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Determinants of household drinking-water source in Indonesia: An analysis of the 2007 Indonesian family life survey

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Abstract: Safe drinking water is a human right as it is an essential element to sustain life and maintain human health. Literature review confirms that there are many aspects that should be considered in providing safe drinking water in an equitable manner. Therefore, evidence-based data at national level are needed to inform policy-making process. This study presents data regarding drinking water ladder and its determinants using partial proportional odds regression model. Drinking water sources were classified into three categories, unimproved sources, improved sources and piped water on the premises. The overall model is statistically significant ($p < 0.001$) with McFadden adjusted R^2 of 0.157. The correlates include spatial variables, environmental variables, demographic variables and socioeconomic position. There are disparities across major islands and rural-urban areas with the former lagging behind. Moreover, the higher the household is in terms of sanitation ladder, the more likely they have access to improved water sources. Similarly, socio-economic status also determines the use of improved water sources. Recommendations are provided in the light of the results.

Subjects: Environmental Health; Environmental Health & Safety

Keywords: Indonesia; drinking water; disparity; socio-economic status; partial proportional odds model; IFLS

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PUBLIC INTEREST STATEMENT

Access to safe drinking water is of importance to sustain life and health since it contributes to preventing the spread of waterborne disease. This article aims at informing policy-makers of Government of Indonesia by explaining factors related to access to improved water source including environmental, socio-demographic and geographical matters. The article also addresses the occurrence of disparities in access to improved water source and proposes appropriate solutions to reduce the disparities and accelerate the coverage of drinking water. These include issuance of a legal framework for water resource management, which is currently vacant and implementation of drinking water programmes closing the gaps occurred. As such, all Indonesian people will have access to adequate supply of safe drinking water as to achieve the goal of universal coverage in 2019.

1. Introduction

Water is very vital for human health (Benelam & Wyness, 2010), hence, access to safe drinking water is a human right (United Nations, 2010; WHO, 2003). This was emphasised in one of the Millennium Development Goals (MDGs) Target 7.C: “Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation” (United Nations, 2015). According to the most recent MDGs report, the global population has achieved the target for drinking water but not for improved sanitation (United Nations, 2015). In the case of Indonesia, the latest accessible MDG report produced by the State Ministry of National Development Planning (BAPPENAS) reported that the drinking water target will be met by 2015 (BAPPENAS, 2014a). However, when it is disaggregated, urban-rural disparity exists with household located in latter areas as laggards. This is also the case with access to improved sanitation facilities. These disparities are also confirmed in other studies (Patunru, 2015; Prasetyoputra & Irianti, 2013). All of the aforementioned issues in water and sanitation can lead to preventable burden of disease (Fink, Gunther, & Hill, 2011; Prüss-Ustün et al., 2014).

Globally, there are many studies that explore the correlates of access to improved drinking water (Adams, Boateng, & Amoyaw, 2015; Balasubramaniam, Chatterjee, & Mustard, 2014; Blakely, Hales, Kieft, Wilson, & Woodward, 2005). However, studies that examine the factors associated with access to improved drinking water source in Indonesia is limited. Patunru (2015) analysed the Indonesia National Socio-Economic Survey (SUSENAS) and found spatial differences of population exposed to unimproved water source. Addressing the problems related to lack of access to improved water sources needs an improved comprehension of demographic and socio-economic factors at household level. Therefore, this study is aimed at determining the correlates of households’ access to improved drinking-water sources in Indonesia. It is done by analysing the fourth wave of the Indonesia Family Life Survey (hereafter IFLS-4).

The rest of the paper is as follows. Section 2 discusses the data and methods used. Section 3 presents the main empirical results. The penultimate Section 4 discusses the main empirical results. Section 5 concludes and provides recommendations.

2. Methods

2.1. Data source

Data for the study were drawn from the fourth wave of the Indonesia Family Life Survey 2007. IFLS 2007 is an ongoing longitudinal socio-economic and health survey conducted by RAND, the Center for Population and Policy Studies (CPPS) of the University of Gadjah Mada and Survey Meter (Strauss, Witoelar, Sikoki, & Wattie, 2009). The IFLS data-sets are publicly accessible at RAND’s website (<http://www.rand.org/labor/FLS/IFLS.html>). The first wave of IFLS was conducted in 1993 and its results are representative of 83% of the Indonesian population spread across 13 out of 26 provinces at that time. Detailed sampling procedures can be seen elsewhere (Strauss et al., 2009).

2.2. Study population and sample size

The IFLS 2007 comprises 44,103 individuals living in 13,535 households. For the purpose of this study, however, household level data will be used, and information at individual level was aggregated to household level.

2.3. Ethics statement

The study is a further data analysis of publicly available secondary data-set. The survey and its procedures have been reviewed and approved by Institutional Review Boards (IRBs) in the USA (at RAND) and in Indonesia (at University of Gadjah Mada). Additional ethical clearance was not sought as such.

2.4. Dependent variable

The only dependent variable used for this study was “drinking water source” (henceforth DWS) at household level. Following the Joint Monitoring Programme (JMP) between the World Health

Organization (WHO) and United Nations Children’s Fund (UNICEF) (WHO/UNICEF JMP, 2006, 2014), the dependent variable was defined as follows:

$$Y = \begin{cases} 1 & \text{if the household used unimproved drinking water source} \\ 2 & \text{if the household used improved drinking water source} \\ 3 & \text{if the household used piped water source} \end{cases}$$

As drinking water source has been traditionally been presented as “drinking water ladder” (WHO/UNICEF JMP, 2014), it is treated as an ordinal variable in this study.

