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ABSTRACT

Household air pollution (HAP) is a major public health concern in many low- and middle-income countries. In the past few decades, population growth has led to increases in the number of individuals cooking with solid fuels and exposure to biomass and coal smoke. Globally, millions of deaths each year are linked to indoor air pollution, with women and children affected disproportionately. There is limited understanding of trends and geographic variation in HAP, which has made targeting of interventions challenging. This paper identifies HAP trends; examines associations between HAP and household characteristics in Bangladesh, India, Indonesia, Nepal, and the Philippines; and estimates district-level exposure to HAP in all of these countries except for Indonesia, where global positioning system data were lacking. The results indicated a decreasing overall trend in use of solid fuel for cooking in these countries. However, disparities persisted in all countries. The greatest reductions in use of solid fuel were among wealthier households, while the poorest households continued to be the most affected by HAP. The district-level estimates of HAP are summarized in maps that clearly highlight hot spots that can be targeted for interventions.

Key words: Household air pollution, indoor air pollution, district-level estimates

1 INTRODUCTION

Biomass and solid fuels such as wood, charcoal, crop residues, and dung—in addition to coal—are used as a primary source of household fuel and energy for billions of individuals worldwide. Globally, cooking with solid fuels has increased due to population growth. Most regions experienced a downward trend in the percentage of households cooking with solid fuels between 1990 and 2010, with a global reduction from 53% to 41% (Bonjour et al. 2013). Although all regions experienced declines, the rates before and after the declines in Africa (82% to 77%), Southeast Asia (83% to 61%), and the Western Pacific (66% to 46%) were higher than the global average, whereas those in the Eastern Mediterranean (48% to 35%), the Americas (27% to 14%), and Europe (23% to 7%) were lower than the global average (Bonjour et al. 2013). The problem of exposure to HAP as a result of cooking with polluting fuels continues to almost exclusively impact low- and middle-income countries (LMIC), with less than 1% of the population in high-income countries accessing polluting fuels. In 2016, 83% of the population in LMIC in the African region, 59% of the population percent in the Southeast Asia region, and 42% of the population in the Western Pacific region relied primary on polluting cooking fuel options such as coal, wood, charcoal, dun, crop residues, or kerosene (World Health Organization 2018a). The percentages of the population relying primarily on polluting fuels in the Eastern Mediterranean, the Americas, and Europe were 31%, 16%, and 6%, respectively, during the same year (World Health Organization 2018a).

Biomass and coal smoke contains several pollutants that are hazardous to people's health and have been implicated as agents for numerous diseases in developing countries (Ezzati and Kammen 2002). The pollutants include respirable particulate matter, carbon monoxide, nitrogen oxides, formaldehyde, benzene, 1,3-butadiene, polycyclide aromatic hydrocarbons, and other toxic organic compounds (Mishra and Retherford 2006). Indoor air pollution is a risk factor for several leading causes of death, including stroke, ischemic heart disease, chronic obstructive pulmonary disease, and lung cancer. It is linked to about 1.5 million deaths annually due to acute lower respiratory infections, chronic obstructive lung disease, and lung cancer (World Health Organization 2006; World Health Organization 2018b). Women and children, especially in developing countries, are disproportionately exposed to polluted air because of the use of biomass for cooking and heating. HAP from biomass and solid fuels used for cooking and heating is a risk factor for several health outcomes associated with child survival, such as pneumonia, low birth weight, stillbirth, and noncommunicable diseases (Dherani et al. 2008; Pope et al. 2010; Smith, Mehta, and Maeusezahl-Feuz 2004; Tielsch et al. 2009). HAP doubles the risk of pneumonia and other acute lower respiratory infections, thus contributing to half of the deaths from pneumonia among children under age 5 (World Health Organization 2018b). Reduction of air pollution, specifically HAP, is a critical component of attaining Sustainable Development Goals (SDGs). Amegah and Jaakkola (2016) recommend action for seven SDGs (SDGs 3, 6, 7, 11, 12, 13, and 15). For instance, for SDG 3 (*Ensure healthy lives and promote well-being for all at all ages),* the recommended action is to reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination by 2030. For SDG 7 (*Ensure access to affordable, reliable, sustainable, and modern energy for all),* several recommendations aim to increase access to clean energy and increase the use of renewable energy by 2030.

Several studies have found associations between HAP and various forms of lung or respiratory-related complications. HAP exposure increased the risk of lung cancer among individuals in Nepal who had never smoked (Raspanti et al. 2016). In Bangladesh, HAP is a leading cause of respiratory illness and has

contributed to under-5 mortality (Naz, Page, and Agho 2015). A case-control study conducted in Bhaktapur, Nepal, found that the use of biomass as a household fuel source was a risk for acute lower respiratory infection in young children (Bates et al. 2013). Other studies have specifically examined the relationship between HAP and children's health outcomes. Cooking indoors increased the risk of neonatal mortality, infant mortality, acute respiratory infection (ARI), low birth weight, and Cesarean delivery in Bangladesh (Khan et al. 2017). In India, the use of cooking fuel in households was associated with increased risk of mortality in children under age 5, and these associations were higher in rural areas and for households without a separate kitchen for cooking (Naz, Page, and Agho 2016). Smoke exposure can contribute to stunting by causing anemia and low birthweight. In Nepal, children with such exposure showed a considerably higher prevalence of stunting than children with no exposure (84.6% versus 15.4%) (Dadras and Chapman 2017). Further, in India, a study found that the prevalence of anemia was higher among children in households using biofuel than among those in households using cleaner fuels (Mishra and Retherford 2006).

In several countries, interventions have succeeded in reducing the rates of HAP. These interventions have focused on changing behavior, improving stoves and household ventilation, and promoting the adoption of new technologies and the utilization of renewable energy sources (Amegah and Jaakkola 2016; Smith et al. 2011). To effectively implement and target interventions to address the negative impacts of HAP, better understanding of the populations that are most affected, as well as of regional and geographic variation, is needed. Yet, few studies have systematically examined geographic or regional variations in rates of HAP. A meta-analysis of 25 case-control studies examined the association between household coal use and lung cancer. Regional stratification of mainland China and Taiwan found geographic variation in the risk of lung cancer associated with household coal use (Hosgood III et al. 2011). Other studies have found variation in the level of exposure between urban and rural populations and variation within locations such as coastal or mountainous areas (Huboyo et al. 2014; Mestl et al. 2007).

Studies have also identified sociodemographic and socioeconomic factors that are associated with HAP. Women and children tend to have greater exposure to HAP (Duflo, Greenstone, and Hanna 2008; Siddharthan et al. 2018). One study in Bangladesh found not only that the poorest and least-educated households have higher levels of exposure to HAP but also that women and children have higher levels of exposure than men (Dasgupta et al. 2006). In Bangladesh, levels of indoor air pollution were found to be dangerously high for many poor families (Huq et al. 2004). Economic status also affects the level of exposure. Individuals with more wealth and education are more likely to have adequate ventilation, which reduces exposure to HAP, and wealthier individuals are more likely to have market access and the ability to own a modified stove.

There is limited understanding of trends in HAP, the characteristics of populations and individuals who are most affected by HAP, and geographic variation in rates of HAP within a country. This paper attempts to fill these gaps by identifying HAP trends, examining associations between HAP and household characteristics, and estimating HAP at the district level. While the links between HAP and health are well documented, estimating HAP at the district level provides key information to inform the targeting of interventions.

2 DATA AND METHODS

2.1 Data and Measurement

The study used data from surveys conducted by The Demographic and Health Surveys (DHS) Program in 2005 and later in Bangladesh, India, Indonesia, Nepal, and the Philippines. DHS surveys are conducted approximately every five years in each country, and standardized protocols are used to ensure comparability over time and between countries. Table 1 lists the surveys used in the study and the number of households included by urban and rural residence. DHS surveys use a two-stage cluster sampling design to draw a sample that is representative of the country, for urban and rural areas separately, and for each unit at the country's first administrative level (usually geographic regions). In the first stage of each survey, clusters or enumeration areas were selected from the country's most recent census sampling frame with probability proportional to the population size of clusters. In the second stage, a systematic sample of households in each cluster (usually 20-30 households per cluster) was selected. A household questionnaire was administered to an adult household member (usually the household head or spouse) to collect information on household characteristics, such as water and sanitation, and on household assets.

Table 1 Number of households included in the analysis by country, survey, and residence

	Urban	Rural	Total
Bangladesh 2007	8,133	2,267	10,400
Bangladesh 2011	12,836	4,305	17,141
Bangladesh 2014	12,456	4,844	17,300
India 2005-06	73,462	35,579	109,041
India 2015-16	391,702	209,807	601,509
Indonesia 2007	23,818	16,883	40,701
Indonesia 2012	22,362	21,490	43,852
Indonesia 2016	24,505	23,458	47,963
Nepal 2006	7,234	1,473	8,707
Nepal 2011	9,280	1,546	10,826
Nepal 2016	4,259	6,781	11,040
Philippines 2008	6,192	6,277	12,469
Philippines 2013	7,700	7,104	14,804
Philippines 2017	14,793	12,703	27,496

The household respondent was also asked about the main type of fuel used for cooking. Based on the responses to this question, we defined HAP from cooking to be present if the fuel used for cooking included coal/lignite, charcoal, wood, straw, shrubs/grass, agricultural crop, or animal dung. Otherwise, clean fuels were defined as electricity, liquid propane gas (LPG), natural gas, and biogas. The cooking location, either indoors or outdoors, was also recorded.

Other household-level variables that are commonly found to be associated with HAP in the literature were also examined. These included household wealth quintiles, household crowdedness (four or more household members on average sharing a sleeping room), region, and urban-rural residence (Ghimire et al. 2019; Khan et al. 2017; Naz et al. 2018).

2.2 Analysis

Descriptive analysis

We described the current levels of HAP, trends in HAP, and specific types of fuel used for cooking for each country. The trend analysis assessed changes in HAP over time by household characteristics, including urban-rural residence, region, wealth, and crowdedness. For this part of the analysis, HAP was dichotomized into solid fuel use (either indoors or outdoors) and clean fuel use. Statistical testing was performed to test the significance of the changes over time for each of the background categories. Adjustments for the complex sample design were included in all analyses.

A limitation of this study is the cross-sectional nature of the data, which does not allow for reliable modeling of the association between HAP and child health outcomes such as low birth weight and ARI symptoms. There is also the issue of the timing to the exposure of HAP that may not correspond to the outcomes, especially for ARI symptoms that are only measured for the last two weeks before the survey. We also do not know the duration of exposure to HAP.

