USE OF UNSAFE COOKING FUELS AND BOILING PRACTICE AMONG INDONESIAN HOUSEHOLDS: EMPIRICAL EVIDENCE FROM THE 2012 DEMOGRAPHIC AND HEALTH SURVEY

Penggunaan Bahan Bakar Memasak yang Tidak Aman dan Perilaku Merebus Air: Bukti Empiris dari Survei Demografi dan Kesehatan Indonesia 2012

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ABSTRAK

Sumber air minum yang *improved* tidak selalu aman secara mikrobiologi. Maka, rumah tangga biasanya merebus air sebelum diminum. Namun, kebiasaan ini berpotensi untuk mengganggu kesehatan apabila rumah tangga tersebut menggunakan bahan bakar masak yang tidak aman. Data dari Survei Demografi dan Kesehatan Indonesia (SDKI) 2012 dianalisis untuk memeriksa hubungan antara penggunaan bahan bakar memasak yang tidak aman dengan pemilihan merebus sebagai metode pengolahan air minum pada tingkat rumah tangga. Model-model regresi probit bivariat dan multivariat dicocokkan pada data dan dibandingkan dengan menggunakan rerata efek marginal (REM) dan tingkat kepercayaan 95 persen sebagai ukuran hubungan. Hasil analisis ini mengungkapkan bahwa penggunaan minyak tanah sebagai bahan bakar memasak berhubungan secara signifikan dengan probabilitas merebus air yang lebih tinggi (p = 0,006; REM: 0,019; SK 95%: 0,0056, 0,0333). Hal ini juga berlaku pada bahan bakar padat (p < 0,001; REM: 0,3115; SK 95%: 0,3026, 0,3203). Hubungan-hubungan ini tetap signifikan, walaupun melemah (Minyak tanah, p < 0,001; REM: 0, 02706; SK 95%: 0,0186, 0, 0355; Bahan bakar padat, p < 0.001; REM: 0,0373; SK 95%: 0,02839, 0,0463), ketika variabel-variabel lain dimasukkan ke dalam model multivariat. Penulis menyarankan perlunya promosi teknologi pengolahan air minum rumah tangga selain merebus agar dapat mengurangi dampak kesehatan karena asap yang disebabkan oleh bahan bakar yang tidak aman untuk memasak air. Selain itu, pemangku kepentingan juga perlu merealisasikan akses paripurna terhadap air minum dan sanitasi yang aman agar dapat mengurangi kebutuhan akan perilaku merebus air.

Kata kunci: Bahan bakar tidak aman, perilaku merebus air, regresi probit, SDKI 2012

ABSTRACT

Improved drinking-water sources need not be microbiologically safe. Hence, households usually boil their water prior to drinking. However, this practice can potentially harm health when households rely on unsafe cooking fuels. In Indonesia, little is known about the association of use of unsafe fuels with boiling practice. Hence, an analysis was carried out to elicit information regarding boiling practice using unsafe fuels. Such information would be useful in determining appropriate household water treatments. Data from the 2012 Indonesia Demographic and Health Survey (IDHS) were analysed to examine the relationship between the use of unsafe cooking fuel and choosing boiling as household water treatment. Bivariate and multivariate probit regression models (PRM) were fitted and compared using average marginal effects (AME) and its respective 95 per cent confidence interval (95% CI) as measures of association. The results suggest that using kerosene as cooking fuel is positively significantly associated with higher probability of practicing boiling (p = 0.006; AME: 0.019; 95% CI: 0.0056, 0.0333). This is also true for use of solid fuel (p< 0.001; AME: 0.3115; 95% CI: 0.3026, 0.3203). These association holds, albeit attenuated (Kerosene, p< 0.001; AME: 0.02706; 95% CI: 0.0186, 0.0355; Solid fuel, p< 0.001; AME: 0.0373; 95% CI: 0.02839, 0.0463), after the control variables are included. The authors suggest that stakeholders should promote the use of other household water treatment technologies to reduce the boiling practice using unsafe cooking fuels as to minimize the risk of smoke related infections. Moreover, universal access and equity to safe drinking water and sanitation facility in Indonesia should be realised to reduce demand of boiling water using unsafe cooking fuels.
Keywords: *Boiling practice, unsafe cooking fuel, probit regression, 2012 IDHS*

INTRODUCTION

In 2012, it was estimated that there were 842,000 diarrhoea deaths attributable to inadequate drinking-water, sanitation, and hand-hygiene. Improving access to improved drinking-water sources and improved sanitation facility, as defined by the Joint Monitoring Programme (JMP) between the World Health Organization (WHO) and the United Nations Children's Fund (WHO/UNICEF JMP, 2008), can reduce the risk of diarrhoeal diseases and prevent those unfortunate deaths (Burström, Macassa, Öberg, Bernhardt, & Smedman, 2005; Ezeh, Agho, Dibley, Hall, & Page, 2014; Fink, Günther, & Hill, 2011; Wolf et al., 2014). However, improved drinking-water sources need not be safe (Bain et al., 2012; Onda, LoBuglio, & Bartram, 2012; Shaheed, Orgill, Montgomery, Jeuland, & Brown, 2014; Shaheed et al., 2014), as microbial contamination affects all kinds of water source (Bain et al., 2014). This engenders many kinds of health risks (Bartram & Cairncross, 2010; Prüss-Üstün, Kay, Fewtrell, & Bartram, 2004).

Household water treatment (HWT) is usually used by household that do not have the luxury of access to clean and safe water (Rosa & Clasen, 2010). One of the forms of HWT is boiling, which is deemed effective in killing microorganisms and easier to administer than other water treatments (Brown & Sobsey, 2012; Clasen et al., 2008; Clasen, Thao, Boisson, & Shipin, 2008; Rosa, Miller, & Clasen, 2010). This treatment can improve water quality and it can reduce even further incidences of diarrhoea (Clasen, Roberts, Rabie, Schmidt, & Cairncross, 2007; Clasen, Schmidt, Rabie, Roberts, & Cairncross, 2007; Fewtrell et al., 2005). Boiling, however, is not without drawbacks. First, there is evidence that makes effectiveness of boiling questionable (Gupta et al., 2007) and it provides no residual protection (Mintz, et al., 2001). Second, there is a potential for recontamination if the storage is unsafe (Mintz, et al., 2001; Clasen & Bastable, 2003) or if the user has ill-hygiene practices (Rufener, Mäusezahl, Mosler, & Weingartner, 2010). Lastly, boiling water using unsafe cooking fuel (e.g. solid fuels, kerosene) can produce harmful smoke (WHO, 2010).

Regarding HWT technologies which are considered to be safer and economically sustainable, Lantagne, Quick, and Mintz (2007) point out that there are five technologies that can be implemented at household level, namely chlorination, filtration (bio-sand and ceramic), solar disinfection, combined filtration/chlorination, and combined flocculation/chlorination. These options, however, always have disadvantages. Therefore, a holistic assessment should be conducted prior the implementation of such technologies. Nevertheless, these options are promising in the absence of drinking water treatment system and safe cooking fuels.