2.5. Independent variables

The independent variables for this study were carefully chosen based on public health significance and statistical significance (Hosmer, Lemeshow, & Sturdivant, 2013). Fifteen independent variables consisting of *island* (Java, Sumatera, Bali, Nusa Tenggara Barat/Nusa Tenggara Timur); *place of residence* (urban area, rural area); *sanitation ladder* (unimproved facility, improved facility); *type of dwelling* (single unit single level, other types); *number of household members*; *marital status of household head* (not married, married, separated/divorced/bereaved); *sex of household head* (male, female); *average of number of internal migration of household members*; *education of household head* (none, primary, junior high, senior high, college or university); *household head worked last year* (no, yes); *health card ownership* (no, yes); *letter of poor utilisation* (no, yes); *participation in PKPS-BBM* (Program Kompensasi Pengurangan Subsidi Bahan Bakar Minyak; no, yes); *household wealth and share of food expenditure* (in percentage points). Household wealth was represented by wealth index which is a composite indicator.

2.6. Statistical analysis

The statistical analysis comprises four stages. First, wealth index scores were computed. Second, summary statistics of the dependent variable and all independent variables were produced. Third, bivariate regression analyses were done for each of the independent variables, with statistical significance evaluated at the 5% level of significance. The purpose of this was to select the independent variables for the final model. Fourth, multivariate analysis was performed. The steps of the statistical analysis are elaborated in the following sections.

The first step was computing the wealth index which is a composite score derived from 24 variables of ownership of assets (*house, land, livestock, large stem plants, vehicle, television, fridge, deposit, receivables, jewelleries and furniture*) and housing characteristics variables (“animal waste in surroundings, no piles of trash in surroundings, no stagnant water in surroundings, house not under or next to a stable, house has sufficient ventilation, house has moderately-sized yard, house has kitchen outside, cooking room and sleeping room are separated, material of floor, material of wall and material of roof”). The scores were computed using polychoric principal component analysis (PCA), which can take into account ordinal form of categories (Kolenikov & Angeles, 2004, 2009). The wealth index scores have polychoric correlation coefficient (ρ) of 0.3904 and variance explained of the first component of 0.2158.

The last step of the statistical analysis was to perform a multivariate regression analysis. As the dependent variable is a three-category ordinal outcome, it is common to employ ordinal logit or probit regression models. However, these models rely on the “parallel regression assumption” which requires the effects of independent variables to be equal at different categories (Long & Freese, 2014). A violation of this assumption could lead to misleading results. In this study, the parallel regression assumption was assessed using Brant test (Brant, 1990; Long & Freese, 2014), which resulted in rejection of the null hypothesis ($\chi^2 = 1704.73$; $p < 0.001$). This indicates that overall, there was a violation of the parallel regression assumption on several independent variables. Consequently, the use of ordinal logit or probit regression models is not appropriate.

Alternatively, one can use multinomial logit or probit regression models. However, choosing this option could lead loss of information from the ordered nature of the dependent variable (Fotso, Ezech, Madise, Ziraba, & Ogollah, 2009). Moreover, there is a potential loss of efficiency in employing multinomial regression models as oppose to ordinal regression models (Peterson & Harrell, 1990). For these reasons, partial proportional odds model (PPOM), a special case of generalised ordered logit model (Fullerton & Xu, 2012; Williams, 2006), was employed in place of ordinal and multinomial regression models. The advantage to using PPOM is that it is more accurate than ordinal regression models and more parsimonious than multinomial regression models (Mayer & Foster, 2015). Moreover, PPOM has been used in many previous studies with ordinal dependent variables such as Fotso et al. (2009), Mayer and Foster (2015) and Klinikleri (2015). To fit the PPOM to the data, the *gologit2* packaged developed by Williams (2006) was used, with the parallel regression assumption was relaxed at the one per cent level of significance. This command was an improvement of Fu's (1998) *gologit* command, which, as a general model, can be written as follows:

$$P(DWS_i > j) = g(X\beta_j) = \frac{\exp(\alpha_j + INDVAR_i\beta_j)}{1 + [\exp(\alpha_j + INDVAR_i\beta_j)]}, j = 1, 2, \dots, M - 1 \quad (1)$$

where M is the number of categories of the ordinal dependent variable (i.e. 3) (Williams, 2006). When the model of drinking water source is expressed in terms of probabilities it becomes

$$P(DWS_i = 1) = 1 - g(INDVAR_i\beta_1) \quad (2a)$$

$$P(DWS_i = 1) = g(INDVAR_i\beta_{j-1}) - g(INDVAR_i\beta_{j-1}), j = 2, \dots, M - 1 \quad (2b)$$

$$P(DWS_i = M) = g(INDVAR_i\beta_{M-1}) \quad (2c)$$

where DWS is the drinking-water source and INDVAR denotes independent variables. The association between the independent variables and the dependent variables was measured in odds ratio (OR) and its 95% confidence interval (CI). Listwise deletion was conducted to handle missing values in the data-sets prior to all statistical analyses (Dong & Peng, 2013). All of the statistical analyses were performed using Intercooled STATA version 13.1 (StataCorp, 2013).