District-level estimation

DHS surveys are not designed to collect data that are representative of the second subnational administrative level (ADMIN 2, usually districts). However, recent developments in model-based geostatistics allow health indicators to be estimated at the ADMIN 2 level (Graetz et al. 2018; Mosser et al. 2019; Osgood-Zimmerman et al. 2018). The geostatistical modeling used to estimate the household use of solid fuel at the district level can be summarized in a few steps. First, individual household-level DHS data were aggregated to the DHS cluster level, for which latitude and longitude information was collected. Second, selected geospatial covariates gathered from multiple sources were processed with R software to extract the corresponding values for the DHS clusters. These geospatial covariates measure environmental and socioeconomic characteristics and have been shown to correlate well with DHS indicators in different settings (Alegana et al. 2015; Gething et al. 2015). The selected geospatial covariates were travel time to the nearest settlement with >50,000 inhabitants, aridity, diurnal temperature range, precipitation, potential evapotranspiration, daily maximum temperature, elevation, enhanced vegetation index, daytime land surface temperature, diurnal difference in land surface temperature, nighttime land surface temperature, population distribution, and livestock density (for cattle and goats). A description of these variables, as well as their sources, is discussed in detail in Mayala et al. (2018). Third, stacked generalized ensemble models were used to generate surfaces based on cluster-level DHS data and spatial covariates. The predicted surfaces were then adjusted for spatial dependence through a Bayesian geostatistical model that produces pixel-level (5x5 km) estimates of the outcome, with associated uncertainties. Finally, the pixel-level estimates were aggregated to the district level. More detail about geospatial covariate processing in R, stacked generalization models, and the Bayesian geostatistical model can be found in Mayala et al. (2019).

We estimated household use of solid fuel at the district level for Bangladesh, Nepal, and the Philippines for the most recent survey using the model-based geostatistics approach. District-level use for India was estimated directly from the survey since it was designed to be representative of the 640 districts in India. Global positioning system data were not collected in DHS surveys in Indonesia; therefore, use of solid fuel at the district level was not estimated for Indonesia. For each of the three countries using the model-based geostatistics approach, we predicted surface maps at the levels of pixels and districts. Uncertainty (width

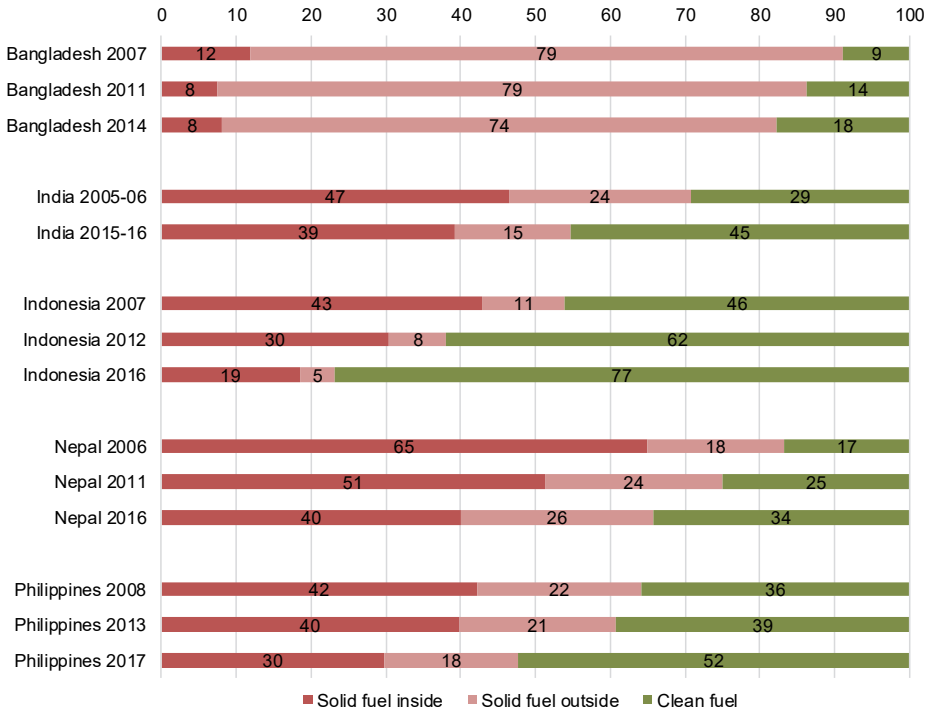
of the 95% conference interval) at the district level was also estimated. These estimates are summarized in the appendix and also represented by maps.

3 RESULTS

3.1 Levels, Trends, and Types of HAP

Figure 1 presents the trends in HAP in each country. The most recent survey in each country indicated various levels of use of solid fuel. Bangladesh had the highest level, with 82% of households in 2014 relying on solid fuel for cooking, although most households (74%) cooked with solid fuel outside the house. In India and Nepal, more than half of the households used solid fuel for cooking: 54% in India (2015-2016) and 66% in Nepal (2016). The lowest level of HAP was reported in Indonesia, at 23% in 2016.

Figure 1 Percent distribution of households by type of fuel used for cooking

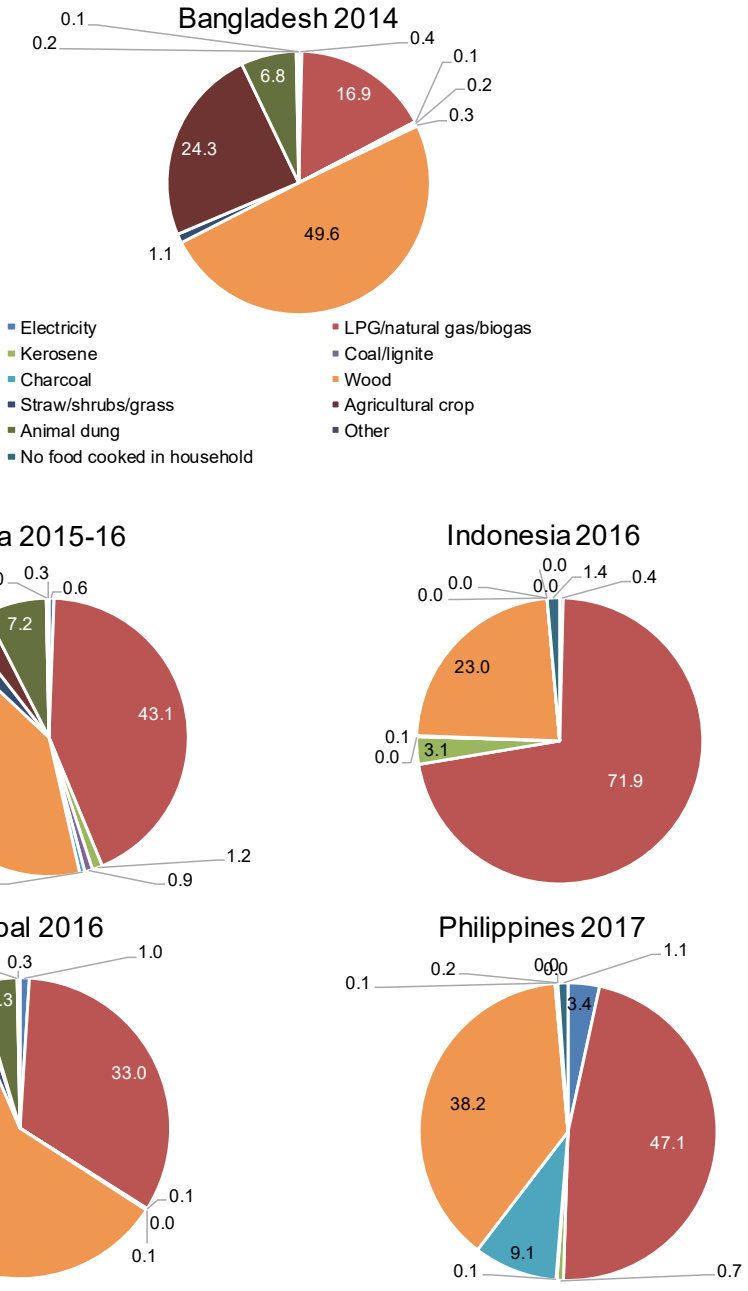


Examining multiple surveys in each country allowed trends to be seen over a 10-year period between 2005/06 and 2016/17, except for Bangladesh, which had a shorter observation period from 2007 to 2014. Over time, there was a decreasing trend in use of solid fuel, both inside and outside the house, in all five countries. The use of clean fuel increased in all five countries. The decreases in solid fuel use between the earliest survey and the most recent survey ranged from 9 percentage points in Bangladesh to 31 percentage points in Indonesia. Conversely, Bangladesh had the lowest increase in use of clean fuel, and Indonesia had the greatest increase. In 2016, more than three-fourths of Indonesian households used clean fuel for cooking. Approximately half of households in the recent surveys in the Philippines and India used clean fuel, approximately a third of households in Nepal, and less than a fifth in Bangladesh.

Figure 2 shows different types of fuel reported in the most recent survey in each country. Among the solid fuel types, wood was commonly reported by all countries, ranging from 23% in Indonesia to 59% in Nepal. Agricultural crops were also commonly used in Bangladesh, by 24% of households. Animal dung was

sometimes reported as fuel for cooking in Bangladesh, India, and Nepal, but by less than 10% of households. Other solid fuel types such as straw, shrubs, and grass were rarely reported. Among the clean fuel types, LPG/natural gas/biogas was the most reported, ranging from 17% of households in Bangladesh to 72% in Indonesia. More than 40% of households in India and the Philippines also used LPG, natural gas, or biogas for cooking. Electricity was rarely used for cooking in any country.