Studies have shown that smoke from combustion of biomass fuel may be associated with higher risk of acute lower respiratory infection (ALRI) (Rehfuess, Best, Briggs, & Joffe, 2013; Rehfuess, Tzala, Best, Briggs, & Joffe, 2009), asthma (Agrawal, 2012; Agrawal, Pearce, &Ebrahim, 2013), and adverse maternal outcomes (Abusalah et al., 2012; Epstein et al., 2013; Pope et al., 2010; Sreeramareddy, Shidhaye, & Sathiakumar, 2011). This is worrisome as the use of solid fuels is still considerably high among households in low- and middle-income (LMI) settings. A recent study that used data from 155 countries (of which 97% are LMI countries) estimated that 41 per cent of households still rely on solid fuels in 2010, despite a decline of 21 per cent after three decades (Bonjour et al., 2013). Moreover, 59 per cent of rural households in Indonesia still use wood as cooking fuel (Statistics Indonesia, BKKBN, MOH, & ICF International, 2013).

In addition, boiling of drinking-water can increase financial burden of households (Gilman & Skillicorn, 1985). It was found that the cost of boiling ranges from 1 per cent to 7 per cent of income (or expenditure) (Clasen, T., et al., 2008; Clasen, T. F., et al., 2008; Psutka, Peletz, Michelo, Kelly, & Clasen, 2011). Even, boiling is considered to be economically and environmentally unsustainable (Mintz, E., Bartram, J. & Lochery, P., 2001; WHO, 2007). Boiling drinking-water, although favoured in

Indonesia as HWT, also poses health hazard if performed using unsafe cooking fuel. Despite such potential financial and health implications, to date, there are no studies in Indonesia that address the relationship between the use of unsafe cooking fuel and boiling practice. Therefore, the objective of this study is to investigate whether households that rely on unsafe cooking fuel have higher probability of boiling their water prior to drinking it.

MATERIALS AND METHODS

Data Source

The data come from the latest cross-sectional Indonesia Demographic and Health Survey (IDHS) fielded in 2012. The 2012 IDHS is part of a series of comparable, nationally representative surveys that have been conducted in more than 85 countries worldwide since 1984 (Corsi, Neuman, Finlay, & Subramanian, 2012). The 2012 IDHS was conducted in 33 provinces and the samples for each province were stratified by urban and rural areas. A more detailed explanation of the sampling procedure can be seen elsewhere (Statistics Indonesia, et al., 2013). For this study, household level data that comes from the household recode of IDHS 2012 that consists of 43,852 households were analysed. The household recode contains information on housing characteristics and inventory of household assets.

Ethical Consideration

This study is a secondary analysis of the 2012 IDHS which data are publicly available and all respondents have been de-identified. Therefore, additional ethical review was not sought.

Dependent Variable

The dependent variable in this study is whether the household boils their water before drinking it (0, no; 1, yes). This variable is at the household level. Although there are other types of HWT, such as chlorination, solar disinfection (Grundy, Wright, and Conroy, 2004); we only analyse boiling practice as it has potentially adverse financial and health consequences.

Main Independent Variable

The main independent variable was type of cooking fuel. In 2012 IDHS, information on cooking fuel was obtained by asking: "What type of fuel does your household mainly use for cooking?" There is 12-fold classification of cooking fuels in the standard DHS questionnaire: electricity, LPG/natural gas, biogas, kerosene, coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crop, animal dung, no food cooked in household, and other/unknown (Statistics Indonesia, et al., 2013). Different from previous studies that grouped type of cooking fuels into two categories (i.e. high pollution fuels and low pollution fuels) (Agrawal, 2012; Sreeramareddy, et al., 2011), kerosene is coded as an independent category (coded 2), as it is considered safer than solid fuels but less safer than electricity or gas (Lam, Smith, Gauthier, & Bates, 2012). Then, electricity, LPG/natural gas, biogas, and "no food cooked" were classified into low pollution cooking fuel (coded 1), while coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crop, animal dung, and other fuels were classified into solid fuel (coded 3).

Control Variables

The following variables served as control variables: development region (1, Sumatera; 2, Java; 3, Bali and Nusa Tenggara; 4, Kalimantan; 5, Sulawesi; 6, Maluku and Papua), rurality (1, urban area; 2, rural area), drinking-water source (1, piped water; 2, branded bottled water; 3, refilled bottled water; 4, rainwater collection; 5, surface water; 6, spring water; 7, protected ground water; 8, unprotected ground water), type of sanitation facility (1,improved facility; 2, unimproved facility; 3, no facility/open defecation) (WHO/UNICEF JMP, 2006), availability of proper hand washing facility (0, no; 1, yes), highest education of household head (1, none; 2, incomplete primary; 3, complete primary; 4, incomplete secondary; 5, complete secondary; 6, college or higher), and wealth index quintiles (1, lowest; 2, second; 3, middle; 4, fourth; 5, highest).

Construction of Wealth Index

Wealth index has been widely used as a surrogate to expenditure data in depicting socioeconomic position (SEP) of households (Howe et al., 2012; Vyas & Kumaranayake, 2006). The wealth index provided in the IDHS 2012 was estimated based on principal component analysis (PCA) designed by Filmer and Pritchett (Filmer & Pritchett, 2001), from information on household's assets, housing characteristics, and water and sanitation (Rutstein, 2008; Rutstein & Johnson, 2004). However, a new wealth index was created using a different method, polychoric PCA (Kolenikov & Angeles, 2004, 2009), and in the process we omitted variables such as type of cooking fuel, type of drinking-water source, type of sanitation facility to prevent overlapping. This method can take into account the ordinal form of variables (Kolenikov & Angeles, 2009). In total, there were 17 variables included in the wealth index including household ownership of assets, and type of material of floor, wall, and roof. The explained variance was 36.65 per cent for the first component and the polychoric correlation coefficient (ρ) = 0.3814. The higher the values of those indicators the better the wealth index in explaining relative SEP of households (Kolenikov & Angeles, 2009). The scores were then grouped into quintiles with approximately even proportions.

Statistical Analysis

Simple summary statistics (i.e. percentage for categorical variables and mean for continuous variables) are shown for the main independent variable (type of cooking fuel) and selected control variables. For the bivariate and multivariate statistical analyses, probit regression model (PRM) was chosen over logistic regression model (LRM) (Hosmer, Lemeshow, & Sturdivant, 2013; Long & Freese, 2014). First, this study focuses more on the differential probability of boiling water based on the type of cooking fuel rather than the magnitude of individual covariates. Second, the common outcome of boiling practice (in 67.83% of households) will cause the LRM coefficients to exaggerate the relationship between cooking fuel and boiling practice (Sainani, 2011).

