# OPEN BURNING OF HOUSEHOLD SOLID WASTE AND CHILD RESPIRATORY HEALTH: EVIDENCE FROM INDONESIA

## Pembakaran Sampah Rumah Tangga dan Kesehatan Pernasafasan Anak: Bukti dari Indonesia

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**ABSTRAK**

Pembakaran sampah rumah tangga yang tidak terkendali menciptakan banyak polutan berbahaya. Menurut Riskesdas 2013, satu dari dua rumah tangga Indonesia dilaporkan membakar sampah mereka di tempat terbuka. Oleh karena itu, analisis ini bertujuan untuk menguji hubungan antara pembakaran terbuka limbah padat rumah tangga dan pengalaman ISPA pada anak-anak di Indonesia dari sumber data yang sama. Kami memasang model regresi logistik sederhana dan multivariabel untuk menguji hubungan antara paparan pembakaran terbuka limbah padat rumah tangga dan pengalaman ISPA pada anak di bawah 5 tahun dari data Riskesdas 2013. Hasil analisis menunjukkan hubungan yang signifikan antara pembakaran terbuka limbah rumah tangga dan pengalaman ISPA pada anak-anak Indonesia. Secara khusus, kami menemukan proporsi yang lebih tinggi dari pembakaran terbuka di area ini terkait dengan risiko ISPA yang lebih tinggi. Hubungan ini tetap signifikan secara statistik setelah variabel penjelas lainnya dimasukkan. Namun, kami tidak menemukan hubungan yang signifikan antara pembakaran terbuka di tingkat rumah tangga. Temuan ini mengindikasikan bahwa anak-anak juga dapat terkena polusi udara luar ruangan selain dari polusi udara dalam ruangan yang berasal dari penggunaan bahan bakar memasak yang tidak aman. Dengan temuan ini, kami merekomendasikan semua pemangku kepentingan termasuk masyarakat untuk mengatasi praktik umum pembakaran sampah secara terbuka.

**Kata kunci**: Riskesdas 2013, pembakaran sampah terbuka, pencemaran udara, ISPA

***ABSTRACT***

*Uncontrolled burning of household solid waste creates many harmful pollutants. The Basic Health Research (Riskesdas) 2013 found that one in two Indonesian households burned their solid waste in the open. Therefore, the study is aimed at examining the relationship between open burning of household solid waste and experience of ARI among under-5 children in Indonesia using the same source of data.We fitted simple and multivariable logistic regression models to the 2013 Riskesdas to examine the association between exposure to open burning of household solid waste and ARI experience among U-5 children.The results showed a significant association between open burning of household waste and ARI experience among Indonesian children. Specifically, we found a higher proportion of open burning in the area is associated with a higher risk of ARI. This relationship remains statistically significant after the other covariates were included. We did not observe, however, a significant association between open burning at the household level.These findings imply that children may also be exposed to outdoor air pollution besides from indoor air pollution emanating from the use of unsafe cooking fuel. Given these findings, we urge all stakeholders including the community to tackle the prevalent practice of open burning.*

**Keywords:** *Riskesdas 2013, household solid waste, open burning, air pollution, ARI*

## INTRODUCTION

Household solid wastes include wastes generated by the daily activities of households but excludes faeces (Damanhuri, E., Handoko, W., & Padmi, 2014; Reddy, 2011). These type of waste also contributes to greenhouse gas (GHG) emissions which influence climate change, albeit relatively small compared to other sources (Permadi, Thi, & Oanh, 2013). However, it is also can

become a potential source of energy through energy recovery efforts (Scarlat, Motola, Dallemand, Monforti-ferrario, & Mofor, 2015). Nonetheless, household solid waste can pose a threat to the environment if not managed properly. This potential threat includes contamination of land and water bodies and air pollution resulted from burning solid wastes, and methane release and disease pathogens from landfills (Bai et al., 2017; Kumar, 2016).