Figure 2 Percent distribution of households by type of fuel used for cooking



3.2 Differentials and Changes Over Time in HAP by Household Background Characteristics

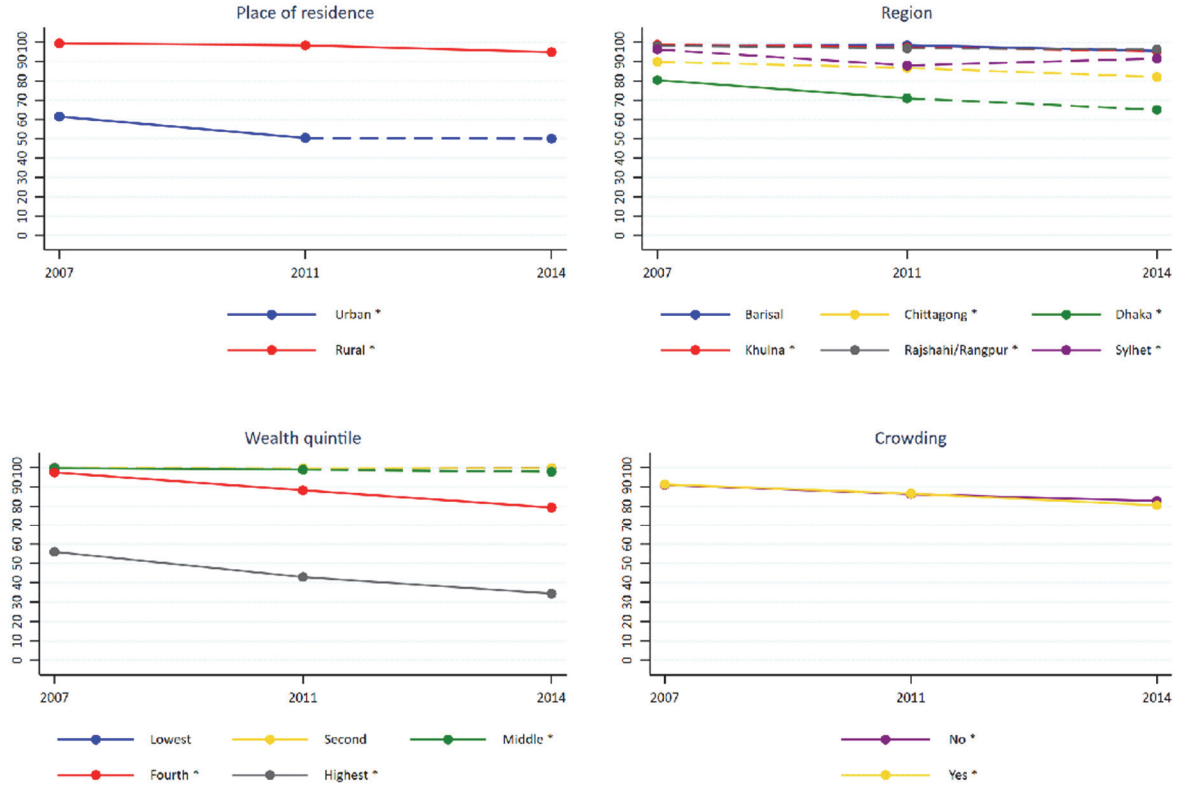
The decrease in the use of solid fuel at the national level was also observed by several household background variables. Figures 3 to 7 and Appendix Tables A.1 to A.5 show trends and significance of differences between surveys in the use of solid fuel by place of residence, wealth quintile, crowding, and region. In the figures, a solid line between consecutive surveys indicates a significant difference, while a dotted line indicates no significant difference. An asterisk next to the category label in the figure legend indicates a significant difference between the first and third surveys.

Bangladesh had the highest use of solid fuel and also the smallest decrease in use when compared with the other countries. By 2014, 82% of households in Bangladesh were still using solid fuel. The percentages differed by place of residence, wealth quintile, and region but not by crowding (see Appendix Table A.1). Over time, the largest decreases in Bangladesh were in households from the fourth and highest wealth quintiles, decreasing by approximately 20 percentage points between the earliest and most recent surveys for these two quintiles (Figure 3). By region, we saw large and significant declines in Dhaka and Sylhet between 2007 and 2011. However, between the two most recent surveys, only Barisal had a significant decline in household use of solid fuel, and the decline was slight and only marginally significant.

In India, Indonesia, and the Philippines, the decrease in the use of solid fuel between the two most recent surveys was significant across all household characteristics (Figures 4, 5, and 7 and Appendix Tables A.2 to A.4). The largest decreases in solid fuel use in these countries were found within wealth quintiles. In both India and the Philippines, households from the middle and fourth wealth quintiles decreased their solid fuel use by approximately 30 percentage points between the earliest and most recent surveys. In Indonesia, solid fuel use decreased by more than 50 percentage points in households from the second and middle quintiles. A large decrease of approximately 30 percentage points was also observed in the South region in India (see Appendix Table A.2).

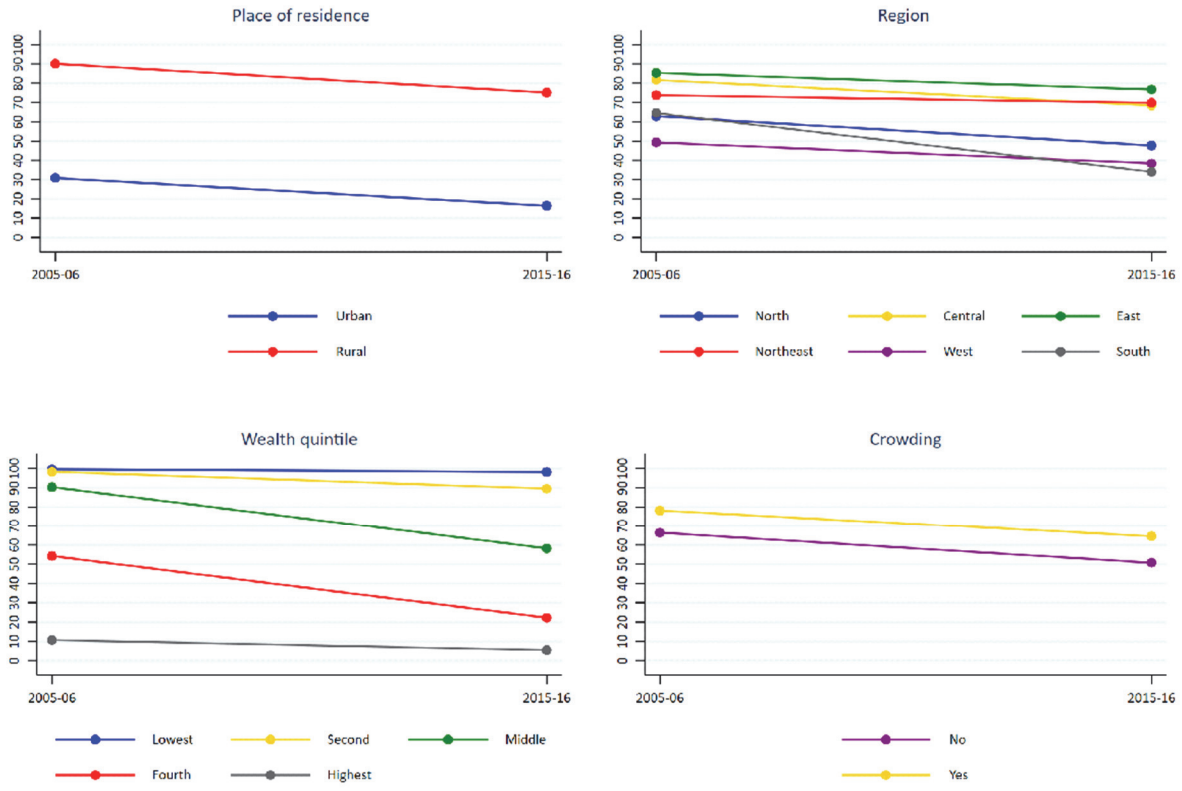
In Nepal, the use of solid fuel for cooking in urban households increased significantly between the two most recent surveys, from 29% in 2011 to 52% in 2016. However, significant decreases in use of solid fuel were observed in all wealth groups and most regions. The largest decrease, by 26 percentage points, was among households from the fourth quintile (Figure 6).

Figure 3 Trends in use of solid fuel for cooking by household characteristics, Bangladesh



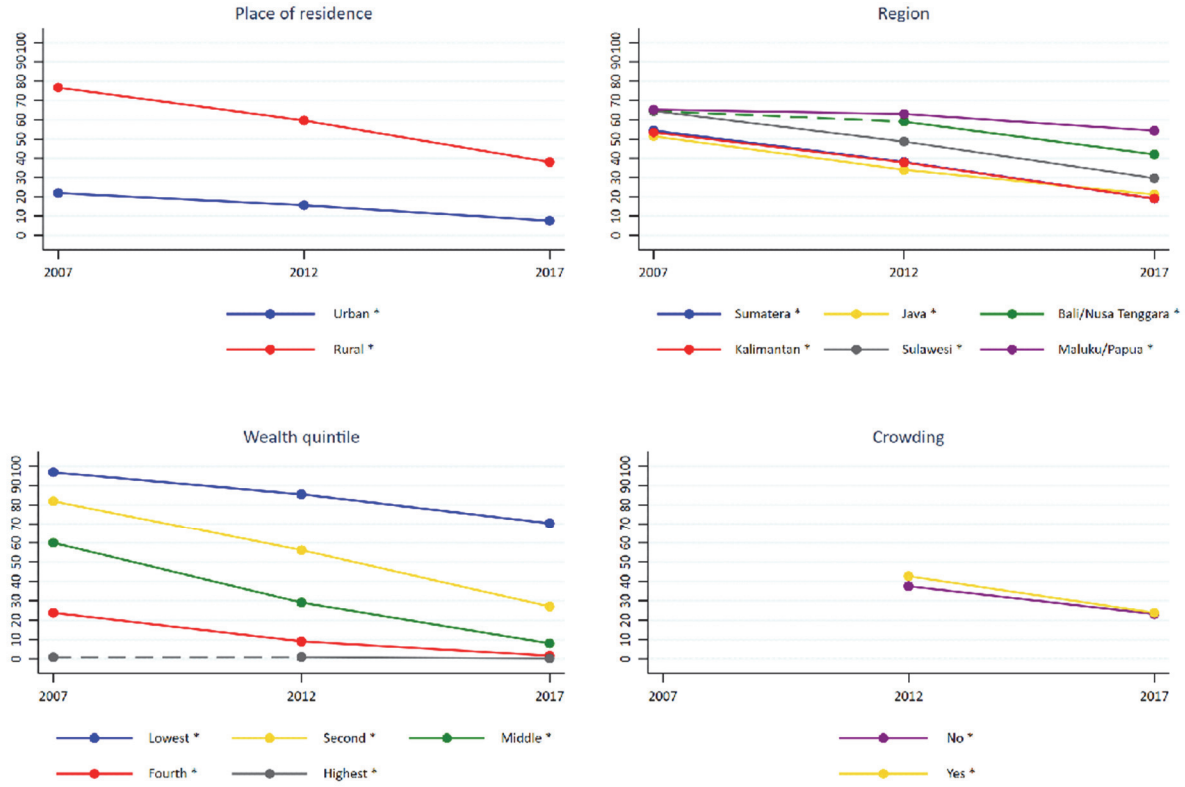
Crowding = Four or more people per sleeping room
Solid line = Significant difference between the two consecutive surveys
Dotted line = No significant difference between the two consecutive surveys
* Significant difference between the first and third surveys

Figure 4 Trends in use of solid fuel for cooking by household characteristics, India