The coefficients from the PRM cannot be directly interpreted, hence, it is converted into average marginal effects (AME) along with its respective 95 per cent robust confidence intervals (95% CI) (Long & Freese, 2014). A test of collinearity was conducted by examining the variance inflating factor (VIF) of each explanatory variable, and as a rule of thumb, a VIF valued at more than 10 is an indicator of severe collinearity (Gujarati, 2004). As for the performance of the regression model, we use area under the receiver operating characteristic (ROC) curve (AUC) as an indicator (Fawcett, 2006). Finally, the regression results will be plotted using the "COEFPLOT" command (Jann, 2013). When the 95 per cent CI of the AMEs intersects with the zero line in the y axis, then the category is statistically insignificant at the five per cent level of significance. All of the statistical analyses were performed using Intercooled Stata version 13.1 (StataCorp, 2013).

RESULTS

Characteristics of Sample

To handle the missing values in the data, listwise deletion was performed (Dong & Peng, 2013). This procedure yielded a sub-sample of 42,652 households (97.26% of IDHS 2012 full household sample).

Table 1. Descriptive statistics for selected variables based on IDHS 2012 (N = 42,652)

Variable	Categories	%	VIF
Boiling Practice	No	32.39	N.A.
	Yes	67.61	N.A.
Type of cooking fuel	Low pollution fuel (Ref.)	43.57	N.A.
	Kerosene	15.82	1.61
	Solid fuel	40.61	3.43
Region	Sumatra (Ref.)	28.11	N.A.
	Java	27.60	2.13
	Bali & Nusa Tenggara	9.21	1.38
	Kalimantan	10.34	1.43
	Sulawesi	16.18	1.57
	Maluku & Papua	8.56	1.44
Residence	Urban area (Ref.)	47.43	N.A.
	Rural area	52.57	3.14
Drinking-water source	Piped water (Ref.)	13.20	N.A.
	Branded bottled water	8.53	1.67
	Refilled bottled water	21.78	2.37
	Rainwater collection	4.21	1.34
	Surface water	4.09	1.44
	Spring water	10.80	1.96
	Protected ground water	28.49	2.97
	Unprotected ground water	8.90	1.67
Sanitation facility	Improved (Ref.)	59.34	N.A.
	Unimproved	22.70	1.61
	Open defecation	17.66	1.79
Hand-washing station is available	No (Ref.)	25.36	N.A.
	Yes	74,64	4.39
Education of household head	No formal education (Ref.)	7.51	N.A.
	Incomplete primary	18.39	2.74
	Complete primary	22.91	3.28
	Incomplete secondary	17.87	2.81
	Complete secondary	22.34	3.60
	College or higher	10.98	2.53
Wealth index quintiles	Lowest (Ref.)	20.00	N.A.
	Second	20.02	2.08
	Third	20.13	2.41
	Fourth	19.92	2.85
	Highest	19.93	3.52

Notes: Ref.: Reference category; N.A.: Not applicable
Source: Author's calculation

Table 1 presents simple summary statistics of selected variables. Of the sample, almost 68 per cent of households reported boiling their water prior to drinking. In regard to type of cooking fuel, the majority of the household reported using low pollution fuels (43.57%), followed by solid fuels (40.61%), and kerosene (15.82%). In terms of region, most households lives in Sumatera (28.11%) and Java (27.60%), followed by Sulawesi (16.18%), Kalimantan (10.34%), then Maluku and Papua (8.56%). There are more households living in rural areas (52.57%) than in urban areas (47.43%).

Drinking-water supply, sanitation facility, and hand washing facility are environmental variables in this study. In the sample, protected ground water is the predominant water source (28.49%), followed by refilled bottled water (21.78%), piped water (13.20%), and water spring (10,80%). As for sanitation facility, 59.34 per cent of households have access to improved ones, 22.70 per cent use unimproved facilities, while 17.96 per cent have open defecators as household members. In terms of the hand washing facility, the majority of households (74.64%) reported having proper ones.

There is an irregularity in the pattern of education ladder of household head. The majority of households (22.91%) are headed by someone with complete primary education, while only 11 per cent are headed by someone with college degree or higher. One fourth of the sample are headed by someone with education lower than primary school, and just over 22 per cent are headed by someone with secondary education. As for wealth index quintiles, the sample are evenly distributed (around 20% in each quintile).

Type of Cooking Fuel and Boiling Practice

The final multivariate model was statistically significant ($\chi^2_{(24)}$ = 19,491.41, $p<$ 0.001) with very high AUC of 93.84 per cent and adjusted McFadden's R^2 of 57.6 per cent. The average VIF of the model is 2.18 with no explanatory variables having VIF that exceeds 10.

Figure 1 presents the unadjusted and adjusted AMEs of cooking fuel type. In the unadjusted model, using kerosene is significantly associated with higher probability of boiling practice (p = 0.006; AME: 0.0195; 95% CI: 0.0056, 0.0333). Moreover, using solid fuel is associated with even higher probability of boiling water prior to drinking ($p<$ 0.001; AME: 0.3115; 95% CI: 0.3026, 0.3203).