The stream of municipal solid waste in Indonesia mainly comes from households and traditional markets (Aprilia, A., Tezuka, T., & Spaargaren, 2012; Aye & Widjaya, 2006). However, the most recent result of the Indonesian Basic Health Research conducted in 2013 (*Riset Kesehatan Dasar* - Riskesdas) reported that 50% of Indonesian households burn their solid wastes in the open. Moreover, plastics/styrofoam are estimated to in the range of 12% to 18% of solid waste composition (Damanhuri, E., Handoko, W., & Padmi, 2014; Damanhuri, Wahyu, Ramang, & Padmi, 2009). Furthermore, burning household solid waste emanates many harmful particulates which pollutes the air (Gullett et al., 2010; Hoornweg, D., & Bhada-Tata, 2012; Li, Lei, Bei, & Molina, 2012; Ochoa et al., 2012; Vergara & Tchobanoglous, 2012). Many studies have shown evidence on the deleterious health effects of the pollution emanated from burning solid waste on morbidity and mortality (Burnley, 2014; Kodros, Wiedinmyer, Ford, Cucinotta, & Gan, 2016; Lelieveld, Evans, Fnais, Giannadaki, & Pozzer, 2015; Schwartz, Bind, & Koutrakis, 2017; Shibata, Wilson, Watson, Leduc, & Meng, 2014).

Moreover, the scale of the health effects of burning household solid waste in the open could be massive given the fact that Indonesia is the fourth most populated country in the world, with population over 255 million in 2015 based on the latest Intercensal Population Census (Badan Pusat Statistik, 2016) What is worrying is that exposure to particulate matter (PM), one of the pollutants resulted from burning solid waste, adversely affect the respiratory health of children (Shibata et al., 2014).

Given the issues above, it is interesting and imperative to know whether exposure to pollution from burning household solid waste in the open affect respiratory health of children. Hence, the objective of the study is to examine the relationship between open burning of household solid waste and experience of ARI among children in Indonesia.

Research on solid waste management in developing countries including Indonesia is lagging behind that in developed countries (Nwachukwu, Ronald, & Feng, 2017). The existing studies mostly focused on the management and the environmental impact of solid wastes (Damanhuri, E., Handoko, W., & Padmi, 2014; Damanhuri et al., 2009; Permadi et al., 2013; Safitri, Fujiwara, Chaerul, & Damanhuri, 2014). To the best of our knowledge, no study had tested the association between open burning and ARI experience among children in Indonesia at the time when this article was written.

## MATERIALS AND METHOD

We employed data from the third round of Indonesian Baseline Health Research (*Riset Kesehatan Dasar* – Riskesdas) conducted in 2013 by the National Institute of Health Research and Development (NIHRD). Riskesdas is a community based-survey conducted every three years since 2007 that collects data on baseline health data and health indicators which are representative of the 33 provinces at the time of the survey. The NIHRD had obtained informed consent from the respondents before interviews and preserved their anonymity during the data processing. More detailed information on the ethical and sampling procedures can be read elsewhere (NIHRD, 2013).

Riskesdas 2013 has obtained an ethical clearance (No. LB.02.01/5.2/KE.006/2013) from the Institutional Research Board (IRB) of the NIHRD of the Indonesian Ministry of Health. As this study is a further analysis of secondary data, no additional ethical clearance is required.

The 2013 Riskesdas collected data from 1,027,763 individuals from 294,959 households and is representative of the 33 provinces at the time of the survey(NIHRD, 2013). For the study, however, we confined the sample to children aged less than five years (0-59 months) which is equivalent to 82,666 children living in 72,092 households as the initial sample size. This sample size was then reduced due listwise deletion according to missing observations (Dong & Peng, 2013). This cleaning process resulted in a final analytical sample of 82,359 children (99.85%) residing in 71,832 households.

In the 2013 Riskesdas, the households were asked how do they manage household waste, and the response options were six-fold: (1) collected by sanitation service, (2) buried underground, (3) composted, (4) burned in the open, (5) thrown into a gutter/river/sea, (6) thrown elsewhere. Sources of air pollution can come from outdoor and indoor. Hence, for the study, exposure to open burning of household waste is represented by two variables: (1) Household burn their waste in the open; and (2) Proportion of households that openly burn their waste in the area. For the first variable, the original household waste management variable was coded into a two-category variable (the household manages waste by burning it, yes vs no) which becomes the main exposure variable (open burning of household waste). Further, for the second variable, the proportion of household that openly burns their waste in every census block (primary sampling unit) was calculated (see NIHRD [2013]) for detailed information regarding census blocks).