3. Results

3.1. Sample characteristics

The listwise deletion procedure yielded an analytic sample of 12,213 households. The base category for this variable is piped water source. The results of descriptive analyses of the dependent and independent variables are presented in Table 1. Less than half of the households used improved sources (45.5%), followed by unimproved sources (32.9%), while only 21.6% used piped water as their main drinking-water source. More than half (53.5%) of households were located in urban areas, while the rest (46.5%) were located in rural areas. The majority of households lived in Java Island (58.2%) and in Sumatera Island (20.8%). In terms of sanitation ladder, almost two out of three households (65.2%) used improved facility. The predominant type of house is single unit (74.6%). The majority of household head were married (79.4%). Most households were headed by a male (82.0%). Approximately 27.8% of households were headed by a person with no formal education. The majority of household head worked last year (86.7%). Participation of household in social protection programmes is one indication that a household is considered poor. In terms of which, only 16.5% of household owned health card, 10.2% had utilised letter for poor and 20.7% participated in PKPS Program.

Table 1. Descriptive analyses of variables (N = 12,213)

Variables	N	Per cent (%)	Mean	Median	Min	Max
Drinking water source						
Unimproved	4,020	32.92				
Improved	5,552	45.46				
Piped	2,641	21.62				
Place of residence						
Rural	5,685	46.55				
Urban	6,528	53.45				
Island of residence						
Java	7,102	58.15				
Sumatera	2,538	20.78				
Bali	571	4.68				
NTB & NTT	780	6.39				
Sulawesi	597	4.89				
Kalimantan	625	5.12				
Sanitation ladder						
No facility	1,961	16.06				
Unimproved facility	2,287	18.73				
Improved facility	7,965	65.22				
Number of household members			5.37	5	1	39
House is a single unit type						
No ^a	3,100	25.38				
Yes	9,113	74.62				
Marital status of household head						
Not married	904	7.40				
Married	9,694	79.37				
Separated/divorced/bereaved	1,615	13.22				
Sex of household head						
Male	10,009	81.95				
Female	2,204	18.05				
Average number of internal migration of household members			0.67	0	0	11
Education of household head						
None	3,392	27.77				
Primary	3,113	25.49				
Junior high	1,692	13.85				

(Continued)

Table 1. (Continued)

Variables	N	Per cent (%)	Mean	Median	Min	Max
Senior high	2,711	22.20				
College/ university	1,305	10.69				
Household head worked last year						
No	1,622	13.28				
Yes	10,591	86.72				
Household has health card						
No	10,201	83.53				
Yes	2,012	16.47				
Household has utilised letter for poor (SKTM)						
No	10,964	89.77				
Yes	1,249	10.23				
Household participates in PKPS Program						
No	9,684	79.29				
Yes	2,529	20.71				
Wealth index score			0.00	0.17	-4.73	2.61
Share of food expenditure (%)			56.15	57.43	0	97.22

Note: °Other types of house include: (1) single unit multiple levels, (2) duplex single level, (3) duplex multiple levels, (4) multiple unit single levels, (5) house on stilts, (6) high-rise/apartment buildings, and (6) house-store units.

3.2. Multivariate regression analysis

Table 2 shows the multivariate relationships between the dependent and independent variables. The final multivariate model is statistically significant ($p < 0.001$) with McFadden adjusted R^2 of 0.157. The results comprises two equations. The first equation presents the ORs of unimproved DWS compared to improved or piped DWS. While the second equation presents the ORs of piped DWS compared to improved or unimproved DWS.

Both the spatial variables, place of residence and island of residence, were found to be significantly associated with the differences in odds of DWS. It was observed that urban households were more likely to have access to better water sources as opposed to their rural counterparts. Households located in urban areas were more likely to use piped or improved DWS than to use unimproved DWS (OR: 2.59; 95% CI: 2.36–2.84). Likewise, urban households were more likely to use piped DWS than improved DWS or unimproved DWS (OR: 2.26; 95% CI: 2.04–2.51). Moreover, variation in odds of access to piped DWS was observed across island of residence.

The housing variables were sanitation facility of household (in the form of sanitation ladder), number of household members and type of house. It was observed that households with unimproved sanitation facility have higher odds of using improved or piped DWS than using unimproved DWS, compared to those with no facility (OR: 1.39; 95% CI: 1.22–1.59). This was also true with the odds of using piped DWS as opposed to using other DWSs (OR: 1.55; 95% CI: 1.33–1.82). Moreover, households with improved sanitation facility were observed to have higher odds of using improved or piped DWS than using unimproved DWS, compared to those with no facility (OR: 2.55; 95% CI: 2.26–2.89). This was also the case with odds of using piped DWS in contrast to using other DWSs (OR: 1.77; 95% CI: 1.50–2.01).