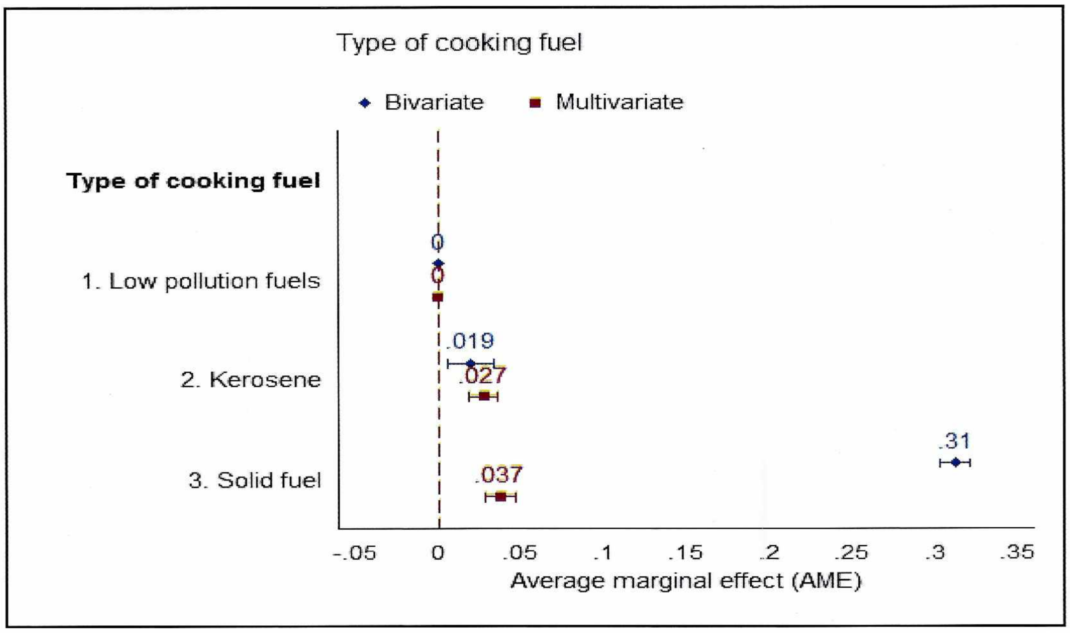
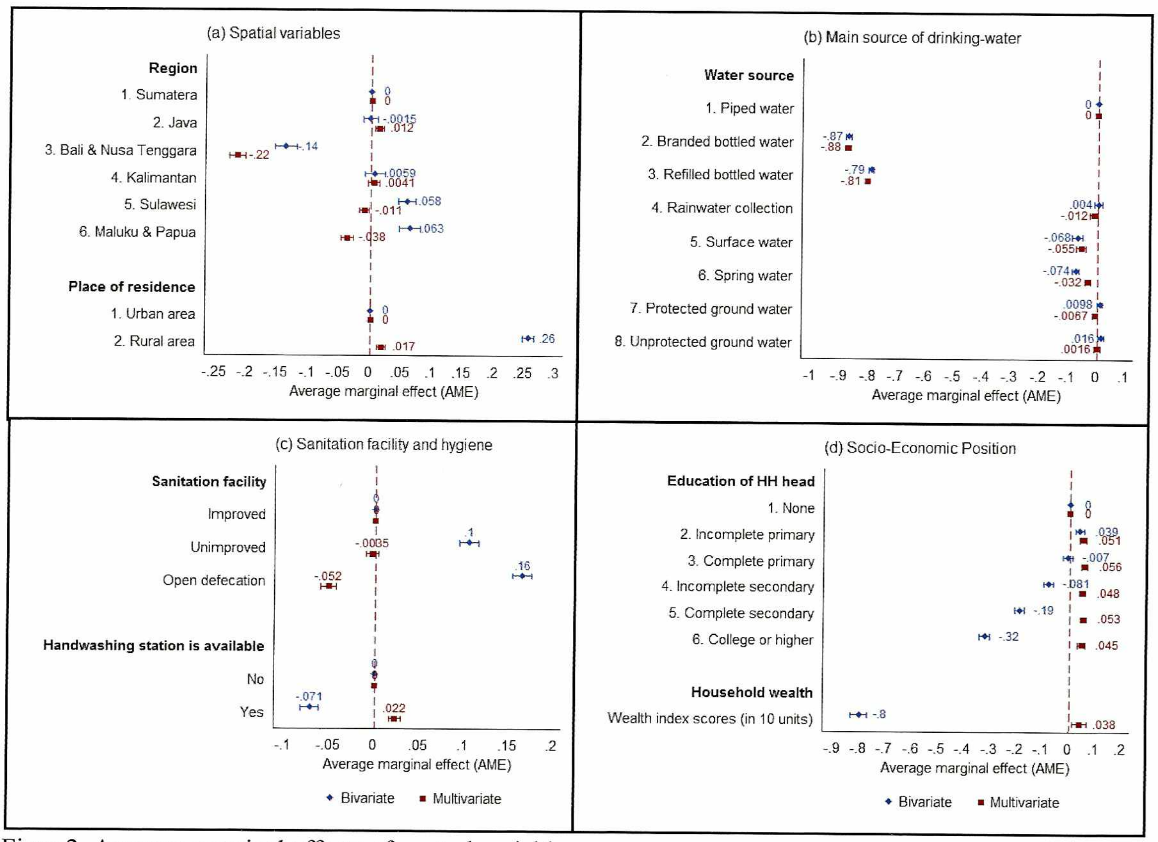


Figure 1. Average marginal effects of cooking fuel type

In the adjusted model, the likelihood of boiling practice in a household that uses kerosene is higher than that in the unadjusted one (p< 0.001; AME: 0.0271; 95% CI: 0.0186, 0.0355). However, the association between using solid fuel and boiling practice is attenuated in the adjusted model (p< 0.001; AME: 0.0373; 95% CI: 0.0284, 0.0463).

The control variables includes region, place of residence, main source of drinking-water, sanitation facility, availability of proper hand washing station, education of household head, and wealth index quintiles. Figure 2 presents both unadjusted and adjusted AMEs of the control variables.

Control Variables



Figur 2. Average marginal effects of control variables

Spatial Variables

The spatial variables in this study are region (in six categories) and place of residence (urban area versus rural area). The direction of AMEs differs across regions both in the unadjusted model and in the adjusted one (**Error! Reference source not found.**). With regard to place of residence, households living in rural areas have higher probability of practicing boiling (*p*< 0.001; AME: 0.2559; 95% CI: 0.2472, 0.2645) than those living in urban areas. However, the figure decreased after covariates are included in the model (*p*< 0.001; AME: 0.0168; 95% CI: 0.0102, 0.0233).

Main source of drinking-water

The main source of drinking-water is classified into eight categories with piped water as the reference category. The unadjusted and adjusted AMEs of the drinking-water sources are similar with several categories being statistically insignificant. The probability of boiling when households drink from branded bottled is statistically lower than that in households who use piped water in the unadjusted model (*p*< 0.001; AME: -0.8717; 95% CI: -0.8818, -0.8616) and in the adjusted one (*p*< 0.001; AME: -0.8769; 95% CI: -0.8872, -0.8666). Moreover, the probability of boiling when households drink from refilled bottled is statistically lower than that in households who use piped water (Unadjusted AME: -0.7933; 95% CI: -0.8029, -0.7836; Adjusted AME: -0.8070; 95% CI: -0.8162, -0.7978). When the main water source is rainwater collection, the probability of boiling does not significantly differ both in the unadjusted model (p = 0.557; AME: 0.0040; 95% CI: -0.0093, 0.0173) and adjusted one (p = 0.083; AME: -0.0116; 95% CI: -0.0248, 0.0015).

Households who use surface water as their main source of drinking-water have lower likelihood of boiling, compared to reference households, both in the unadjusted model (p< 0.001; AME: -0.0678; 95% CI: -.0853, -0.0503) and in the adjusted one (p< 0.001; AME: -0.0550; 95% CI: -0.0714, -0.0387).

Households who gets their water from spring are less likely to practice boiling, compared to reference households, both in the unadjusted (p< 0.001; AME: -0.0736; 95% CI: -0.0858, -0.0615) and in the adjusted one (p < 0.001; AME: -0.0320; 95% CI: -0.0420, -.0220).

Households who source water from protected ground water sources are more likely to boil compared to those who source from piped connection (p = 0.016; AME: 0.0098; 95% CI: 0.0019, 0.0177). This association, however, becomes insignificant and changes direction (p = 0.080; AME: -0.0067; 95% CI: -0.0142, 0.0008). Lastly, households who get their water from unprotected ground water sources are more likely to boil their water (p = 0.002; AME: 0.0155; 95% CI: 0.0057, 0.0254), but this becomes statistically insignificant as other covariates (see Figure 2b.) were included in the model (p = 0.742; AME: 0.0016; 95% CI: -0.0080, 0.0112).