To represent child respiratory health, we use experience of Acute Respiratory Infections (ARI) among under-5 children during the past one month preceding the survey. The parents or caregiver were asked whether the child has been diagnosed with ARI by a health worker (medical doctor/nurse/midwife) in the past one month preceding the survey. The dependent variable is coded as 1 if the response is 'Yes' and coded as 0 if the response is "No". The sample is deleted if the response is "Do not know".

There are other covariates that act as controls for the open burning variables (Acharya, Mishra, & Berg-Beckhoff, 2014; Agustina, Shankar, Ayuningtyas, Achadi, & Shankar, 2014; Dahal, Johnson, & Padmadas, 2009; Smith et al., 2013; Upadhyay, Singh, Kumar, & Singh, 2015). We categorised these variables into five groups: (1) living environment; (2) spatial variables; (3) child characteristics; (4) socio-demographic characteristics; and (5) economic characteristics. The living environment only consists of type of main cooking fuel (electricity/gas, kerosene, charcoal/briquettes, fire-wood). Meanwhile the spatial variables comprise three variables, namely region of residence (Sumatera, Java, Bali & Nusa Tenggara, Kalimantan, Sulawesi, Papua), place of residence (urban area vs rural area), and slum area residence (no vs yes).

The next group, child characteristics, consist of sex of child (male vs female) and age of child (<12 months, 12-23 months, 24-35 months, 36-47 months, 48-59 months). Moreover, the socio-demographic characteristics comprise sex of household head (male vs female), education of household head (none, elementary school, junior high school, senior high school, college or higher), marital status of household head (married, bereaved, divorced, never married), number of household members (household size, in persons), number of children aged less than five years old (one vs two or more). Lastly, the economic variables consist of household head is working (no vs yes), house is self-owned (no vs yes), household received/bought rice for the poor (no vs yes), and wealth index score (in units).

We fitted simple and multivariable logistic regression models to examine the relationship between open burning of household waste and ARI experience among children(Hosmer, Lemeshow, & Sturdivant, 2013). As the measure of association, we use odds ratio (OR) at three levels of significance (10%, 5%, and 1%). The model fitting procedure was done in four stages. First, we fitted simple logistic regression

models to find out which covariates are significantly related to dependent variable. Then in the second stage, we fitted a multivariable logistic regression model with only the two variables representing exposure to open burning of household waste (i.e. open burning at the household level and area level). In the next stage, type of cooking fuel was added into the model. Then in the final stage, all covariates that were statistically significant in the first stage were added into the final logistic regression model. We performed all of the statistical analysis using STATA version 13.1(StataCorp, 2013).

## RESULTS

Figure 1 presents the ways in which Indonesian household disposed of their solid waste. It can be seen that only one in five households (21.66%) rely on sanitation service to collect their solid waste. Waste that are not collected are disposed of in many different ways. The predominant method is by open burning (49.23%). The rest of the methods are thrown into water sewer/river/sea (12.61%), thrown elsewhere (11.89%), buried (3.82%), and composted (0.79%).