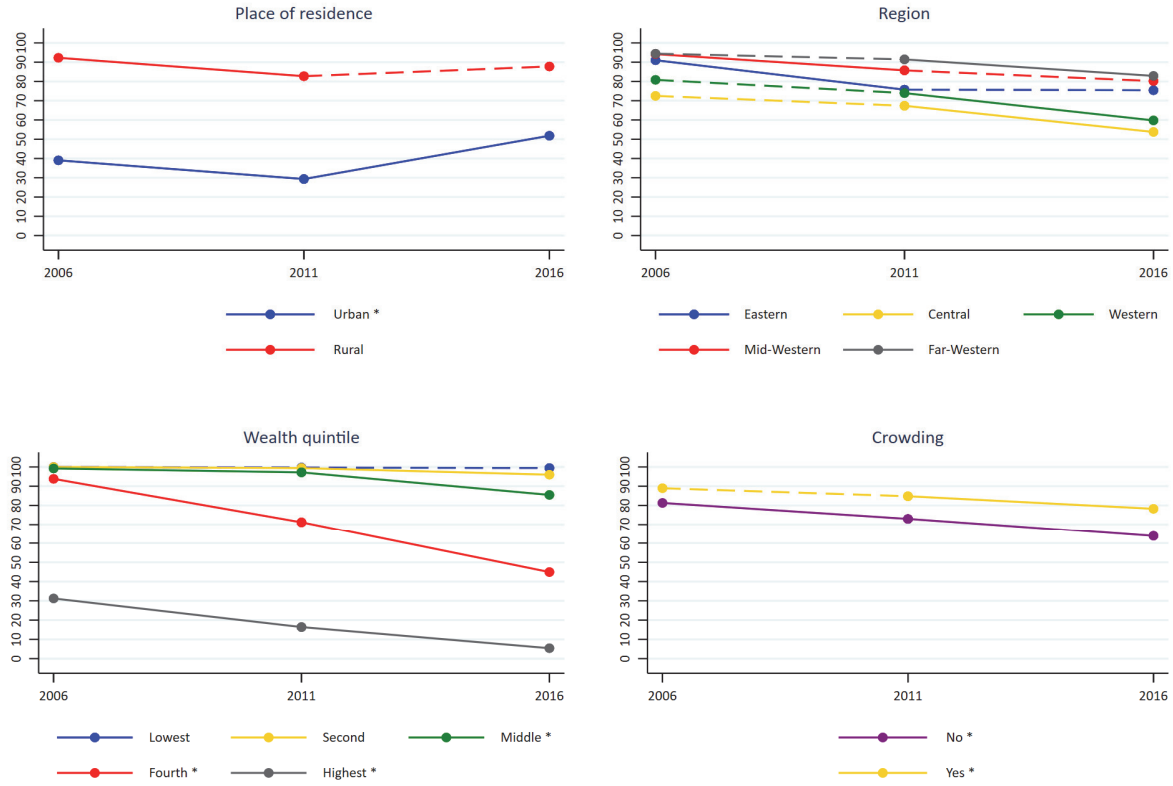
Crowding = Four or more people per sleeping room
Solid line = Significant difference between the two consecutive surveys
Dotted line = No significant difference between the two consecutive surveys
* Significant difference between the first and third surveys

Figure 5 Trends in use of solid fuel for cooking by household characteristics, Indonesia



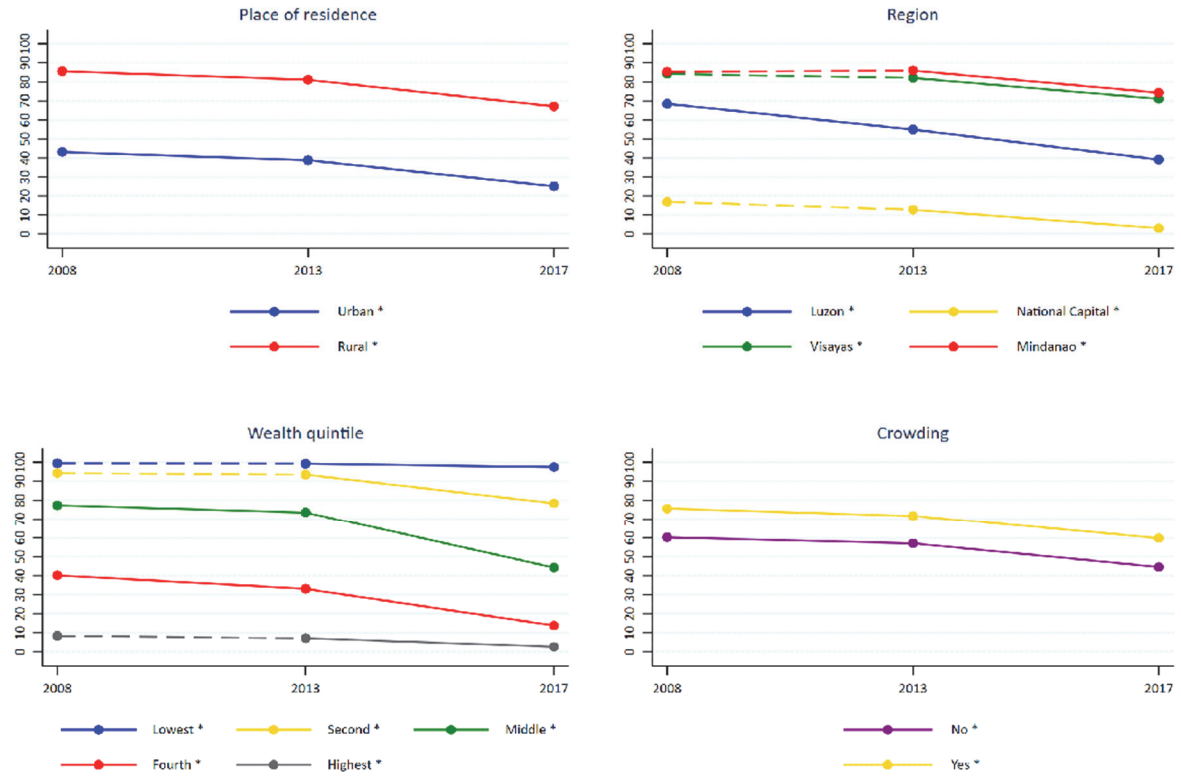
Crowding = Four or more people per sleeping room
Solid line = Significant difference between the two consecutive surveys
Dotted line = No significant difference between the two consecutive surveys
* Significant difference between the first and third surveys

Figure 6 Trends in use of solid fuel for cooking by household characteristics, Nepal



Crowding = Four or more people per sleeping room
Solid line = Significant difference between the two consecutive surveys
Dotted line = No significant difference between the two consecutive surveys
* Significant difference between the first and third surveys

Figure 7 Trends in use of solid fuel for cooking by household characteristics, the Philippines



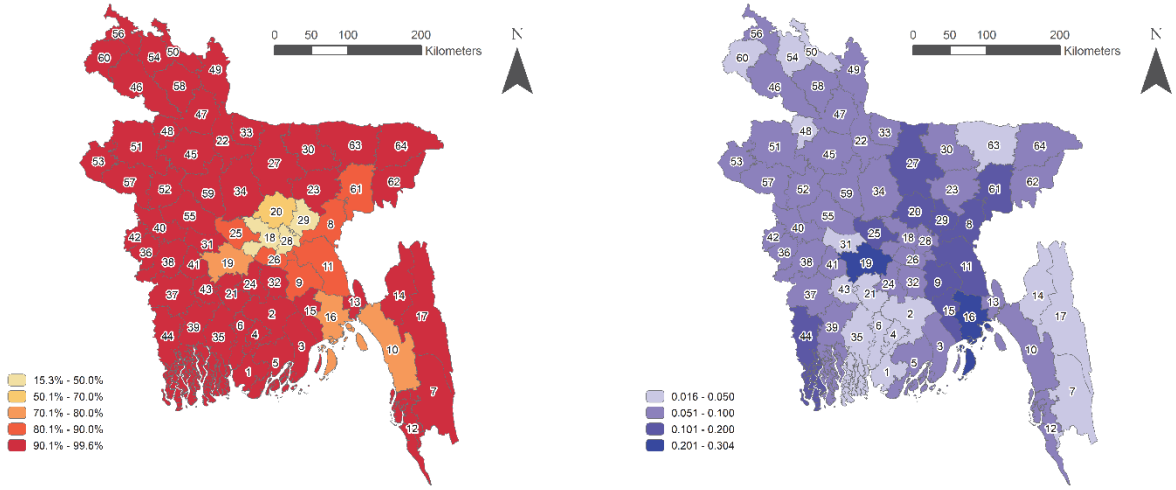
Crowding = Four or more people per sleeping room
Solid line = Significant difference between the two consecutive surveys
Dotted line = No significant difference between the two consecutive surveys
* Significant difference between the first and third surveys

Disparities by all background variables persisted in the most recent survey for all five countries. The largest gaps were by wealth quintile (see Appendix Tables A.1 to A.5). In India, Nepal, and the Philippines, the difference in the use of solid fuel between the lowest and highest wealth quintiles for the most recent survey was more than 90 percentage points. The gap was approximately 60 percentage points in Bangladesh and about 70 percentage points in Indonesia. Because of the strong association between wealth and place of residence, large disparities were also seen in the most recent surveys by place of residence. In all five countries, the smallest gaps in use of solid fuel were by crowding.

3.3 District-level Estimates of HAP

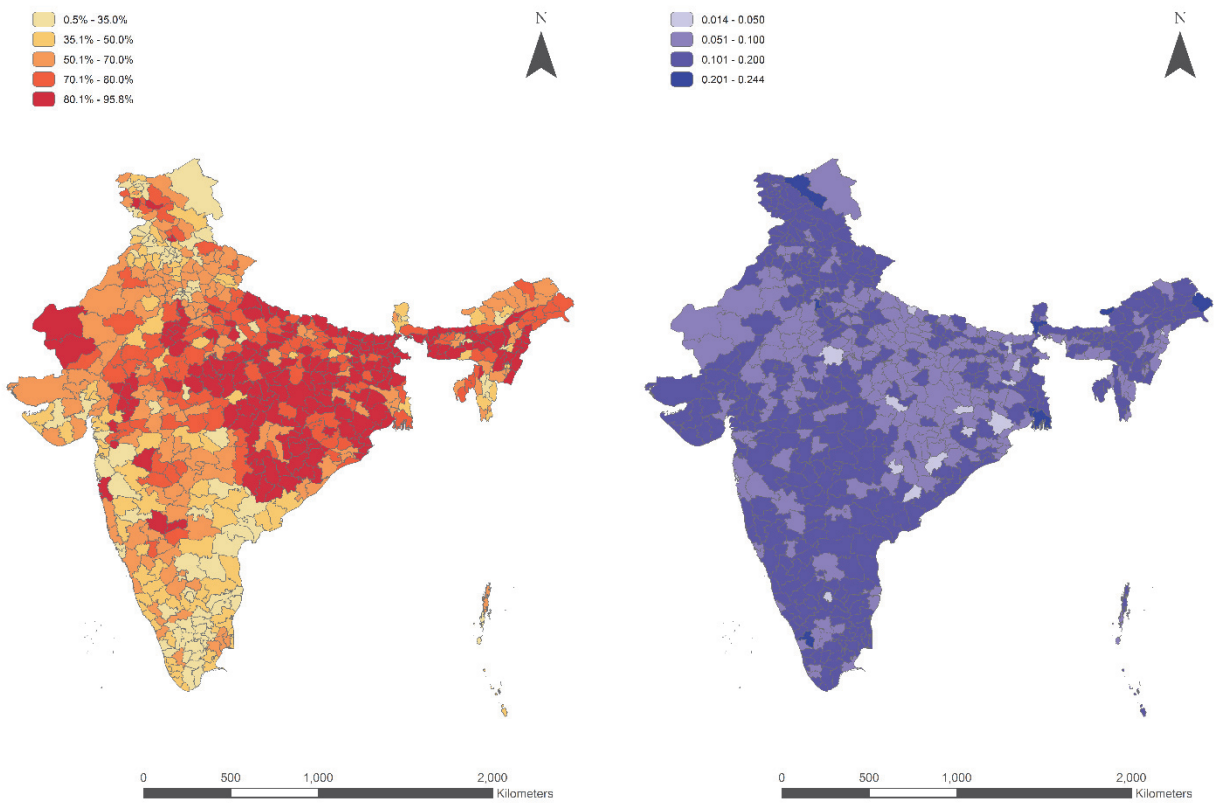
We used model-based methodology to estimate HAP at the district level in each country except Indonesia. Estimates could not be produced for Indonesia because global positioning system data were not collected for that survey. Estimates are shown through maps with corresponding confidence intervals (CIs) in Figures 8 to 11 and by district name in Appendix Tables A.6 to A.9. The CI maps present the width of the CIs for the district-level estimates. Darker colors on the maps on the right side denote wider CIs, which represent larger errors in the estimates.