Sanitation and Hygiene

The sanitation and hygiene variables are sanitation facility of household and availability of proper hand washing facility. Sanitation facility of household comprises three categories with improved sanitation facility being the reference category. Households who uses unimproved sanitation facility have higher likelihood to boil their water prior to drinking (p< 0.001; AME: 0.1045; 95% CI: 0.0938, 0.1152) compared to reference households. In the adjusted model, however, the direction of the relationship changes and became statistically insignificant (p = 0.301; AME: -0.0035; 95% CI: -0.0102, 0.0032). Households whose members are open defecators are more likely to practice boiling (p< 0.001; AME: 0.1645; 95% CI: 0.1535, 0.1754). However, the direction of this association also changed when other covariates are taken into account (p< 0.001; AME: -0.0518; 95% CI: -0.0600, -0.0436).

Households who have proper hand washing facility have lower probability of boiling their water prior to drinking compared to those who do not (p< 0.001; AME: -0.0712; 95% CI: -0.0811, -0.0614). In the adjusted model, however, the relationship flipped into a positive and statistically significant one (p< 0.001; AME: 0.0223; 95% CI: 0.0159, 0.0286).

Socio-Economic Position

The variables that depict SEP are highest education of household head and wealth index quintiles. The former consist of six categories with having no formal education being the reference category. With regard to unadjusted association between highest education of household head and boiling practice, there is a gradient where the higher the education the lower the probability of a household to boil water. However, these relationships changes when other covariates are included in the model, where having more education compared to none is associated with higher probability of practicing boiling (**Error! Reference source not found.**.d).

As for wealth index, for every 10 unit increase in the standardised score the probability boiling practice decreases (p< 0.001; AME: -0.8004; 95% CI: -0.8319, -0.7688). However, this relationship turned around when other covariates were included in the final model (p = 0.007; AME: 0.0382; 95% CI: 0.0104, 0.0661).

DISCUSSION

This study found that more than two thirds (67.61%; 95% CI: 67.17%, 68.06%) of households boil their drinking-water. This does not have health implications when their source of energy for boiling is safe. However, when otherwise, this could bring about health implications, especially related to respiratory health.

Main independent variable

Households who use kerosene has 2.7 per cent higher probability of boiling their water to make it safer for drinking compared to those who use low pollution fuels. Previous studies have shown that the use of kerosene as cooking fuel is associated with increased risk of tuberculosis and acute respiratory infections (ARI) (Kilabuko & Nakai, 2007; Pokhrel et al., 2010). Furthermore, households who use solid fuels have 3.7 per cent higher likelihood of practicing boiling compared to reference households. Use of solid fuels also have been shown to be associated with many health risks (Rehfuess, Bruce, & Smith, 2011; Sumpter & Chandramohan, 2013). This implies that shifting boiling practice to other safer HWTs (e.g. solar disinfection), may lead to reduction in respiratory health risks.

Control variables

Spatial Variables

There is a difference in boiling practice in terms of place of residence. The probability of a household living in a rural area to practice boiling is 1.7 per cent higher than their urban counterparts. This is different with the Rosa and Clasen's study where they found that globally, boiling is more commonly practiced by urban households than by rural households (Rosa & Clasen, 2010). One explanation for this is that some technologies of HWT other than boiling are less accessible in rural areas than in urban areas (Wright & Gundry, 2009). In Indonesia, it is reported that the use of ceramic, sand or other filter is six times higher in urban households than in rural households (Statistics Indonesia, et al., 2013).

Main drinking-water source

Type of main source of water for drinking was found to be associated with differences in the probability of boiling water. Use of branded bottled water and refilled bottled are negatively associated with boiling water prior to drinking. Households who drink from the former were found to have 88 per cent less probability and households who drink from the latter have 81 per cent less probability compared to those who drink from piped water.

There are three possible explanations behind this. First, people perceive bottled water as safer than tap water (Doria, 2010; Doria, 2006). A study by Ward et al. (2009) supports this notions where they found that most participants believes that bottled water beget additional health benefits. Second, dissatisfaction with tap water organoleptic (particularly taste) (Doria, 2010; Doria, 2006). A study by Espinosa-García et al. (2014) supports this as they found the main reason behind choosing bottled water instead of tap water as drinking-water source is the organoleptic characteristics of tap water. Third, physical quality of drinking water source may also affect preference. This is true as perception is drinking-water is influenced by improvements in physical water quality in the form of taste, odour, and turbidity (Wright, Yang, Rivett, & Gundry, 2012).

Moreover, households who drink from surface water was found to have 6 per cent less probability of boiling and households who drink from spring water was found to have 3 per cent less probability of boiling compared to those who drink from piped water. These findings are similar to that of Nawaz, Rahman, Graham, Katz, and Jekel (2001) where they found that only half of surveyed people who drank river water boil their water to make it safer. They further explored and found that the main reason of not boiling was their disbelief of health benefits of boiling.

Sanitation facility and hygiene

Households whose members defecate openly have 5.2 per cent less probability of boiling their water for drinking than those whose members defecate in an improved sanitation facility. Moreover, households who have proper hand washing facility were found to have 2.2 per cent higher probability of boiling their drinking water than those who do not. In an assessment conducted by Olembo, Kaona, Tuba, and Burnham (2004), sanitation facility was used to construct housing index where ownership in proper sanitation (reflected in better housing index) was found to be positively and significantly associated with HWT uptake.

Socio-economic position

The variables used to depict SEP were educational attainment of household health and household wealth. The results suggest having experienced formal education is associated with higher probability of boiling practice than having none. The probabilities are: 5.1 per cent higher (some primary education), 5.6 per cent higher (complete primary education), 4.8 per cent higher (incomplete secondary education), 5.3 per cent higher (complete secondary education), and 4.5 per cent higher (college or higher). This is similar to the finding from a previous study that demonstrated a positive relationship between education and use of water filtration as HWT (Wright & Gundry, 2009). In terms of educational attainment, the proportion of boiling practice was higher in the lower level, indicating that those who had higher level of education did use boiled water (Shoda, et al., 2011).

The second variable depicting SEP is household wealth represented in wealth index scores, is found to be positively associated with probability of boiling practice. The boiling practice probability increases by 3.8 per cent for every 10 unit increase in wealth index scores. This is consistent with previous research which found that the proportion of budget used for boiling in poorer households are larger than that in more affluent households (Gilman & Skillicorn, 1985). Boiling practice is considered adequate as point-of-use treatment due to its effectiveness in removing or killing pathogens (WHO/UNICEF JMP, 2006). Other adequate technologies include chlorine and water filters. The use of these has also been shown to be positively associated with household wealth (Giné Garriga & Pérez Foguet, 2013).