Table 2. Multivariate analyses of independent variables for drinking water ladder (N = 12,213)

Variables	Eq. 1 = Unimproved vs. (Improved & Piped)		Eq. 2 = (Unimproved & Improved) vs. Piped	
	OR	95% CI	OR	95% CI
Place of residence				
Rural area (Ref.)	1	-	1	-
Urban area	2.588***	[2.357; 2.840]	2.260***	[2.035; 2.510]
Island of residence				
Java (Ref.)	1	-	1	-
Sumatera	0.516***	[0.464; 0.575]	1.505***	[1.337; 1.693]
Bali	0.857	[0.698; 1.051]	2.719**	[2.252; 3.284]
NTB & NTT	0.393***	[0.332; 0.466]	1.265**	[1.043; 1.536]
Sulawesi	1.096	[0.895; 1.343]	2.192***	[1.796; 2.677]
Kalimantan	2.095***	[1.702; 2.580]	5.295***	[4.407; 6.363]
Sanitation ladder				
No facility (Ref.)	1	-	1	-
Unimproved facility	1.391***	[1.220; 1.587]	1.552***	[1.326; 1.818]
Improved facility	2.554***	[2.257; 2.889]	1.766***	[1.503; 2.075]
Number of household members	1.017***	[1.004; 1.031]		Same ^a
House is a single unit type				
No (Ref.)	1	-		
Yes	0.768***	[0.704; 0.838]		Same
Marital status of household head				
Not married (Ref.)	1	-	1	-
Married	0.705	[0.569; 0.875]	2.320***	[1.867; 2.883]
Separated/divorced/bereaved	0.672	[0.525; 0.860]	1.980***	[1.548; 2.532]
Sex of household head				
Male (Ref.)	1	-	1	-
Female	0.926	[0.794; 1.081]	1.204**	[1.022; 1.419]
Average number of internal migration of household members	0.923***	[0.886; 0.961]		Same
Education of household head				
None (Ref.)	1	-	1	-
Primary	0.968	[0.874; 1.071]		Same
Junior high	1.069	[0.944; 1.210]		Same
Senior high	1.472***	[1.278; 1.697]	0.882*	[0.767; 1.014]
College/university	2.047***	[1.639; 2.557]	0.998	[0.837; 1.189]
Household head worked last year				
No (Ref.)	1	-		
Yes	0.852***	[0.760; 0.955]		Same
Household has health card				
No (Ref.)	1	-		-
Yes	0.930	[0.836; 1.035]		Same
Household has utilised letter for poor				
No (Ref.)	1	-		-

(Continued)

Table 2. Multivariate analyses of independent variables for drinking water ladder (N = 12,213)

Variables	Eq. 1 = Unimproved vs. (Improved & Piped)		Eq. 2 = (Unimproved & Improved) vs. Piped	
	OR	95% CI	OR	95% CI
Yes	0.903	[0.795; 1.025]		Same
Household participates in PKPS-BBM program				
No (Ref.)	1	–	1	–
Yes	0.697***	[0.624; 0.779]	1.072	[0.940; 1.223]
Wealth index score	1.194***	[1.146; 1.244]	1.021	[0.977; 1.068]
Share of food expenditure (%)	0.990***	[0.987; 0.992]		Same

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

Notes: OR = odds ratio; CI = confidence interval; Ref. = referent category; Eq. = equation; NTB = *Nusa Tenggara Barat*; NTT = *Nusa Tenggara Timur*.

*Estimates for (unimproved & improved) vs. piped are the same with unimproved vs. (improved or piped).

In terms of household size, the relationship between number of household members and DWS was proportional in both equations, where one additional member corresponds to higher odds of using better DWS (OR: 1.02; 95% CI: 1.00–1.03). Finally, the relationship between type of housing and DWS was proportional in both equations, where housing type of single unit single level, compared to other types, was associated with lower odds of having access to better DWS (OR: 0.77; 95% CI: 0.70–0.84).

The demographic variables were marital status of household head, sex of household head and the average number of internal migration of household members. Marital status of household head was observed to be significantly associated with the odds of using piped as opposed to using other DWSs, with households headed by a married person (OR: 2.32; 95% CI: 1.87–2.88) or separated/divorced/bereaved person (OR: 1.98; 95% CI: 1.55–2.53) are of higher odds compared to households headed by someone who never married. As for sex of household head, it was found that there was no significant difference with respect to the odds of using improved or piped DWSs as opposed to using unimproved DWSs (OR: 0.93; 95% CI: 0.79–1.08). However, female-headed households were found to have higher odds of using piped DWS compared to male-headed households (OR: 1.20; 95% CI: 1.02–1.42). Moreover, the average number of internal migration is associated with lower odds of using improved or piped than using unimproved sources. It is also associated with lower odds of using piped source than using the other two sources of water. The magnitude of those relationships is proportional (OR: 0.92; 95% CI: 0.89–0.96).

The socio-economic variables were education of household head, employment in previous year, health card ownership, utilisation of letter for poor, participation in PKPS program, household wealth, and share of food in the monthly per capita expenditure of household. This study found that household head with senior high school education (OR: 1.47; 95% CI: 1.28–1.70) or college/university education (OR: 2.05; 95% CI: 1.64–2.56) were more likely to use improved or piped DWSs than unimproved DWSs compared to households headed by a non-educated person. Moreover, household head's employment in last year was found to be negatively associated with access to better DWSs (OR: 0.85; 95% CI: 0.76–0.96).

The only statistically significant social protection variables was participation in PKPS-BBM (OR: 0.70; 95% CI: 0.62–0.78). Furthermore, higher household wealth was observed to be significantly associated with higher odds of using better DWSs. One unit increase in wealth index score

corresponds to increased odds of using improved or piped DWSs than using unimproved DWSs (OR: 1.19; 95% CI: 1.15–1.24). However, wealth index did not significantly differentiate between the odds of using piped DWS as opposed to using other DWSs.