Figure 8 **District-level estimates (left) and 95% CIs (right) of household use of solid fuel for cooking, Bangladesh DHS 2014**



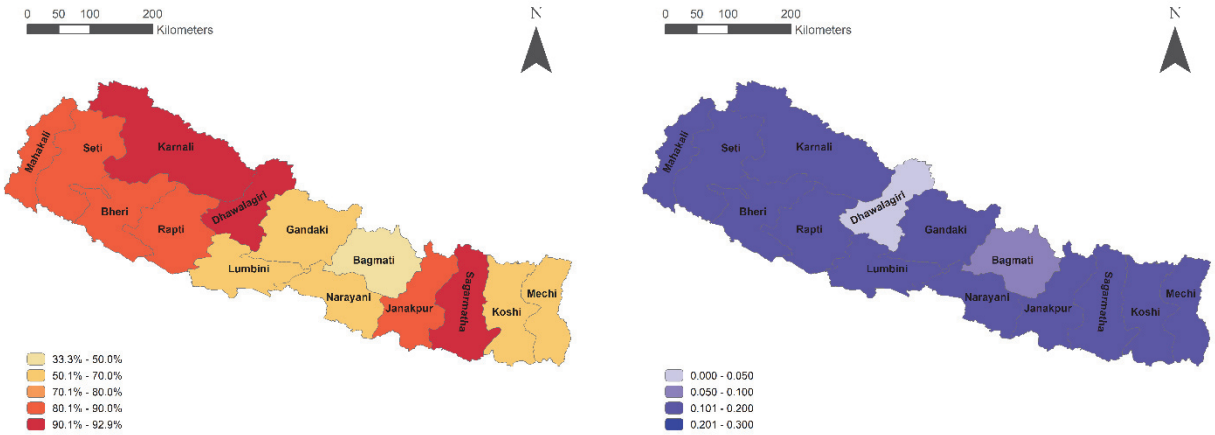
The map on the left in Figure 8 shows that the use of solid fuel in Bangladesh was more than 90% in most districts. The lowest use was in the central districts of Dhaka division, where less than a quarter of the households in three districts used solid fuel for cooking (see Appendix Table A.6). In Dhaka district, only 15% (95% CI: 13%, 18%) used solid fuel. Every district from the Barisal and Khulna regions in the south of Bangladesh had rates of solid fuel use of 95% or higher. Most districts in these regions also had a relatively low level of uncertainty, as shown in the map on the right in Figure 8.

Figure 9 **District-level estimates (left) and 95% CIs (right) of household use of solid fuel for cooking, India DHS 2015-2016**



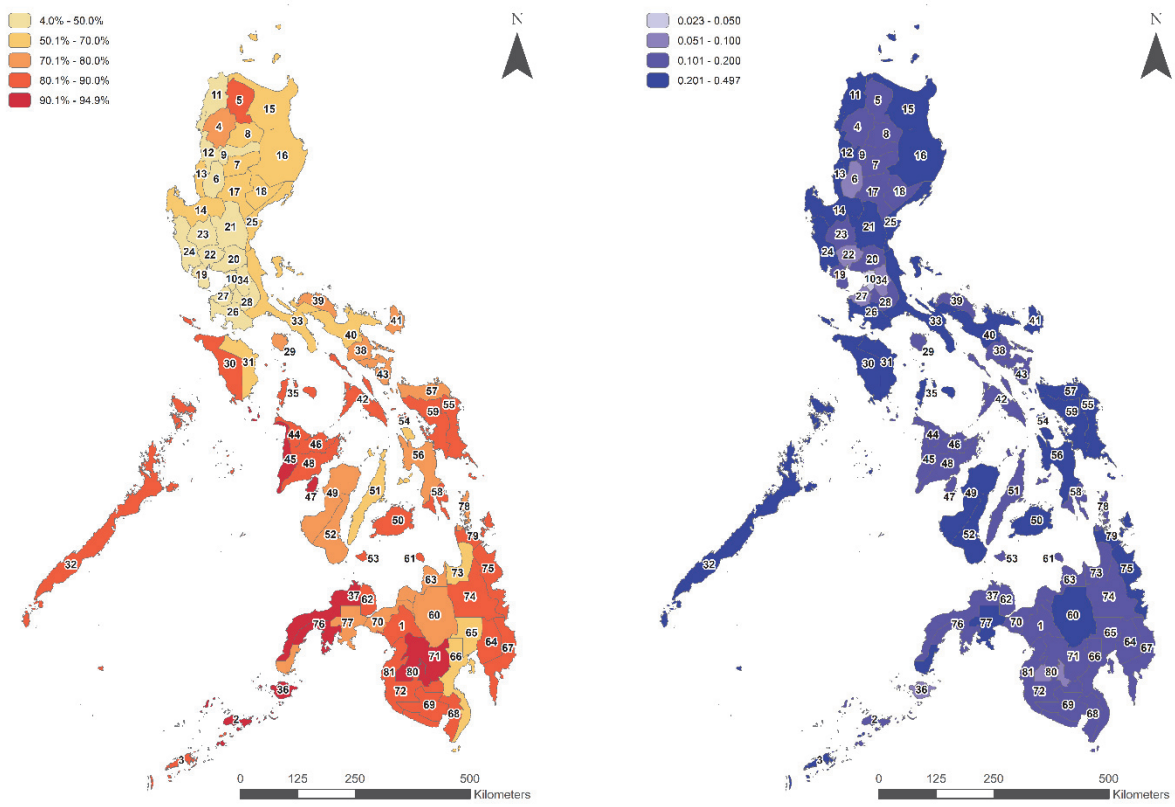
The map on the left in Figure 9 shows a wide range of use of solid fuel for cooking across India's 640 districts. Solid fuel was very common in northeastern areas, with rates of use higher than 80% in most districts. The highest rate of use was in Jamtara district, at 96% (95% CI: 93%, 97%) (see Appendix Table A.7 for district ID 363). The use of solid fuel was relatively low in southern and northern districts. Indeed, several districts had less than 5% of households reporting the use of solid fuel: Srinagar, Chandigarh, North West, North, North East, East, New Delhi, Central, West, Southwest, South, Daman, Hyderabad, Bangalore, Mumbai, and Suburban (district IDs 10, 55, 90-98, 495, 518, 519, 536, and 572). The range of uncertainty for the estimates was below 20 percentage points in most districts (see map on the right in Figure 9). As in other countries, the use of solid fuel was higher in rural areas than in urban areas in every district, with a difference of up to 89 percentage points between the two (i.e., in Sonbhadra district).

Figure 10 District-level estimates (left) and 95% CIs (right) of household use of solid fuel for cooking, Nepal DHS 2016



On average, two-thirds of households in Nepal used solid fuel for cooking in 2016. The map on the left in Figure 10 indicates that half of the 14 districts reported a level of 80% or higher, with three districts (Dhawalagiri, Karnali, and Sagarmatha) reporting a level higher than 90%. The only district in which less than half of households used solid fuel was Bagmati, at 33% (95% CI: 28.8, 37.6%) (see Appendix Table A.8). As shown in the map on the right in Figure 10, the range of uncertainty for the estimates for most districts fell between 10 and 20 percentage points.

Figure 11 District-level estimates (left) and 95% CIs (right) of household use of solid fuel for cooking, the Philippines NDHS 2017



The map on the left in Figure 11 shows that in the Philippines, solid fuel use increases from north to south (with a few exceptions). The lowest rate of use was in Metro Manila, at 4% (95% CI: 3%, 5%) (see Appendix Table A.9). The surrounding provinces also had low levels of solid fuel use, ranging from 10% to 15%. These provinces are part of the Calabarzon and Central Lazon regions, but these regions had a few provinces with levels of solid fuel use above 50%. The highest solid fuel use was in the Autonomous Region in Muslim Mindanao (ARMM), ranging from 83% (in Shariff Kabunsuan province) to 95% (in Basilan province). Other provinces in the central and south of the country had moderate to high use, with more than 70% of households in most provinces using solid fuel for cooking. The level of uncertainty in these estimates ranged from moderate to high (i.e., between 10 and 20 percentage points), as shown in the map on the right in Figure 11.

4 DISCUSSION AND CONCLUSIONS

The adverse impacts of HAP on health, especially for women and children, have been well documented. Previous studies have examined this important issue in individual countries, but limited research has examined the levels of and trends in HAP in multiple countries (Bonjour et al. 2013). This study adds to that research and is also the first study to estimate the district-level use of solid fuel for cooking. Using data from nationally representative household surveys and geostatistical models, we assessed the levels of HAP from the use of solid fuel at the national, regional, and district levels and over time in five Southeast Asian countries. Overall, our analysis reveals a decreasing trend in use of solid fuel for cooking in these countries, which is in line with the model estimates based on data from the World Health Organization (Bonjour et al. 2013). Disparities in exposure by urban-rural residence, socioeconomic status, and geographic region persisted in all countries. We found the greatest reductions in use of solid fuel among relatively wealthy households, while the poorest households continued to be the most affected by HAP.