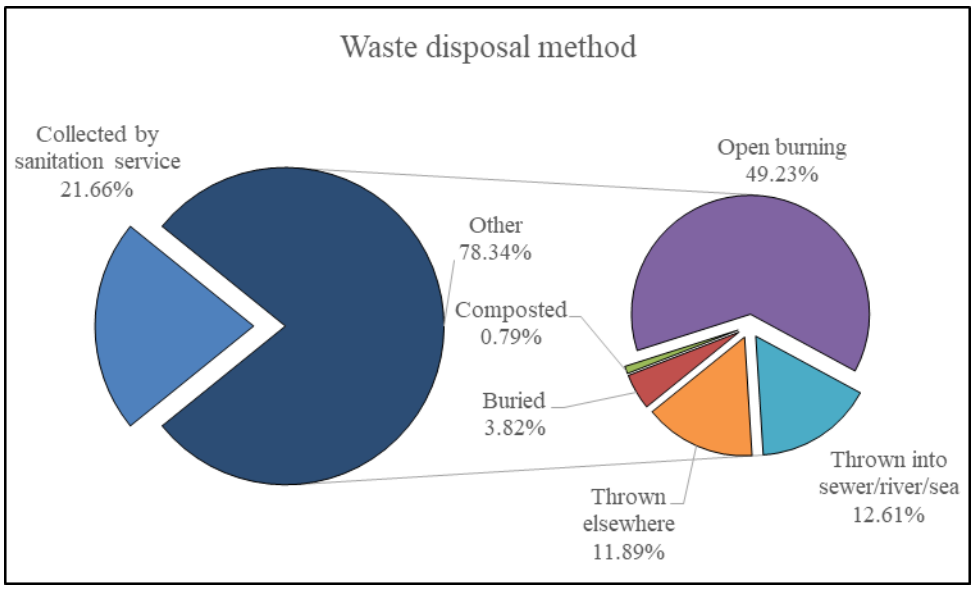


Figure 1. Waste disposal methods use by Indonesian households ($N$ = 71,832 households)

Table 1 presents the sample characteristics of the study variables, including dependent and independent variables. In the sample, it is reported that almost one in every four children (23.98%) had been diagnosed with ARI in the past four weeks. As for the exposure variables, almost half of the households reported burning their waste in the open (48.60%). This phenomenon is also found in major cities in other developing countries such as Brazil (Alfaia, Costa, &Campos, 2017), Sri Lanka (Karunarathne, 2015), the Democratic Republic of Congo(Din, G.Y., & Cohen, 2016), Ghana (Oduro-Appiah et al., 2017), Lao PDR(Babel & Vilaysouk, 2016),and India (Ramaswami, Baidwan, & Nagpure, 2016). This practice of burning waste is done usually to avoid rubbish from accumulating in residential area.

Table 1. Sample characteristics of the study variables (dependent and independent variables, N = 82,359 U-5 children)

| Variables | N | % | Mean | Min | Max |
|---|---|---|---|---|---|
| Dependent variable | | | | | |
| Child recently been diagnosed with ARI | | | | | |
| No | 62,610 | 76.02 | | | |
| Yes | 19,749 | 23.98 | | | |
| Living environment | | | | | |
| Household burns waste in the open | | | | | |
| No | 42,336 | 51.40 | | | |
| Yes | 40,023 | 48.60 | | | |
| Proportion of households in the area that openly burn waste | 82359 | - | 0.48 | 0.00 | 1.00 |
| Type of main cooking fuel | | | | | |
| Electricity/gas (Ref.) | 42,486 | 51.59 | | | |
| Kerosene | 12,423 | 15.08 | | | |
| Charcoal/briquettes | 508 | 0.62 | | | |
| Firewood | 26,942 | 32.71 | | | |
| Spatial characteristics | | | | | |
| Region of residence | | | | | |
| Sumatera | 25,401 | 30.84 | | | |
| Java | 21,801 | 26.47 | | | |
| Bali & Nusa Tenggara | 7,663 | 9.30 | | | |
| Kalimantan | 8,259 | 10.03 | | | |
| Sulawesi | 11,212 | 13.61 | | | |
| Papua | 8,023 | 9.74 | | | |
| Place of residence | | | | | |
| Urban area (Ref.) | 36,932 | 44.84 | | | |
| Rural area | 45,427 | 55.16 | | | |
| Household resides in a slum area | | | | | |
| No (Ref.) | 68,000 | 82.57 | | | |
| Yes | 14,359 | 17.43 | | | |
| Child characteristics | | | | | |
| Sex of child | | | | | |
| Female (Ref.) | 42,066 | 51.08 | | | |
| Male | 40,293 | 48.92 | | | |
| Age of child (in months) | | | | | |
| <12 | 14,741 | 17.90 | | | |
| 12-23 | 15,959 | 19.38 | | | |
| 24-35 | 15,854 | 19.25 | | | |
| 36-47 | 17,461 | 21.20 | | | |
| 48-59 (Ref.) | 18,344 | 22.27 | | | |
| Socio-demographic characteristics | | | | | |
| Sex of household head | | | | | |
| Male (Ref.) | 71,177 | 86.42 | | | |
| Female | 11,182 | 13.58 | | | |
| Education of household head | | | | | |
| None | 12,542 | 15.23 | | | |
| Elementary school | 23,587 | 28.64 | | | |
| Junior high school | 15,729 | 19.10 | | | |
| Senior high school | 23,461 | 28.49 | | | |
| College or higher (Ref.) | 7,040 | 8.55 | | | |
| Marital status of household head | | | | | |
| Married (Ref.) | 78,538 | 95.36 | | | |
| Bereaved | 2,740 | 3.33 | | | |
| Divorced | 917 | 1.11 | | | |
| Never married | 164 | 0.20 | | | |
| Household size | 82359 | - | 4.90 | 2.00 | 23.00 |
| Number of U-5 children | | | | | |
| One (Ref.) | 61,741 | 74.97 | | | |