Limitations of the Study

There limitations of this study are threefold. First, the IDHS was administered in a cross-sectional manner, hindering the establishment of causality. Second, despite the high AUC and overall significance of the model, there may still be unobserved confounding. Third, this study did not consider use of proper household drinking-water storage. Therefore, the results of this study should be interpreted with the aforementioned caveats in mind. Nonetheless, the issue of the potential side effects of boiling which implicates children's health raised in this study cannot be overlooked.

CONCLUSION AND RECOMMENDATIONS

Using household level data from the 2012 IDHS, the association between use of unsafe cooking fuel and practice of boiling water prior to drinking was analysed. The results suggest that households that rely on unsafe cooking fuel are having higher likelihood of choosing boiling as their HWT. This association is robust when other covariates are taken into account in the final model as controls. Although boiling of drinking-water can improve safety of drinking-water, it may bring about unintended consequences in the form of higher risk of ALRI, especially among children. Therefore, availability of other HWT options should be increased to lower the demand of boiling of drinking-water in Indonesia. The Government of Indonesia (GoI) needs to work with other stakeholders concerned in providing a much safer HWT such as chemical-based water treatment (e.g. chlorination) and filtration (e.g. ceramic filtration). However, the provision of HWT should be corroborated with interventions that improves adherence to HWT in order to obtain higher health gains.

Moreover, in the long run, universal access and equity to improved drinking-water and sanitation facility in Indonesia should also be realised. This is intended to reduce the demand for boiling water. Lastly, more studies should be conducted to understand the types of point-of-use water treatment technologies that are desired and affordable by households that need them the most.

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REFERENCES

Abusalah, A., Gavana, M., Haidich, A.-b., Smyrnakis, E., Papadakis, N., Papanikolaou, A., & Benos, A. (2012). Low birth weight and prenatal exposure to indoor pollution from tobacco smoke and wood fuel smoke: A matched case-control study in Gaza Strip. *Maternal and Child Health Journal, 16*(8), 1718-1727. doi: 10.1007/s10995-011-0851-4.

Agrawal, S. (2012). Effect of indoor air pollution from biomass and solid fuel combustion on prevalence of self-reported asthma among adult men and women in India: Findings from a nationwide large-scale cross-sectional survey. *Journal of Asthma, 49*(4), 355-365. doi: 10.3109/ 02770903.2012.663030.

Agrawal, S., Pearce, N., & Ebrahim, S. (2013). Prevalence and risk factors for self-reported asthma in an adult Indian population: a cross-sectional survey. *The International Journal of Tuberculosis and Lung Disease, 17*(2), 275-282. doi: 10.5588/ijtld.12.0438.

Bain, R., Cronk, R., Hossain, R., Bonjour, S., Onda, K., Wright, J., . . . Bartram, J. (2014). Global assessment of exposure to faecal contamination through drinking water based on a systematic review. *Tropical Medicine & International Health, 19*(8), 917–927. doi: 10.1111/tmi.12334.

Bain, R. E. S., Gundry, S. W., Wright, J. A., Yang, H., Pedley, S., & Bartram, J. K. (2012). Accounting for water quality in monitoring access to safe drinking-water as part of the Millennium Development Goals: lessons from five countries. *Bulletin of the World Health Organization, 90*(3), 228–235A. doi: 10.2471/BLT.11.094284.

Bartram, J., & Cairncross, S. (2010). Hygiene, sanitation, and water: Forgotten foundations of health. *PLoS Med, 7*(11), e1000367. doi: 10.1371/journal.pmed.1000367.

Bonjour, S., Adair-Rohani, H., Wolf, J., Bruce, N. G., Mehta, S., Prüss-Ustün, A., . . . Smith, K. R. (2013). Solid fuel use for household cooking: Country and regional estimates for 1980-2010. *Environmental Health Perspectives, 121*(7), 784-790. doi: 10.1289/ehp.1205987.

Brown, J., & Sobsey, M. D. (2012). Boiling as household water treatment in cambodia: A longitudinal study of boiling practice and microbiological effectiveness. *The American Journal of Tropical Medicine and Hygiene, 87*(3), 394-398. doi: 10.4269/ajtmh.2012.11-0715.

Burström, B., Macassa, G., Öberg, L., Bernhardt, E., & Smedman, L. (2005). Equitable child health interventions: The impact of improved water and sanitation on inequalities in child mortality in Stockholm, 1878 to 1925. *American Journal of Public Health, 95*(2), 208-216. doi: 10.2105/AJPH.2003.034900.

Clasen, T., McLaughlin, C., Nayaar, N., Boisson, S., Gupta, R., Desai, D., & Shah, N. (2008). Microbiological effectiveness and cost of disinfecting water by boiling in Semi-urban India. *The American Journal of Tropical Medicine and Hygiene, 79*(3), 407-413.

Clasen, T., Roberts, I., Rabie, T., Schmidt, W., & Cairncross, S. (2007). Cochrane review: Interventions to improve water quality for preventing diarrhoea. *Evidence-Based Child Health: A Cochrane Review Journal, 2*(1), 226-329. doi: 10.1002/ebch.122.

Clasen, T., Schmidt, W.-P., Rabie, T., Roberts, I., & Cairncross, S. (2007). Interventions to improve water quality for preventing diarrhoea: systematic review and meta-analysis. *BMJ, 334*.

Clasen, T. F., & Bastable, A. (2003). Faecal contamination of drinking water during collection and household storage: the need to extend protection to the point of use. *Journal of Water and Health, 1*(3), 109-115.

Clasen, T. F., Thao, D. H., Boisson, S., & Shipin, O. (2008). Microbiological effectiveness and cost of boiling to disinfect drinking water in Rural Vietnam. *Environmental Science & Technology, 42*(12), 4255-4260. doi: 10.1021/es7024802.

Corsi, D. J., Neuman, M., Finlay, J. E., & Subramanian, S. V. (2012). Demographic and health surveys: a profile. *International Journal of Epidemiology, 41*(6), 1602-1613. doi: 10.1093/ije/dys184.

Dong, Y., & Peng, C.-Y. J. (2013). Principled missing data methods for researchers. *SpringerPlus, 2*(1), 222. doi: 10.1186/2193-1801-2-222.

Doria, M. d. F. (2010). Factors influencing public perception of drinking water quality. *Water Policy, 12*(1), 1-19. doi: 10.2166/wp.2009.051.

Doria, M. F. (2006). Bottled water versus tap water: understanding consumers' preferences. *Journal of Water and Health, 4*(2), 271-276. Retrieved from http://www.iwaponline.com/jwh/004/0271/0040271.pdf.

Epstein, M. B., Bates, M. N., Arora, N. K., Balakrishnan, K., Jack, D. W., & Smith, K. R. (2013). Household fuels, low birth weight, and neonatal death in India: The separate impacts of biomass, kerosene, and coal. *International Journal of Hygiene and Environmental Health, 216*(5), 523-532. doi: 10.1016/j.ijheh.2012.12.006.