Bangladesh shows persistently high use of solid fuel for cooking. Reductions over time are less noticeable than in other countries. At the district level, more than 90% of households in most districts were using solid fuel for cooking in 2014. Clearly, HAP is a critical public health issue in Bangladesh; it contributes to 4% of the national burden of diseases (World Health Organization 2007). While the overall use of solid fuel is high in Bangladesh, most households reported cooking outside of the house or in a separate building. Research from Bangladesh has shown that cooking outside the house is associated with lower risks of ARI and low birth weight than is cooking inside the house, regardless of type of fuel (Khan et al. 2017). In another study, PM10 concentration was found to be lower in households that cooked in a separate kitchen or had doors and windows open after cooking (Dasgupta et al. 2006). A study conducted in India also found that in addition to fuel type, kitchen type was an important predictor of HAP (Balakrishnan et al. 2004). Given the universally high use of solid fuel in Bangladesh, a complete transition to clean energy will take time and be challenging. The government of Bangladesh aims to install improved cookstoves in 30 million households by 2030. Several improved cook stove programs are now being implemented with the support of international donors (Jain and Sadeque 2017). Other cost-effective options such as improving ventilation by changing space configurations and cooking locations should be encouraged, especially in poor areas.

Indonesia has the lowest use of solid fuel among the five countries studied. The country has also seen the greatest reduction in use over time, with use decreasing by more than half in the past decade. More than three-quarters of the households used clean fuel for cooking in 2016. The government of Indonesia's substantial investment in national energy subsidy programs has contributed to these improvements (Pertamina and World LP Gas Association 2015). Indonesia has been particularly successful in transitioning to clean household fuels including LPG, biogas, and electricity (Gardiner 2019). Between 2007 and 2012, the country successfully implemented a massive project to convert the primary fuel for cooking from kerosene to LPG in more than 50 million households (Budya and Arofat 2011; Pertamina and World LP Gas Association 2015). The success of this project may have contributed to the significant increases in use of clean fuel for cooking observed between 2007 and 2012 in this analysis. Despite all these improvements and the low use of solid fuel on average, individuals in the poorest households still suffer from high exposure to HAP today. The use of LPG was found to be strongly associated with household income (Thoday et al. 2018). Target subsidies for low-income families should be considered.

India has a wide range of use of solid fuel for cooking across its districts. Solid fuel is very common in districts in northeastern areas but relatively low in districts in the south and north. India had the largest number of deaths due to illness caused by use of solid fuel in 2017 (Ritchie and Roser 2019). Since early 1980, the government of India has implemented several interventions to reduce HAP, including the widespread promotion and distribution of improved cooking stoves (Sinha 2002). However, due to various reasons including cultural factors, cost of maintenance, and poor design of the stoves, the uptake of improved cookstoves has remained low, especially in rural areas, and emissions from air pollutants have remained high (Khandelwal et al. 2017; Sinha 2002). The government recently implemented initiatives to introduce clean cooking to households by increasing access to LPG, improving stoves, and subsidizing fuel for poor households. Assessing the impact of these initiatives will be important for future policies and programs. Along with these initiatives, programs targeting other barriers such as a lack of awareness of the health risks of HAP are also warranted.

Nepal's overall level of HAP is high, with more than 80% of households in half of the country's districts using solid fuel for cooking. In contrast to trends in other countries, the use of solid fuel in urban areas appeared to have substantially increased in the most recent survey when compared with the two previous surveys. However, this increase is spurious and likely due to the use of different urban-rural classifications in the most recent DHS survey. Because many areas designated as rural in previous surveys were designated as urban in the 2016 DHS survey, comparisons between surveys by urban and rural place of residence should be interpreted with caution. As in other countries, households in low socioeconomic groups (the poorest wealth quintiles) are disproportionately affected by HAP, and the reduction over time was negligible. Previous research in Nepal has also shown that fuel choices and cooking practices are associated with household socioeconomic status (Ghimire et al. 2019). Given the limited access to clean fuel and limited subsidies from the government in Nepal, economic affordability plays a critical role in a household's access to clean fuel. Western districts have the highest levels of use. The government of Nepal has several policies and guidelines to reduce emissions from indoor open burning of biomass, including the National Indoor Air Quality Standard and Implementation Guidelines 2009, the Rural Renewable Energy Policy, and the National Rural Electrification Programme. The Alternative Energy Promotion Center has also headed a clean stove program aimed at promoting cleaner cooking fuels and clean cooking stoves. It has been noted that much more effort is needed. Specifically, prioritization of policies on biomass energy and incentivization for the use of improved cooking stoves are needed (Sigdel 2007).

The Philippines has made substantial improvements in the use of clean fuel, with about 50% of households using clean fuel for cooking. Despite limited government policies that promote the use of clean cooking technologies, clean cooking is associated with access to LPG, which has grown rapidly in the Philippines since the 1990s. Factors contributing to the increased utilization of LPG include competitive economics, improvements to product availability, and safety (SEforALL 2019; World Bank 2020). As in other countries, the use of solid fuel for cooking in the Philippines differs by place of residence, region, and wealth quintile. Although use has decreased in both urban and rural areas, the use of solid fuel in rural areas remains high, with more than 60% of households using it as their source for cooking. Regionally, the use of solid fuel increases from north to south with the lowest levels of use in the national capital. Variation across wealth quintiles is similar to that in other countries, with nearly all households in the lowest quintile but only about 5% of households in the highest quintile using solid fuel for cooking. These findings are in line with previous research showing higher use of solid fuel in lower income groups and a strong negative correlation between income and the use of dirty fuels (Arcenas et al. 2010). Studies conducted in the Philippines

examining the costs and benefits of switching to improved stoves, specifically improved wood stoves, have found that such a change would benefit health and save time (Arcenas et al. 2010).

Other countries have also seen a fair reduction in use of solid fuel given various interventions including the promotion and distribution of improved cooking stoves. Improved cooking stove interventions gained momentum alongside rising concerns about the depletion of natural forest resources, and they have successfully reduced indoor air pollution in certain contexts in several countries (Barnes 2005). However, some issues prevent sustainable use of improved stoves, including cultural factors, cost of maintenance, and poor design, especially in low-income settings (Amegah and Jaakkola 2016). For example, in India, despite a massive program, the uptake of improved cooking stoves remains low, especially in rural areas, and emissions from air pollutants are still high (Khandelwal et al. 2017; Sinha 2002). Important considerations for increasing uptake of improved cooking stoves include designs that meet the needs of the local context; effective marketing strategies; facilitation of local production or job creation, and assurance that user perceptions, community participation, and local energy policies are taken into account.

Similar to what previous research has shown, we found that households with low socioeconomic status are disproportionately affected by HAP and that the reduction in use of solid fuel has been much less among those households. In all five countries, while the reduction was the greatest among the relatively wealthy households (those in the third and fourth wealth quintiles), changes among the poorest households were minimal. Improved stoves and alternative types of fuel are not easily affordable for low-income households. Countries need low-cost interventions to reduce HAP. Some possibilities include tending fires (with smaller pieces of wood and reduced duration of burning), stove maintenance and use, ventilation use, and safer locations for children while fires are burning (Barnes 2005).

Interventions that promote increased ventilation to reduce fine particulate matter, the use of chimney stoves to reduce smoke exposure, and the separation of kitchens from living areas have been shown to reduce HAP and improve health outcomes (Mehta 2002; Thompson et al. 2011; Weaver et al. 2017). In addition to improved infrastructure and locally adapted solutions, behavioral change interventions focused on acceptability and use of clean cooking alternatives can help reduce the pollution from cooking (Naz, Page, and Agho 2018; Rhodes et al. 2014). Studies have also found that government efforts alone do not go far enough in reducing HAP; to implement effective interventions, coordination and support for affordable solutions is needed from both the government and the commercial sector (Zhang and Smith 2007).

An important contribution of this study is the estimation of use of solid fuel for cooking at the second subnational administrative level (district level). Except for the recent DHS survey in India, DHS data are only representative of the national and first administrative levels. District-level estimates, however, can be critical because interventions are often planned and implemented at the district level. To design more targeted programs to reduce HAP, it is imperative to understand geographic differences in level of exposure. The district-level estimates indicate wide geographic differentials in the use of solid fuel for cooking in the studied countries, especially in India and the Philippines. These estimates can assist policymakers in identifying districts that need interventions.

A limitation of this study is the cross-sectional nature of the data, which do not allow for reliable modeling of the association between HAP and child health outcomes such as low birth weight and ARI symptoms. For the study of low birth weight, we also did not know the duration of HAP exposure while a mother was

pregnant. ARI symptoms are only reported for the two weeks before the survey and cannot capture the possible chronic association between ARI and HAP. Another limitation is the self-reporting of HAP. We cannot know whether solid fuel was the only source of cooking fuel or was used only at certain times or for specific food preparation. Households have been found to use more than one source of fuel for cooking in what is referred to as fuel stacking (Thoday et al. 2018). The concentration or level of pollution produced from solid fuels can vary over time within the same household. Future studies to examine the link between HAP and health outcomes, using different types of data, could be designed to avoid some of these methodological issues.

In conclusion, this report has shown that use of solid fuel in households has declined in every country included in the analysis. The declines may reflect a combination of successful interventions and improvements is socioeconomic status. Analysis by household characteristics has shown that disparities still exist, and interventions that target rural and poor households can potentially further decrease HAP. It is imperative that interventions be tailored for different socioeconomic levels. The district-level analysis can further pinpoint the locations where these interventions are most needed.