| Variables | N | % | Mean | Min | Max |
|---|---|---|---|---|---|
| Two or more | 20,618 | 25.03 | | | |
| Economic characteristics | | | | | |
| Household head is working | | | | | |
| No (Ref.) | 9,621 | 11.68 | | | |
| Yes | 72,738 | 88.32 | | | |
| House is self-owned | | | | | |
| No (Ref.) | 18,886 | 22.93 | | | |
| Yes | 63,473 | 77.07 | | | |
| Household received/bought rice for the poor | | | | | |
| No (Ref.) | 39,253 | 47.66 | | | |
| Yes | 43,106 | 52.34 | | | |
| Wealth index score | 82359 | - | -0.03 | -3.08 | 3.32 |

Note: Min = Minimum, Max = Maximum. Numerical variables are presented by its mean, minimum, and maximum values.
Source: Authors' calculation

Table 2 presents the relative odds of a child experiencing ARI in the four stages of the development of the final multivariate regression model. The first column presents the ORs from simple logistic regression between the covariates and ARI. In this stage, household open burning variable and proportion of households that practice open burning was found to be statistically significant.

In Model A, we include only household open burning variable and proportion of households that practice open burning. In this stage, open burning at household level was no longer statistically significant at any of the three levels of significance. Moreover, in Model B we included type of main cooking fuel. The proportion of households that practises open burning in the area remained statistically significant.

Furthermore, in Model C, which is the final multivariable regression model, we put in all other covariates except for marital status of household head and employment of household head because these variables remained statistically insignificant. Model C was statistically significant ($P<0.001$). In this model, the proportion of households that openly burn their waste, albeit weakened, remain significant. The children who live in an area that has higher proportion that burns their wastes in the open are of higher risk of ARI (OR = 1.06). A possible explanation for this is that children do not spend all of their time inside the house. They may be carried by their mothers outside or play by themselves outside and hence exposed to the pollution emanated from the open burning of household waste in their backyard or their neighbours' backyard.