4. Discussion

This section outlines a careful interpretation of the main findings of this study, which investigated the factors associated with access to improved drinking-water sources in Indonesia. Consistent with previous studies (Adams et al., 2015; Fotuè & Sikod, 2012; Hopewell & Graham, 2014; Nketiah-Amponsah, Aidam, & Senadza, 2009; Pullan, Freeman, Gething, & Brooker, 2014; Rahut, Behera, & Ali, 2015), this study found geographical disparities across island of residence and between urban and rural areas where households residing in urban areas are more likely to have access to better water sources (i.e. piped or improved water source).

As for housing variables, having adequate sanitation facility corresponds to higher likelihood of having access to better DWSs. This parallels the findings of Nketiah-Amponsah et al. (2009) which observed that owning clean toilet facility was associated with higher likelihood of access to piped DWS compared to other types of DWSs. Moreover, consistent with a previous study by Fotuè and Sikod (2012), household size is positively associated with access to better DWSs. However, more recent studies did not find any significant relationship between household size and access to improved DWS (Adams et al., 2015; Rahut et al., 2015). Finally, living in a single unit single level house, as oppose to living in other house types, corresponds to lower probability of having access to better DWSs. A possible explanation would be that this particular type accommodates for less affluent households than the other types of housing, which includes: (1) single unit multiple levels, (2) duplex single level, (3) duplex multiple levels, (4) multiple unit single levels, (5) house on stilts, (6) high-rise/apartment buildings and (6) house-store units.

With respect to demographic characteristics of household, marital status of household head significantly differentiates the probability of owning access to better DWSs. Household headed by a married or ever-married person has are more likely to use better DWSs. Moreover, female headship was observed to be significantly correlated with access to better DWSs. This was consistent with previous studies (Adams et al., 2015; Rahut et al., 2015). The latter study argued that a possible explanation behind such relationship is that having access to better DWSs reduces the burden of fetching water for household purposes. Furthermore, the more frequent the household members migrate, the lower the odds of using piped sources compared to the other two sources although Brueckner (2013) suggested that the average number of internal migration is negatively associated with having water source located outside of dwelling. However, this association was not found to be statistically significant.

This study also highlighted the importance of socio-economic variables associated with access to adequate DWSs. Education has commonly been used as a socio-economic indicator (Oakes & Kaufman, 2006). Existing literature suggest a positive relationship between educational attainment of household head and probability of having access to improved DWS (Adams et al., 2015; Rahut et al., 2015). In line with those studies, this study also find a similar relationship. Although, a household head needs to have senior high school or higher to have significantly higher probability of accessing better DWSs.

In terms of employment of household head, the negative relationship between having a job last year and odds of having access to better DWSs is unexpected. This implies that having a job does not ensure one has access to better DWSs. Moreover, participation in social protection programmes indicates that a household is poor (Hardjono, Akhmadi, & Sumarto, 2010). In this study, the only significant social protection variable was “participation in PKPS-BBM”, while health “ownership of health card” and “utilisation of letter for poor” were found to be insignificant. Another indicator of household affluence, wealth index, was shown to be positively and significantly associated with likelihood of owning access to better DWSs. This is consistent with previous studies (Adams et al., 2015; Blakely

et al., 2005; Nketiah-Amponsah et al., 2009; Rahut et al., 2015). This is not surprising as more affluent households have higher financial capacity to afford better DWs.

4.1. Policy implications

Despite the progress over two decades, the study revealed that disparities in access to drinking water in Indonesia remain a huge challenge. Therefore, there is much to be done to achieve universal access of drinking water in 2019 as stated in National Medium-term Development Plan 2015–2019 (*Rencana Pembangunan Jangka Menengah Nasional 2015–2019*) (BAPPENAS 2014b). To address the challenge, the Government of Indonesia (GoI) has provided a regulatory framework to govern the development of sustainable drinking water supply across 34 provinces involving local authorities as to reduce inequality. The government has implemented drinking water provision programmes through urban water supply operated by drinking water companies (*Perusahaan Air Minum Daerah*, PDAM) and community managed-water supply in 1990s, which is for rural people since majority of villages is not served by water utilities. However, these programmes would not meet the targets of universal access to drinking water by 2019 if there were no strategic breakthroughs to accelerate the progress. In fact, there is a gap between the coverage of improved drinking water in 2013 (57.8%) and the targeted access in 2019 (100.0%) as within four years the percentage of people should be added to serve is 42.2% (Irianti, Prasetyoputra, Saputro, & Sasimartoyo, 2014). This coverage is much smaller than that of GLAAS report in early 2014, which was 85% (WHO, 2014). Nevertheless, this gap should be eliminated within a short time.

Moreover, the law No. 7/2004 concerning Water Resource was repealed in 2013 since it failed to govern water resource management which regard to human rights of Indonesian people in access to drinking water supply. Therefore, Indonesia has returned to Law No. 11/1974 concerning Irrigation, which does not contain arrangements of private and government responsibilities in managing water supply for all purposes. The question remains, “Can this law address the complexity of drinking water supply to be universally needed by all Indonesian people in good quality and sufficient quantity?” The bottom line is that strong political will is needed as a prerequisite in fulfilment the human rights of drinking water. Therefore, the key stakeholders in national and local levels should refocus in the development of appropriate legislation to accommodate the need for a legal framework in managing water resource based on criteria and indicators to meet the challenges with regard to human rights of obtaining sufficient and safe water for all Indonesian people.