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APPENDIX A USE OF SOLID FUEL FOR COOKING AND DISTRICT-LEVEL HAP ESTIMATES

Appendix Table A.1 Levels and changes in the use of solid fuel for cooking by household background characteristics, Bangladesh

	2007		2011		Diff.[2] 2011-2007	2014		Diff.[2] 2014-2011	Diff.[2] 2014-2007
Variable	% [C.I.]	p[1]	% [C.I.]	p[1]		% [C.I.]	p[1]		
Total	91.1 [89.4,92.5]		86.3 [84.7,87.7]		-4.8***	82.3 [79.5,84.8]		-4.0**	-8.8***
Place of residence		***		***			***		
Urban	61.5 [54.5,68.1]		50.4 [44.8,56.0]		-11.1*	50.0 [44.1,56.0]		-.4	-11.5*
Rural	99.4 [98.8,99.7]		98.4 [97.5,98.9]		-1.0**	94.9 [91.8,96.9]		-3.5***	-4.5***
Wealth quintile		***		***			***		
Lowest	100.0 [..0,..0]		99.3 [98.4,99.7]		-.7	99.8 [99.4,99.9]		.5	-.2
Second	99.9 [99.6,100.0]		99.6 [99.1,99.8]		-.3	99.7 [99.5,99.9]		.1	-.2
Middle	99.7 [99.3,99.9]		98.9 [97.9,99.4]		-.8*	97.8 [96.6,98.7]		-1.0	-1.9***
Fourth	97.5 [96.0,98.5]		88.2 [85.6,90.5]		-9.3***	79.3 [73.8,83.9]		-8.9***	-18.2***
Highest	55.9 [49.7,61.9]		42.9 [38.6,47.2]		-13.0***	34.4 [30.2,38.9]		-8.5**	-21.5***
Crowding									
No	91.1 [89.2,92.6]		86.3 [84.7,87.7]		-4.8***	82.7 [80.0,85.2]		-3.5*	-8.3***
Yes	91.3 [88.4,93.5]		86.5 [83.7,88.9]		-4.8*	80.5 [75.9,84.4]		-6.0*	-10.8***
Region		***		***			***		
Barisal	98.2 [95.5,99.3]		98.4 [97.5,99.0]		.2	95.5 [89.8,98.1]		-3.0*	-2.8
Chittagong	89.8 [85.5,92.9]		86.7 [82.9,89.7]		-3.1	82.0 [74.8,87.5]		-4.7	-7.8*
Dhaka	80.4 [75.5,84.4]		71.0 [66.7,74.9]		-9.4**	65.0 [57.0,72.3]		-6.0	-15.4***
Khulna	98.7 [97.7,99.2]		97.4 [95.6,98.4]		-1.3	95.4 [93.7,96.7]		-1.9	-3.2***
Rajshahi/Rangpur	98.2 [97.1,98.9]		96.8 [95.3,97.8]		-1.4	96.2 [94.6,97.4]		-.5	-2.0*
Sylhet	96.2 [93.1,97.9]		88.0 [84.0,91.0]		-8.3***	91.5 [87.7,94.3]		3.6	-4.7*

Notes: *p<0.05, **p<0.01, ***p<0.001

[1] p-value significance of the covariate in each survey

[2] Difference between the two surveys with the p-value of the difference

Appendix Table A.2 Levels and changes in the use of solid fuel for cooking by household background characteristics, India

Variable	2005-06 % [C.I.]	p[1]	2015-16 % [C.I.]	p[1]	Diff.[2] 2015-16-2005-06
Total	70.8 [69.8,71.8]		54.7 [54.3,55.1]		-16.1***
Place of residence		***		***	
Urban	30.9 [28.7,33.1]		16.4 [15.9,17.0]		-14.5***
Rural	90.2 [89.4,90.9]		75.2 [74.9,75.5]		-15.0***
Wealth quintile		***		***	
Lowest	99.8 [99.7,99.8]		98.3 [98.2,98.4]		-1.4***
Second	98.5 [98.2,98.7]		89.6 [89.2,90.0]		-8.9***
Middle	90.4 [89.6,91.2]		58.2 [57.6,58.9]		-32.2***
Fourth	54.2 [52.6,55.9]		22.2 [21.8,22.7]		-32.0***
Highest	10.6 [9.9,11.4]		5.5 [5.3,5.7]		-5.2***
Crowding		***		***	
No	66.4 [65.3,67.5]		50.7 [50.3,51.1]		-15.7***
Yes	78.2 [77.1,79.3]		64.5 [63.9,65.1]		-13.7***
Region		***		***	
North	63.0 [61.0,64.9]		47.8 [46.8,48.8]		-15.2***
Central	81.8 [79.6,83.9]		68.6 [68.0,69.1]		-13.2***
East	85.4 [83.7,87.0]		76.9 [76.1,77.6]		-8.5***
Northeast	73.9 [70.5,77.1]		69.9 [69.0,70.8]		-4.0*
West	49.4 [46.2,52.6]		38.4 [37.4,39.5]		-10.9***
South	64.6 [62.3,66.9]		34.1 [33.4,34.8]		-30.5***

Notes: *p<0.05, **p<0.01, ***p<0.001
[1] p-value significance of the covariate in each survey
[2] Difference between the two surveys with the p-value of the difference

Appendix Table A.3 Levels and changes in the use of solid fuel for cooking by household background characteristics, Indonesia

Variable	2007 % [C.I.]	p[1]	2012 % [C.I.]	p[1]	Diff.[2] 2012-2007	2017 % [C.I.]	p[1]	Diff.[2] 2017-2012	Diff.[2] 2017-2007
Total	54.0 [52.2,55.9]		38.1 [36.5,39.6]		-16.0***	23.1 [22.1,24.3]		-14.9***	-30.9***
Place of residence		***		***			***		
Urban	22.0 [19.1,25.1]		15.6 [13.6,17.8]		-6.4***	7.6 [6.7,8.5]		-8.0***	-14.4***
Rural	76.8 [74.6,78.8]		59.6 [57.4,61.9]		-17.1***	38.0 [36.1,40.0]		-21.6***	-38.7***
Wealth quintile		***		***			***		
Lowest	97.0 [96.4,97.5]		85.6 [84.2,86.8]		-11.4***	70.4 [68.7,72.0]		-15.2***	-26.6***
Second	81.9 [80.1,83.6]		56.2 [53.9,58.5]		-25.7***	27.0 [25.3,28.8]		-29.2***	-54.9***
Middle	60.0 [57.3,62.6]		29.1 [26.9,31.3]		-30.9***	8.0 [7.1,9.0]		-21.1***	-52.0***
Fourth	23.8 [21.2,26.6]		9.0 [7.8,10.4]		-14.7***	1.6 [1.3,2.0]		-7.4***	-22.2***
Highest	.8 [0.5,1.3]		.9 [0.6,1.3]		.1	.2 [0.1,0.3]		-.7***	-.7***
Crowding				***					
No	NA		37.5 [36.0,39.1]			23.1 [22.0,24.2]		-14.5***	
Yes	NA		42.7 [40.2,45.3]			23.8 [21.7,25.9]		-19.0***	
Region		***		***			***		
Sumatera	54.5 [51.7,57.2]		38.1 [35.9,40.3]		-16.4***	19.1 [17.3,21.0]		-19.0***	-35.4***
Java	51.5 [48.7,54.3]		34.0 [31.7,36.4]		-17.5***	21.2 [19.6,22.9]		-12.8***	-30.3***
Bali/Nusa Tenggara	64.5 [59.8,68.9]		59.1 [55.1,62.9]		-5.4	42.1 [38.3,45.9]		-17.0***	-22.4***
Kalimantan	53.5 [49.3,57.7]		37.9 [34.7,41.1]		-15.7***	19.1 [16.0,22.7]		-18.8***	-34.4***
Sulawesi	64.5 [61.4,67.6]		48.7 [45.5,51.9]		-15.8***	29.7 [26.8,32.7]		-19.0***	-34.9***
Maluku/Papua	65.3 [59.8,70.4]		63.0 [59.1,66.8]		-2.3	54.4 [48.3,60.3]		-8.7*	-10.9**

Notes: *p<0.05, **p<0.01, ***p<0.001
[1] p-value significance of the covariate in each survey
[2] Difference between the two surveys with the p-value of the difference
NA = Not available

Appendix Table A.4 Levels and changes in the use of solid fuel for cooking by household background characteristics, Nepal

Variable	2006 % [C.I.]	p[1]	2011 % [C.I.]	p[1]	Diff.[2] 2011-2006	2016 % [C.I.]	p[1]	Diff.[2] 2016-2011	Diff.[2] 2016-2006
Total	83.3 [78.5,87.2]		75.1 [71.3,78.5]		-8.2**	65.7 [62.4,68.9]		-9.4***	-17.6***
Place of residence		***		***			***		
Urban	39.1 [32.0,46.7]		29.3 [25.8,33.1]		-9.7*	51.8 [47.4,56.3]		22.5***	12.8**
Rural	92.3 [87.3,95.4]		82.7 [78.6,86.2]		-9.6**	87.8 [83.6,91.0]		5.0	-4.5
Wealth quintile		***		***			***		
Lowest	100.0		99.7 [99.1,99.9]		-.3	99.5 [98.8,99.8]		-.2	-.5
Second	100.0		99.4 [98.9,99.7]		-.6***	96.0 [94.7,97.0]		-3.4***	-4.0
Middle	99.2 [98.1,99.7]		97.2 [95.9,98.1]		-2.0*	85.5 [82.8,87.8]		-11.7***	-13.7***
Fourth	93.8 [90.8,95.9]		71.2 [67.2,74.9]		-22.6***	44.9 [40.9,49.1]		-26.3***	-48.9***
Highest	31.2 [25.0,38.3]		16.4 [13.6,19.6]		-14.9***	5.4 [4.3,6.8]		-11.0***	-25.8***
Crowding		***		***			***		
No	81.3 [76.3,85.5]		73.0 [69.1,76.6]		-8.3**	63.8 [60.4,67.1]		-9.2***	-17.5***
Yes	89.0 [84.4,92.3]		84.8 [80.7,88.1]		-4.2	78.2 [74.4,81.6]		-6.6*	-10.7***
Region		***		**			***		
Eastern	91.0 [84.9,94.8]		75.7 [67.7,82.3]		-15.3**	75.4 [68.9,81.0]		-.3	-15.6***
Central	72.5 [61.1,81.6]		67.4 [59.0,74.8]		-5.1	53.8 [47.6,59.9]		-13.6**	-18.7**
Western	80.8 [69.5,88.6]		74.0 [65.2,81.2]		-6.9	59.8 [52.9,66.3]		-14.2*	-21.0**
Mid-Western	94.2 [89.0,97.0]		85.8 [77.9,91.1]		-8.5*	80.2 [73.6,85.4]		-5.6	-14.0***
Far-Western	94.4 [91.9,96.2]		91.5 [87.8,94.1]		-3.0	82.9 [74.5,88.9]		-8.6*	-11.5***

Notes: *p<0.05, **p<0.01, ***p<0.001
[1] p-value significance of the covariate in each survey
[2] Difference between the two surveys with the p-value of the difference

Appendix Table A.5 Levels and changes in the use of solid fuel for cooking by household background characteristics, the Philippines