Table 2. Regression results

| Variables | Unadjusted OR | | Model A Adj. OR | | Model B Adj. OR | | Model C Adj. OR | |
|---|---|---|---|---|---|---|---|---|
| Living environment | | | | | | | | |
| Household burns waste in the open | | | | | | | | |
| No (Ref.) | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Yes | 1.05 | *** | 1.00 | | 1.00 | | 0.99 | |
| Proportion of households in the area that openly burn waste | 1.12 | *** | 1.12 | *** | 1.13 | *** | 1.06 | * |
| Type of main cooking fuel | | | | | | | | |
| Electricity/gas (Ref.) | 1.00 | | | | 1.00 | | 1.00 | |
| Kerosene | 0.95 | ** | | | 0.95 | ** | 1.10 | *** |
| Charcoal/briquettes | 0.84 | | | | 0.84 | * | 0.96 | |
| Firewood | 0.95 | *** | | | 0.94 | *** | 0.98 | |
| Spatial characteristics | | | | | | | | |
| Region of residence | | | | | | | | |
| Sumatera (Ref.) | 1.00 | | | | | | 1.00 | |
| Java | 1.32 | *** | | | | | 1.30 | *** |
| Bali & Nusa Tenggara | 1.13 | *** | | | | | 1.14 | *** |
| Kalimantan | 0.97 | | | | | | 0.98 | |
| Sulawesi | 0.85 | *** | | | | | 0.86 | *** |
| Papua | 0.92 | *** | | | | | 0.94 | * |
| Place of residence | | | | | | | | |
| Urban area (Ref.) | 1.00 | | | | | | 1.00 | |
| Rural area | 1.02 | | | | | | 1.06 | *** |
| Household resides in a slum area | | | | | | | | |
| No (Ref.) | 1.00 | | | | | | 1.00 | |
| Yes | 1.07 | *** | | | | | 1.04 | * |
| Child characteristics | | | | | | | | |
| Sex of child | | | | | | | | |
| Female (Ref.) | 1.00 | | | | | | 1.00 | |
| Male | 1.05 | *** | | | | | 1.06 | *** |
| Age of child (in months) | | | | | | | | |
| <12 | 0.95 | ** | | | | | 0.96 | * |
| 12-23 | 1.34 | *** | | | | | 1.34 | *** |
| 24-35 | 1.20 | *** | | | | | 1.20 | *** |
| 36-47 | 1.06 | ** | | | | | 1.06 | ** |
| 48-59 (Ref.) | 1.00 | | | | | | 1.00 | |
| Socio-demographic characteristics | | | | | | | | |
| Sex of household head | | | | | | | | |
| Male (Ref.) | 1.00 | | | | | | 1.00 | |
| Female | 1.05 | ** | | | | | 1.02 | |
| Education of household head | | | | | | | | |
| None | 1.14 | *** | | | | | 1.13 | *** |
| Elementary school | 1.26 | *** | | | | | 1.20 | *** |
| Junior high school | 1.19 | *** | | | | | 1.14 | *** |
| Senior high school | 1.10 | *** | | | | | 1.07 | ** |
| College or higher (Ref.) | 1.00 | | | | | | 1.00 | |
| Marital status of household head | | | | | | | | |
| Married (Ref.) | 1.00 | | | | | | | |
| Bereaved | 0.98 | | | | | | | |
| Divorced | 0.88 | | | | | | | |
| Never married | 0.92 | | | | | | | |
| Household size | 0.95 | *** | | | | | 0.95 | *** |
| Number of U-5 children | | | | | | | | |
| One (Ref.) | 1.00 | | | | | | 1.00 | |
| Two or more | 0.86 | *** | | | | | 0.96 | * |
| Economic characteristics | | | | | | | | |
| Household head is working | | | | | | | | |
| No (Ref.) | 1.00 | | | | | | 1.00 | |

| Variables | Unadjusted OR | | Model A Adj. OR | Model B Adj. OR | Model C Adj. OR | |
|---|---|---|---|---|---|---|
| Yes | 0.97 | | | | 0.99 | |
| House is self-owned | | | | | | |
| No (Ref.) | 1.00 | | | | 1.00 | |
| Yes | 0.95 | ** | | | 0.93 | *** |
| Household received/bought rice for the poor | | | | | | |
| No (Ref.) | 1.00 | | | | 1.00 | |
| Yes | 1.18 | *** | | | 1.15 | *** |
| Wealth index score | 1.00 | | | | 1.02 | ** |

Notes: Adj. OR = adjusted odds ratio; * $p<0.1$, ** $p<0.05$, *** $p<0.01$,
Source: Authors' calculation

## DISCUSSION

This cross-sectional study was aimed at assessing the relationship between open burning of municipal solid waste and child respiratory health. In the single logistic regression model, both open burning at the household and community level were significantly associated with higher odds of ARI among children. In the final multivariate model, however, only prevalence of open burning at the community level remains significantly associated with elevated odds of ARI. These relationships are consistent with the study by Boadi and Kuitunen which showed a significant relationship between solid waste burning and the incidence of respiratory infections in children (Boadi & Kuitunen, 2005).

Besides open burning, we also have included several control variables. The first control variable, type of cooking fuel, used to represent indoor air pollution, was found to be significantly associated with ARI experience among children. Children who live in households that rely on kerosene for cooking fuel had higher risk of ARI compared to those living in households that use cleaner fuels (OR = 1.10). Although this association is weak, it is consistent with previous studies in terms of its direction of association (Acharya et al., 2014; Upadhyay et al., 2015).

