. It meant that they had 13.42 times to have respiratory diseases, compared to infants and toddlers living in a home with concentrations of PM_{10} that was qualified, no occupants smoke and had eligible ventilation and wall types.

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