Espinosa-García, A. C., Díaz-Ávalos, C., González-Villarreal, F. J., Val-Segura, R., Malvaez-Orozco, V., & Mazari-Hiriart, M. (2014). Drinking water quality in a Mexico City University community: Perception and preferences. *EcoHealth*, 1-10. doi: 10.1007/s10393-014-0978-z.

Ezeh, O., Agho, K., Dibley, M., Hall, J., & Page, A. (2014). The impact of water and sanitation on childhood mortality in Nigeria: Evidence from Demographic and Health Surveys, 2003–2013. *International Journal of Environmental Research and Public Health, 11*(9), 9256-9272.

Fawcett, T. (2006). An introduction to ROC analysis. *Pattern Recognition Letters, 27*(8), 861-874. doi: 10.1016/j.patrec.2005.10.010.

Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L., & Colford Jr, J. M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *The Lancet Infectious Diseases, 5*(1), 42-52. doi: 10.1016/s1473-3099(04)01253-8.

Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data-or tears: an application to educational enrollments in States of India. *Demography, 38*(1), 115-132. doi: 10.2307/3088292.

Fink, G., Günther, I., & Hill, K. (2011). The effect of water and sanitation on child health: evidence from the demographic and health surveys 1986–2007. *International Journal of Epidemiology, 40*(5), 1196-1204. doi: 10.1093/ije/dyr102.

Gilman, R. H., & Skillicorn, P. (1985). Boiling of drinking-water: can a fuel-scarce community afford it? *Bulletin of the World Health Organization, 63*(1), 157-163.

Giné Garriga, R., & Pérez Foguet, A. (2013). Unravelling the Linkages Between Water, Sanitation, Hygiene and Rural Poverty: The WASH Poverty Index. *Water Resources Management, 27*(5), 1501-1515. doi: 10.1007/s11269-012-0251-6.

Grundy, S., Wright, J., & Conroy, R., 2004. A systematic review of health outcomes related to household water quality in developing countries. *Journal of Water and Health,* 2(1). 1-13. Retrieved from http://www.iwaponline.com/jwh/002/0001/0020001.pdf.

Gujarati, D. N. (2004). *Basic Econometrics* (4th ed.). New York: The McGraw–Hill Companies.

Gupta, S. K., Suantio, A., Gray, A., Widyastuti, E., Jain, N., Rolos, R., . . . Quick, R. (2007). Factors associated with E. Coli contamination of household drinking water among tsunami and earthquake survivors, Indonesia. *The American Journal of Tropical Medicine and Hygiene, 76*(6), 1158-1162.

Hosmer, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied Logistic Regression* (4th ed.). Hoboken, New Jersey: John Wiley & Sons, Inc.

Howe, L. D., Galobardes, B., Matijasevich, A., Gordon, D., Johnston, D., Onwujekwe, O., . . . Hargreaves, J. R. (2012). Measuring socio-economic position for epidemiological studies in low- and middle-income countries: a methods of measurement in epidemiology paper. *International Journal of Epidemiology, 41*(3), 871-886. doi: 10.1093/ije/dys037.

Jann, B. (2013). COEFPLOT: Stata module to plot regression coefficients and other results (Version S457686). Boston College Department of Economics. Retrieved from http://ideas.repec.org/c/boc/bocode/s457686.html.

Jessoe, K. (2013). Improved source, improved quality? Demand for drinking water quality in rural India. *Journal of Environmental Economics and Management, 66*(3), 460-475. doi: 10.1016/j.jeem.2013.05.001.

Kilabuko, J., & Nakai, S. (2007). Effects of cooking fuels on acute respiratory infections in children in Tanzania. *International Journal of Environmental Research and Public Health, 4*(4), 283-288. doi: 10.3390/ijerph200704040003.

Kolenikov, S., & Angeles, G. (2004). The use of discrete data in PCA: Theory, simulations, and applications to socioeconomic indices. *Carolina Population Center Working Paper No. 04-85.* Retrieved from http://www.cpc.unc.edu/measure/publications/wp-04-85/at_download/ document.

Kolenikov, S., & Angeles, G. (2009). Socioeconomic status measurement with discrete proxy variables: is principal component analysis a reliable answer? *Review of Income and Wealth, 55*(1), 128-165. doi: 10.1111/j.1475-4991.2008.00309.x.

Lam, N. L., Smith, K. R., Gauthier, A., & Bates, M. N. (2012). Kerosene: A review of household uses and their hazards in low- and middle-income countries. *Journal of Toxicology and Environmental Health, Part B, 15*(6), 396-432. doi: 10.1080/10937404.2012.710134.

Lantagne, D.S., Quick, R., & Mintz, E.D. (2001). *Household water treatment and safe storage options in developing countries: a review of implementation practices.* Retrieved from http://josiah.berkeley.edu/2007Fall/ER275/Readings/DP1-2/Lantagne%20et%20al%202006.pdf

Long, J. S., & Freese, J. (2014). *Regression Models for Categorical Dependent Variables using Stata* (3rd ed.). College Station, Texas: Stata Press.

Mintz, E., Bartram, J., Lochery, P. & Wegelin, M. (2001). Not just a drop in the bucket: expanding access to point-of-use water treatment systems. *American Journal of Public Health,* 91(10), 1565-1570. doi: 10.2105/AJPH.91.10.1565.

Nawaz, H., Rahman, M. A., Graham, D., Katz, D. L., & Jekel, J. F. (2001). Health risk behaviors and health perceptions in the Peruvian Amazon. *The American Journal of Tropical Medicine and Hygiene, 65*(3), 252-256. Retrieved from http://www.ajtmh.org/content/65/3/252.long.

Olembo, L., Kaona, F. A. D., Tuba, M., & Burnham, G. (2004). *Safe Water Systems: An Evaluation of the Zambia Clorin Program.* Baltimore, MD: Johns Hopkins School of Public Health Retrieved from http://www.sswm.info/sites/default/files/reference_attachments/OLEMBO et al 2004 Safe Water Systems.pdf.

Onda, K., LoBuglio, J., & Bartram, J. (2012). Global access to safe water: Accounting for water quality and the resulting impact on MDG progress. *International Journal of Environmental Research and Public Health, 9*(3), 880-894. doi: 10.3390/ijerph9030880.

Pokhrel, A. K., Bates, M. N., Verma, S. C., Joshi, H. S., Sreeramareddy, C. T., & Smith, K. R. (2010). Tuberculosis and Indoor Biomass and Kerosene Use in Nepal: A Case–Control Study. *Environmental Health Perspectives, 118*(4), 558-564. doi: 10.1289/ehp.0901032.