There are several problems encountered by PDAMs, ranging from finance constraints to acceptance of consumers in terms of taste and odour of PDAM/tap drinking water. This leads to increasing use of bottled or refilled waters which are not always safer than tap water. The PDAMs should improve their infrastructures and quality to better serve their consumers. In fact, majority of water utilities fail to provide safe drinking water in the point of use. At the same time, the provision of improved water source for urban households including those in slum areas should not be forgotten. The slow progress of urban water coverage is caused in part by increasing urbanisation (Bain, Wright, Christenson, & Bartram, 2014). Similarly, community-based water organisations in rural areas, which are to accelerate the coverage of rural water supply, also facing challenges in professionalism and sustainability in water services (Setiawan, 2011). The latter is suspected to be “fragile” instead of promising programme in rural areas (Sy, 2011). Therefore, acceleration in providing rural areas with improved drinking water source should be strengthened institutionally as community managed water supply system is susceptible to failure. This is because the organisations of community managed water supply usually do not have comprehensive plan and they rely more on the existing culture in operating the services.

In regard to the relationship of household variables with improved water source, the government should enhance the implementation of integrated programmes, e.g. community-led total sanitation (CLTS) as to eliminate open defecation practices and bring about behavioural change. Moreover, the integrated programmes in non-household settings should also be emphasised, such as water, sanitation, and hygiene (WASH) in schools as to synchronise the increase of drinking water and

sanitation coverage. As such, positive policy environment is needed to involve multi-level of stakeholders in planning, managing and monitoring the implementation of WASH in schools. This healthy practice will eventually embrace healthy behaviour among household members.

Socio-economic factors are found to be related to access to improved drinking water source. To deal with people with less fortunate, the GoI should strengthen community-managed water supply system in rural areas through the development of sustainable financial capacity of community-based organisations (CBOs). Moreover, the coverage of PDAMs should also be expanded as to serve more households in urban areas. At the same time, the PDAMs provide sufficient drinking water for people living in slum areas with regard to their willingness to pay. Hence, the poor people will not spend more than 4% of their daily income for water as stated in Internal Affairs Ministerial Decree No. 23/2006.

Finally, the issuance of a new law concerning water resource management to overcome the vacancy of an appropriate regulatory framework is very urgent to redefine the role of key stakeholders and to implement good governance of water sector. Meanwhile, the existence of inter-ministerial National Water Supply and Environmental Sanitation Working Group should be utilised for coordinating the involvement of key ministries, donor agencies and other stakeholders in achieving universal access of drinking water within the scheduled timeframe.

4.2. Limitations and strengths

There are several limitations to the study. One possible limitation of the analyses is the potential endogeneity of the explanatory variables. Another possible limitation is that there are some observations with negative predicted probability. However, the number of which is small (8 in-sample cases) so it will not affect the results. The third potential limitation is that the data-set analysed is only representative to 83% of the Indonesian population. The fourth potential limitation is the low R^2 of 0.157. Although this low goodness-of-fit is not uncommon in cross-sectional studies (Gujarati & Porter, 2009), this could mean that there are factors that are not accounted for in the final regression model. These limitations should be kept in mind when interpreting the results.

Besides the limitations, the study also has several strengths. First, albeit not fully representative, the sample size is considerably large. Second, IFLS has been conducted since 1993 and its survey questionnaires and procedures have been improved over time. Third, this study used regression technique that elicits more information than the multinomial and binary logit regression techniques.

5. Conclusion

This study was aimed to address the geographical and socio-economic disparities households' access improved drinking-water sources. The findings from this study suggest that regional and urban-rural disparities in access to improved drinking water source exist. These disparities may lead to disparities in the burden of disease related to poor drinking water. Moreover, better sanitation facilities associated with higher odds of having access to better DWSs and household size was positively associated with odds of having access to better DWSs. In terms of demographic factors, households headed by ever married persons and household headed by females were more likely to have access to better DWSs. Internal migration negatively associated with access to better DWSs. As for socio-economic variables, education of household head and household wealth was positively associated with access to better DWSs, while participation in PKPS-BBM program was negatively associated.

In the light of the findings, several recommendations are proposed. First, in the long run, coverage of piped water services should be expanded as it is the most reliable drinking water service. Second, in rural areas where basic infrastructures needed for expanding piped water services are lacking, community-based water supplies should be preferred in the short run to provide safe drinking water. As water from piped services may still be contaminated, the use of household water treatment and safe storage (HWTS) should also be encouraged by local governments to eliminate disparities in

burden of water-related illnesses where community-based water supplies are infeasible. Third, as household wealth determines the use of better DWs, improvements in living standard of Indonesian household could increase their likelihood in accessing better DWs.

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Competing interests

The authors declare no competing interest.