Regarding spatial characteristics, a regional disparity of ARI experience was observed shown by the variety of ORs in the six regions. This similar disparity was also observed in past studies (Dahal et al., 2009). Moreover, a previous study suggests that children residing in rural areas were at higher risk of ARI compared to those residing in urban areas (Agustina et al., 2014). Furthermore, we alsofound from the analysis that indeed rural children had elevated risk compared to their urban fellows (OR = 1.06).

Characteristics of the child also influence the risk of ARI experience. Consistent with a previous study (Siziya, Muula, & Rudatsikira, 2009), boys' risks of experiencing ARI is higher compared to that of girls (OR = 1.06). While the younger the children are, the more likely the experience of ARI is (Amugsi et al., 2015; Bbaale, 2011). We also observed this kind of relationship.

With regard to socio-demographic characteristics, three out of four variables were observed to be statistically significant, namely education of household head, household size, and the number of U-5 children. Sex of household head became insignificant in the final multivariable logistic regression model (Model C). Children who are raised in household headed by someone with lower educational attainment are of higher ARI risk (the magnitude of ORs varies [1.07 to 1.20] but all are negatively associated with ARI risk). Consistent with this relationship, Agustina et al. (2014) found that children raised by mothers with higher educational attainment are less likely to suffer from ARI. Moreover, higher number of household members was associated with lower risk of ARI among children. Also, higher number of U-5 children is correlated with lower risk of ARI among children.

As for the economic characteristics, three variables were found to be statistically associated with the dependent variable, namely tenure, participation in the *Raskin*

program, and household wealth index score. Children living in house owned by the family are less likely to contract ARI. Moreover, children who live in poorer households, indicated by having received or purchased rice from the rice for the poor program (*Raskin*) are at higher risk of ARI. The poor are more likely to practice poor waste management practices such as open burning hence making them more vulnerable to the adverse health effects of open burning (Vergara & Tchobanoglous, 2012). Furthermore, higher wealth index was positively correlated with higher risk of ARI. This relationship is different from previous studies (Agustina et al., 2014; Dahal et al., 2009; Siziya et al., 2009; Upadhyay et al., 2015), where children living in more affluent households experience less ARI.

### Policy Implications

Open burning of household solid waste is still prevalent. Household solid waste in Indonesia comprises kitchen waste and recyclable inorganic wastes (Aprilia, A., Tezuka, T., & Spaargaren, 2012). When the latter is not separated from the former, it may also get burnt and emanate harmful pollution that can hurt the people around. Many cost-effective technologies that can be used to recover energy from waste and reduce pollution are available (Jimenez et al., 2017). However, developing countries like Indonesia may not have the financial capacity to afford those technologies (Bogner et al., 2007).

Given the findings of the study, a concerted effort from the Ministry of Public Works and Housing, the Ministry of Environment and Forestry, and the Ministry of Health to minimise open burning of domestic waste to lower the risk of air pollution. However, the task waste management should not only be borne by the local and national government, but also by the Indonesian households. Each household can implement reduce, reuse and recycling (3R) approaches as to minimise their wastes in environmental friendly technologies.

### *Study Limitations*

The current study is a further analysis of secondary data, the 2013 Riskesdas. As the 2013 Riskesdas is collected in a cross-sectional way, then the results are far from causal inference. Moreover, there may be factors associated with ARI that are not collected in the 2013 Riskesdas such as ambient air pollution. However, despite having some limitations, the current study provides a different perspective on open burning of household waste and child respiratory health.

## CONCLUSION AND RECOMMENDATION

### Conclusion

The current study provided new perspective on household waste management and was aimed at examining the relationship between open burning of household solid waste and experience of ARI among children in Indonesia We observed a significant relationship between the open burning of household waste and ARI experience among Indonesian children. A higher proportion of open burning is associated with higher risk of ARI. We did not observe, however, a significant association between open burning at the household level. These findings mean that reducing outdoor air pollution is also as important as reducing indoor air pollution.

### Recommendations

An integrative effort from all relevant stakeholders in Indonesia including the households themselves is needed to tackle the open burning problem. Also, further studies are needed to gain stronger evidence on the impact of open burning of household waste on children's respiratory health.

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## Conflict of Interest Statement

The authors declare no conflict of interest.

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