Pope, D. P., Mishra, V., Thompson, L., Siddiqui, A. R., Rehfuess, E. A., Weber, M., & Bruce, N. G. (2010). Risk of low birth weight and stillbirth associated with indoor air pollution from solid fuel use in developing countries. *Epidemiologic Reviews, 32*(1), 70-81. doi: 10.1093/epirev/mxq005

Prüss-Üstün, A., Kay, D., Fewtrell, L., & Bartram, J. (2004). Unsafe Water, Sanitation, and Hygiene. In M. Ezzati, A. D. Lopez & C. J. L. Murray (Eds.), *Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attribution to Selected Major Risk Factors.* Geneva: World Health Organization.

Psutka, R., Peletz, R., Michelo, S., Kelly, P., & Clasen, T. (2011). Assessing the microbiological performance and potential cost of boiling drinking water in Urban Zambia. *Environmental Science & Technology, 45*(14), 6095-6101. doi: 10.1021/es2004045.

Rehfuess, E., Best, N., Briggs, D., & Joffe, M. (2013). Diagram-based Analysis of Causal Systems (DACS): elucidating inter-relationships between determinants of acute lower respiratory infections among children in sub-Saharan Africa. *Emerging Themes in Epidemiology, 10*(1), 13. doi: 10.1186/1742-7622-10-13.

Rehfuess, E. A., Bruce, N. G., & Smith, K. R. (2011). Solid Fuel Use: Health Effect. In J. O. Nriagu (Ed.), *Encyclopedia of Environmental Health* (pp. 150-161). Burlington: Elsevier.

Rehfuess, E. A., Tzala, L., Best, N., Briggs, D. J., & Joffe, M. (2009). Solid fuel use and cooking practices as a major risk factor for ALRI mortality among African children. *Journal of Epidemiology and Community Health, 63*(11), 887-892. doi: 10.1136/jech.2008.082685.

Rosa, G., & Clasen, T. (2010). Estimating the scope of household water treatment in low- and medium-income countries. *The American Journal of Tropical Medicine and Hygiene, 82*(2), 289-300. doi: 10.4269/ajtmh.2010.09-0382.

Rosa, G., Miller, L., & Clasen, T. (2010). Microbiological effectiveness of disinfecting water by boiling in Rural Guatemala. *The American Journal of Tropical Medicine and Hygiene, 82*(3), 473-477. doi: 10.4269/ajtmh.2010.09-0320.

Rufener, S., Mäusezahl, D., Mosler, H.-J., & Weingartner, R. (2010). Quality of drinking-water at source and point-of-consumption-drinking cup as a high potential recontamination risk: A field study in Bolivia. *Journal of Health, Population and Nutrition, 28*(1), 34-41.

Rutstein, S. O. (2008). The DHS wealth index: Approaches for rural and urban areas. *DHS Working Paper, 60.* Retrieved from http://www.measuredhs.com/pubs/pdf/WP60/WP60.pdf.

Rutstein, S. O., & Johnson, K. (2004). The DHS Wealth Index. *DHS Comparative Reports No. 6.* Retrieved from http://www.measuredhs.com/pubs/pdf/CR6/CR6.pdf.

Sainani, K. L. (2011). Understanding odds ratios. *PM&R, 3*(3), 263-267. doi: 10.1016/j.pmrj.2011.01.009

Shaheed, A., Orgill, J., Montgomery, M. A., Jeuland, M. A., & Brown, J. (2014). Why "improved" water sources are not always safe. *Bulletin of the World Health Organization, 92*(4), 283-289. doi: 10.2471/BLT.13.119594.

Shaheed, A., Orgill, J., Ratana, C., Montgomery, M. A., Jeuland, M. A., & Brown, J. (2014). Water quality risks of 'improved' water sources: evidence from Cambodia. *Tropical Medicine & International Health, 19*(2), 186-194. doi: 10.1111/tmi.12229.

Shoda, S.V., Menon, M., Trivedi, K., Ati, A., Figueroa, M.E., Ainslie, R., Wannemuehler, K., & Quick, R. (2011). Microbiologic effectiveness of boiling and safe water storage in South Sulawesi, Indonesia. *Journal of Water and Health,* 9(3), 577-585. doi: 10.2166/wh.2011.255.

Sreeramareddy, C., Shidhaye, R., & Sathiakumar, N. (2011). Association between biomass fuel use and maternal report of child size at birth - an analysis of 2005-06 India Demographic Health Survey data. *BMC Public Health, 11*(1), 403. doi: 10.1186/1471-2458-11-403.

StataCorp. (2013). *Stata Statistical Software: Release 13.* College Station, TX: StataCorp LP.

Statistics Indonesia, BKKBN, MOH, & ICF International. (2013). *Indonesia Demographic and Health Survey 2012.* Jakarta, Indonesia: Statistics Indonesia, BKKBN, MOH, ICF International Retrieved from http://dhsprogram.com/pubs/pdf/FR275/FR275.pdf.

Sumpter, C., & Chandramohan, D. (2013). Systematic review and meta-analysis of the associations between indoor air pollution and tuberculosis. *Tropical Medicine & International Health, 18*(1), 101-108. doi: 10.1111/tmi.12013.

Vyas, S., & Kumaranayake, L. (2006). Constructing socio-economic status indices: how to use principal components analysis. *Health Policy and Planning, 21*(6), 459-468. doi: 10.1093/heapol/czl029

Ward, L., Cain, O., Mullally, R., Holliday, K., Wernham, A., Baillie, P., & Greenfield, S. (2009). Health beliefs about bottled water: a qualitative study. *BMC Public Health, 9*(1), 196.

WHO. (2007). *Combating waterborne disease at the household level*. Geneva: World Health Organization. Retrieved from www.who.int/water_sanitation.../**combating_disease**part1lowres.pdf

WHO. (2010). WHO guidelines for indoor air quality: selected pollutants.World Health Organization Regional Office for Europe. Retrieved from www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf.

WHO/UNICEF JMP. (2006). *Core Questions on Drinking Water and Sanitation for Household Surveys*. Geneva: World Health Organization. Retrieved from http://www.who.int/water_sanitation_health/monitoring/oms_brochure_core_questionsfinal24608.pdf.

WHO/UNICEF JMP. (2008). *Progress on drinking water and sanitation: Special focus on sanitation*. Geneva, Switzerland: WHO Press. Retrieved from http://www.unicef.org/media/files/Joint_Monitoring_Report_-_17_July_2008.pdf.

Wolf, J., Prüss-Ustün, A., Cumming, O., Bartram, J., Bonjour, S., Cairncross, S., . . . Higgins, J. P. T. (2014). Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression. *Tropical Medicine & International Health, 19*(8), 928–942. doi: 10.1111/tmi.12331.

Wright, J., & Gundry, S. W. (2009). Household characteristics associated with home water treatment: an analysis of the Egyptian Demographic and Health Survey. *Journal of Water and Health, 7*(1), 21-29. doi: 10.2166/wh.2009.056.

Wright, J., Yang, H., Rivett, U., & Gundry, S. (2012). Public perception of drinking water safety in South Africa 2002-2009: a repeated cross-sectional study. *BMC Public Health, 12*(1), 556. doi: 10.1186/1471-2458-12-556.