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References

- Adams, E. A., Boateng, G. O., & Amoyaw, J. A. (2015). Socioeconomic and demographic predictors of potable water and sanitation access in Ghana. *Social Indicators Research*, 1–15. doi: [10.1007/s11205-015-0912-y](https://doi.org/10.1007/s11205-015-0912-y)
- Bain, R. E. S., Wright, J. A., Christenson, E., & Bartram, J. K. (2014). Rural:urban inequalities in post 2015 targets and indicators for drinking-water. *Science of The Total Environment*, 490, 509–513. doi: [10.1016/j.scitotenv.2014.05.007](https://doi.org/10.1016/j.scitotenv.2014.05.007)
- Balasubramaniam, D., Chatterjee, S., & Mustard, D. B. (2014). Got water? Social divisions and access to public goods in rural India. *Economica*, 81, 140–160. doi: [10.1111/ecca.12056](https://doi.org/10.1111/ecca.12056)
- BAPPENAS. (2014a). *Laporan Pencapaian Tujuan Pembangunan Milenium di Indonesia 2013*. Kementerian Perencanaan Pembangunan Nasional/Badan Perencanaan Pembangunan Nasional (BAPPENAS): Jakarta.
- BAPPENAS. (2014b). *Rancangan Awal Rencana Pembangunan Jangka Menengah Nasional 2015–2019: Buku I Agenda Pembangunan Nasional*. Kementerian Perencanaan Pembangunan Nasional/Badan Perencanaan Pembangunan Nasional: Jakarta: Retrieved from http://un.or.id/documents_upload/publication/Buku%20I%20RPJMN%202015-2019.pdf
- Benelam, B., & Wyness, L. (2010). Hydration and health: A review. *Nutrition Bulletin*, 35, 3–25. doi: [10.1111/j.1467-3010.2009.01795.x](https://doi.org/10.1111/j.1467-3010.2009.01795.x)
- Blakely, T., Hales, S., Kieft, C., Wilson, N., & Woodward, A. (2005). The global distribution of risk factors by poverty level. *Bulletin of the World Health Organization*, 83, 118–126. doi: [10.1590/S0042-96862005000200012](https://doi.org/10.1590/S0042-96862005000200012)
- Brant, R. (1990). Assessing proportionality in the proportional odds model for ordinal logistic regression. *Biometrics*, 46, 1171–1178. Retrieved from <http://www.jstor.org/stable/2532457>
<http://dx.doi.org/10.2307/2532457>
- Brueckner, J. K. (2013). Slums in developing countries: New evidence for Indonesia. *Journal of Housing Economics*, 22, 278–290. doi: [10.1016/j.jhe.2013.08.001](https://doi.org/10.1016/j.jhe.2013.08.001)
- Dong, Y., & Peng, C.-Y. J. (2013). Principled missing data methods for researchers. *SpringerPlus*, 2, 222. doi: [10.1186/2193-1801-2-222](https://doi.org/10.1186/2193-1801-2-222)
- Fink, G., Gunther, 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, 1196–1204. doi: [10.1093/ije/dyr102](https://doi.org/10.1093/ije/dyr102)
- Fotso, J.-C., Ezeh, A., Madise, N., Ziraba, A., & Ogollah, R. (2009). What does access to maternal care mean among the urban poor? Factors associated with use of appropriate maternal health services in the slum settlements of Nairobi, Kenya. *Maternal and Child Health Journal*, 13, 130–137. doi: [10.1007/s10995-008-0326-4](https://doi.org/10.1007/s10995-008-0326-4)
- Fotué, A. L. T., & Sikod, F. (2012). Determinants of the households' choice of drinking water source in Cameroon. *Journal of Sustainable Development in Africa*, 14, 86–97. Retrieved from <http://www.jsd-africa.com/Jsda/Vol14No3-Summer2012A/PDF/Determinants%20of%20the%20Households%20Choice.Luc%20Armand%20Totouom%20Fotue.pdf>
- Fu, V. K. (1998). Estimating generalized ordered logit models. *Stata Technical Bulletin*, 8, 160–164.
- Fullerton, A. S., & Xu, J. (2012). The proportional odds with partial proportionality constraints model for ordinal response variables. *Social Science Research*, 41, 182–198. doi: [10.1016/j.ssresearch.2011.09.003](https://doi.org/10.1016/j.ssresearch.2011.09.003)
- Gujarati, D. N., & Porter, D. C. (2009). *Basic econometrics*. New York, NY: McGraw-Hill.
- Hardjono, J., Akhmadi, N., & Sumarto, S. (Eds.). (2010). *Poverty and social protection in Indonesia*. Singapore: Institute of Southeast Asian Studies.
- Hopewell, M., & Graham, J. (2014). Trends in access to water supply and sanitation in 31 major sub-Saharan African cities: An analysis of DHS data from 2000 to 2012. *BMC Public Health*, 14, 208. doi: [10.1186/1471-2458-14-208](https://doi.org/10.1186/1471-2458-14-208)
- Hosmer, Jr. D. W., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied logistic regression* (4th ed.). Hoboken, NJ: John Wiley & Sons.
<http://dx.doi.org/10.1002/9781118548387>
- Irianti, S., Prasetyoputra, P., Saputra, F. E., & Sasimartoyo, T. P. (2014). A review of access, safety, and use of drinking-water from various sources in Indonesia (Unpublished Report). Jakarta: National Institute of Health Research and Development, Ministry of Health, Republic of Indonesia.
- Kementerian Perencanaan Pembangunan Nasional. (2014). *Rancangan Awal Rencana Pembangunan Jangka Menengah Nasional 2015–2019: Buku I Agenda Pembangunan Nasional*. Jakarta: Kementerian

- Perencanaan Pembangunan Nasional/Badan Perencanaan Pembangunan Nasional. Retrieved from http://un.or.id/documents_upload/publication/Buku%201%20RPJMN%202015-2019.pdf
- Klinikleri, T. (2015). Undernutritional status of children in Ethiopia: Application of partial proportional odds model. *Journal of Biostatistics*, 7, 77–89. Retrieved from <https://doaj.org/article/2053d576dbb74891b52b463b123705b6>
- 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, 128–165. doi:10.1111/j.1475-4991.2008.00309.x
- Long, J. S., & Freese, J. (2014). *Regression models for categorical dependent variables using stata* (3rd ed.). College Station, TX: Stata Press.
- Mayer, A., & Foster, M. (2015). Understanding recession and self-rated health with the partial proportional odds model: An analysis of 26 countries. *Plos One*, 10, e0140724. doi:10.1371/journal.pone.0140724
- Nketiah-Amponsah, E., Aidam, P. W., & Senadza, B. (2009). *Socio-economic determinants of sources of drinking water: Some insight from Ghana*. Paper presented at the Conference on International Research on Food Security, Natural Resource Management and Rural Development, University of Hamburg, Germany. Retrieved from <http://www.tropentag.de/2009/abstracts/full/185.pdf>
- Oakes, J. M., & Kaufman, J. S. (Eds.). (2006). *Methods in social epidemiology*. San Francisco, CA: Jossey-Bass.
- Patunru, A. A. (2015). Access to safe drinking water and sanitation in Indonesia. *Asia & the Pacific Policy Studies*, 2, 234–244. doi:10.1002/app5.81
- Peterson, B., & Harrell, F. E., Jr (1990). Partial proportional odds models for ordinal response variables. *Journal of the Royal Statistical Society. Series C (Applied Statistics)*, 39, 205–217. Retrieved from <http://www.jstor.org/stable/2347760>
- Prasetyoputra, P., & Irianti, S. (2013). Access to improved sanitation facilities in Indonesia: An econometric analysis of geographical and socioeconomic disparities. *Journal of Applied Sciences in Environmental Sanitation*, 8, 215–224. Retrieved from <http://www.trisanita.org/jases/v08n3y2013.html>
- Prüss-Ustün, A., Bartram, J., Clasen, T., Colford, J. M., Cumming, O., Curtis, V., & Cairncross, S. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: A retrospective analysis of data from 145 countries. *Tropical Medicine & International Health*, 19, 894–905. doi:10.1111/tmi.12329
- Pullan, R. L., Freeman, M. C., Gething, P. W., & Brooker, S. J. (2014). Geographical inequalities in use of improved drinking water supply and sanitation across Sub-Saharan Africa: Mapping and spatial analysis of cross-sectional survey data. *PLoS Medicine*, 11, e1001626. doi:10.1371/journal.pmed.1001626
- Rahut, D. B., Behera, B., & Ali, A. (2015). Household access to water and choice of treatment methods: Empirical evidence from Bhutan. *Water Resources and Rural Development*, 5, 1–16. doi:10.1016/j.wrr.2014.09.003
- Setiawan, D. (2011). *WSP's sustainable services through domestic private sector participation: Indonesia*. Paper presented at the 6th Rural Water Supply Network Forum 2011 Uganda: Rural Water Supply in the 21st Century: Myths of the Past, Visions for the Future, Kampala, Uganda. Retrieved from <http://water.worldbank.org/sites/water.worldbank.org/files/publication/Indonesia-CBOFinancing-Short-Paper-RWSN-FINAL.pdf>
- StataCorp. (2013). *Stata statistical software: Release 13*. College Station, TX: StataCorp LP.
- Strauss, J., Witoelar, F., Sikoki, B., & Wattie, A. M. (2009). *The fourth wave of the Indonesia family life survey (IFLS4): Overview and Field Report. WR-675/1-NIA/NICHD*. Retrieved from <http://catalog.ihns.org/index.php/catalog/2370/download/37394>
- Sy, J. (2011). *The hard way to the high road: Transition of community-based water groups to professional service providers in Indonesia*. Washington, DC: World Bank. Retrieved from <https://openknowledge.worldbank.org/handle/10986/11687>
- United Nations. (2010). *United Nations General Assembly: Resolution 64/292*. New York, NY: Author. Retrieved from http://www.dgyn.de/fileadmin/user_upload/DOKUMENTE/English_Documents/A-Res-64-292.pdf
- United Nations. (2015). *The Millennium Development Goals Report 2015*. New York, NY: Author Retrieved from http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20%28July%201%29.pdf
- WHO. (2003). *The right to water*. Geneva: Author. Retrieved from http://www.who.int/water_sanitation_health/en/righttowater.pdf
- WHO. (2014). *UN-water global analysis and assessment of sanitation and drinking-water (GLAAS) 2014 report: Investing in water and sanitation: Increasing access, reducing inequalities*. Geneva: Author. Retrieved from http://www.who.int/water_sanitation_health/glaas/2014/glaas_report_2014/en
- 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. (2014). *Progress on sanitation and drinking-water: 2014 update*. Geneva: World Health Organization/ The United Nations Children's Fund. Retrieved from http://www.unwater.org/fileadmin/user_upload/unwater_new/docs/jmp.2014_eng.pdf
- Williams, R. (2006). Generalized ordered logit/partial proportional odds models for ordinal dependent variables. *Stata Journal*, 6, 58–82. Retrieved from <http://www.stata-journal.com/article.html?article=st0097>



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