Variable	2008 % [C.I.]	p[1]	2013 % [C.I.]	p[1]	Diff.[2] 2013-2008	2017 % [C.I.]	p[1]	Diff.[2] 2017-2013	Diff.[2] 2017-2008
Total	64.2 [62.2,66.1]		60.8 [59.3,62.2]		-3.4**	47.7 [45.1,50.3]		-13.1***	-16.5***
Place of residence		***		***			***		
Urban	43.1 [40.4,45.8]		38.7 [36.6,41.0]		-4.3*	25.1 [22.3,28.0]		-13.7***	-18.0***
Rural	85.6 [83.6,87.3]		81.1 [79.1,82.9]		-4.5***	67.1 [63.4,70.6]		-14.0***	-18.5***
Wealth quintile		***		***			***		
Lowest	99.5 [99.2,99.7]		99.3 [98.9,99.6]		-.2	97.5 [96.7,98.2]		-1.8***	-2.0***
Second	94.4 [93.1,95.4]		93.5 [92.4,94.4]		-.8	78.3 [68.7,85.6]		-15.2***	-16.0***
Middle	77.3 [74.6,79.8]		73.5 [71.2,75.7]		-3.8*	44.2 [41.5,47.0]		-29.3***	-33.1***
Fourth	40.1 [37.4,42.9]		33.0 [30.9,35.2]		-7.1***	13.7 [12.2,15.4]		-19.3***	-26.4***
Highest	8.3 [7.0,9.8]		7.1 [6.1,8.3]		-1.2	2.7 [2.1,3.3]		-4.4***	-5.7***
Crowding		***		***			***		
No	60.1 [58.1,62.2]		57.0 [55.4,58.6]		-3.1*	44.5 [41.8,47.3]		-12.5***	-15.6***
Yes	75.6 [73.0,78.0]		71.7 [69.3,73.9]		-3.9*	59.7 [56.7,62.7]		-12.0***	-15.9***
Region		***		***			***		
Luzon	68.4 [65.6,71.2]		54.9 [52.3,57.5]		-13.6***	39.1 [35.9,42.3]		-15.8***	-29.4***
National Capital	16.9 [13.5,20.8]		12.7 [9.9,16.2]		-4.1	3.0 [1.9,4.8]		-9.7***	-13.8***
Visayas	84.2 [81.7,86.3]		82.1 [78.8,84.9]		-2.1	71.0 [66.8,74.8]		-11.1***	-13.2***
Mindanao	85.3 [82.7,87.6]		85.9 [83.8,87.8]		.6	74.2 [64.0,82.4]		-11.7**	-11.1**

Notes: *p<0.05, **p<0.01, ***p<0.001
[1] p-value significance of the covariate in each survey
[2] Difference between the two surveys with the p-value of the difference

Appendix Table A.6 District-level estimates of household use of solid fuel for cooking, Bangladesh DHS 2014

District ID	District name	Estimate	Lower	Upper
1	Barguna	99.6%	97.6%	100.0%
2	Barisal	95.8%	92.9%	97.5%
3	Bhola	95.1%	89.3%	97.7%
4	Jhalokati	97.3%	94.5%	98.7%
5	Patuakhali	97.7%	93.4%	99.4%
6	Pirojpur	99.1%	97.1%	99.8%
7	Bandarban	99.6%	97.7%	100.0%
8	Brahamanbaria	88.5%	81.7%	93.1%
9	Chandpur	87.4%	81.1%	92.2%
10	Chittagong	77.2%	72.2%	80.9%
11	Comilla	88.3%	82.4%	92.7%
12	Cox's Bazar	98.7%	93.2%	99.9%
13	Feni	92.0%	86.4%	95.4%
14	Khagrachhari	99.4%	97.2%	100.0%
15	Lakshmipur	94.2%	86.6%	97.6%
16	Noakhali	74.3%	58.6%	83.2%
17	Rangamati	99.2%	97.2%	99.8%
18	Dhaka	15.4%	12.9%	17.9%
19	Faridpur	79.8%	62.4%	92.8%
20	Gazipur	62.3%	54.7%	68.0%
21	Gopalganj	99.1%	96.2%	99.9%
22	Jamalpur	98.2%	94.2%	99.6%
23	Kishoreganj	95.7%	88.7%	98.4%
24	Madaripur	97.2%	91.7%	99.5%
25	Manikganj	80.5%	71.6%	87.4%
26	Munshiganj	88.6%	84.9%	91.4%
27	Mymensingh	93.7%	85.8%	97.1%
28	Narayanganj	22.8%	18.2%	27.8%
29	Narsingdi	49.7%	41.1%	56.8%
30	Netrakona	98.7%	91.4%	100.0%
31	Rajbari	98.9%	96.7%	99.7%
32	Shariatpur	96.7%	91.7%	99.0%
33	Sherpur	95.5%	89.1%	98.2%
34	Tangail	96.9%	91.3%	99.2%
35	Bagerhat	98.5%	96.2%	99.5%
36	Chuadanga	96.2%	91.9%	98.4%
37	Jessore	97.2%	93.3%	99.0%
38	Jhenaidah	97.0%	93.7%	98.7%
39	Khulna	91.8%	87.7%	94.6%
40	Kushtia	94.6%	90.2%	97.1%
41	Magura	94.6%	90.3%	97.4%
42	Meherpur	95.4%	90.4%	98.1%
43	Narail	99.3%	98.2%	99.8%
44	Satkhira	96.9%	88.7%	99.4%
45	Bogra	92.7%	88.2%	95.7%
46	Dinajpur	97.0%	93.1%	98.9%
47	Gaibandha	96.9%	93.7%	98.7%
48	Joypurhat	98.4%	96.3%	99.5%
49	Kurigram	98.0%	94.4%	99.4%
50	Lalmonirhat	98.8%	95.4%	99.8%
51	Naogaon	97.4%	92.9%	99.2%
52	Natore	97.1%	93.7%	98.9%
53	Nawabganj	98.5%	93.1%	99.9%
54	Nilphamari	96.9%	94.2%	98.5%
55	Pabna	93.6%	89.6%	96.2%
56	Panchagarh	97.8%	94.2%	99.3%
57	Rajshahi	92.8%	89.3%	95.3%
58	Rangpur	94.8%	91.1%	97.2%
59	Sirajganj	92.2%	87.2%	95.6%
60	Thakurgaon	98.8%	96.1%	99.8%
61	Habiganj	90.0%	84.0%	94.8%
62	Maulvibazar	94.1%	88.9%	97.0%
63	Sunamganj	98.1%	95.4%	99.1%
64	Sylhet	90.5%	85.1%	93.7%

Appendix Table A.7 District-level estimates of household use of solid fuel for cooking, India DHS 2015-2016

District ID	District name	Estimate	Lower	Upper
1	Kupwara	50.9%	42.6%	59.2%
2	Badgam	37.8%	28.5%	48.1%
3	Leh	10.9%	7.0%	16.5%
4	Kargil	55.1%	44.7%	65.1%
5	Punch	77.5%	70.8%	83.0%
6	Rajouri	67.1%	57.1%	75.8%
7	Kathua	59.2%	50.5%	67.3%
8	Baramula	27.6%	21.6%	34.7%
9	Bandipore	43.6%	34.2%	53.6%
10	Srinagar	2.1%	0.7%	6.4%
11	Ganderbal	31.4%	22.4%	42.0%
12	Pulwama	21.1%	14.6%	29.5%
13	Shupiyan	56.2%	47.9%	64.3%
14	Anantnag	29.5%	20.8%	40.0%
15	Kulgam	49.2%	42.7%	55.7%
16	Doda	83.8%	76.5%	89.1%
17	Ramban	79.7%	73.4%	84.8%
18	Kishtwar	72.9%	63.1%	80.9%
19	Udhampur	72.5%	63.7%	79.9%
20	Reasi	82.6%	74.8%	88.3%
21	Jammu	25.0%	18.9%	32.4%
22	Samba	49.8%	40.7%	58.8%
23	Chamba	73.9%	65.9%	80.5%
24	Kangra	64.9%	58.2%	71.0%
25	Lahul And Spiti	38.6%	30.6%	47.3%
26	Kullu	61.1%	52.1%	69.4%
27	Mandi	75.7%	68.4%	81.8%
28	Hamirpur	75.4%	70.9%	79.5%
29	Una	67.4%	61.5%	72.8%
30	Bilaspur	80.4%	75.5%	84.6%
31	Solan	47.6%	39.8%	55.5%
32	Sirmaur	60.8%	52.6%	68.5%
33	Shimla	32.0%	25.5%	39.4%
34	Kinnaur	31.1%	25.3%	37.6%
35	Gurdaspur	29.6%	24.6%	35.3%
36	Kapurthala	22.3%	16.5%	29.5%
37	Jalandhar	20.9%	15.9%	27.0%
38	Hoshiarpur	37.1%	31.2%	43.5%
39	Sangrur	44.4%	38.6%	50.4%
40	Fatehgarh Sahib	29.3%	24.3%	34.8%
41	Ludhiana	21.4%	17.4%	26.0%
42	Moga	44.4%	40.0%	48.9%
43	Firozpur	50.1%	42.9%	57.2%
44	Muktsar	40.2%	34.9%	45.7%
45	Faridkot	34.7%	29.0%	40.9%
46	Bathinda	37.1%	30.7%	43.9%
47	Mansa	59.1%	52.8%	65.1%
48	Patiala	31.0%	25.1%	37.6%
49	Amritsar	26.6%	21.6%	32.3%
50	Tarn Taran	44.6%	39.4%	50.0%
51	Rupnagar	32.3%	27.1%	37.9%
52	Sahibzada Ajit Singh Nagar	18.5%	14.2%	23.8%
53	Shahid Bhagat Singh Nagar	47.8%	42.0%	53.7%
54	Barnala	45.5%	40.8%	50.4%
55	Chandigarh	4.1%	1.8%	9.0%
56	Uttarkashi	71.7%	64.8%	77.7%
57	Chamoli	63.3%	56.2%	69.8%
58	Rudraprayag	67.0%	59.7%	73.5%
59	Tehri Garhwal	64.6%	54.1%	73.8%
60	Dehradun	13.9%	10.1%	18.8%
61	Garhwal	64.3%	57.1%	70.9%
62	Pithoragarh	62.5%	55.5%	69.0%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
63	Bageshwar	76.4%	66.7%	83.9%
64	Almora	69.7%	61.2%	77.0%
65	Champawat	69.5%	61.6%	76.3%
66	Nainital	36.6%	30.4%	43.3%
67	Udham Singh Nagar	46.8%	41.3%	52.4%
68	Hardwar	53.1%	47.8%	58.4%
69	Panchkula	22.0%	15.7%	29.9%
70	Ambala	32.0%	25.8%	38.9%
71	Yamunanagar	38.0%	32.5%	43.9%
72	Kurukshetra	40.4%	34.2%	46.9%
73	Kaithal	58.5%	50.4%	66.2%
74	Karnal	45.3%	36.6%	54.3%
75	Panipat	36.2%	30.1%	42.8%
76	Sonipat	51.6%	45.0%	58.2%
77	Jind	63.2%	57.0%	69.0%
78	Fatehabad	60.8%	53.6%	67.6%
79	Sirsa	58.1%	53.1%	63.0%
80	Hisar	60.8%	56.2%	65.2%
81	Bhiwani	66.3%	58.9%	73.0%
82	Rohtak	54.2%	48.1%	60.2%
83	Jhajjar	55.8%	48.9%	62.4%
84	Mahendragarh	66.4%	59.5%	72.6%
85	Rewari	60.8%	55.0%	66.3%
86	Gurgaon	17.0%	13.2%	21.6%
87	Mewat	82.6%	70.3%	90.5%
88	Faridabad	15.9%	10.6%	23.2%
89	Palwal	69.1%	62.6%	75.0%
90	North West	2.8%	1.2%	6.4%
91	North	0.7%	0.1%	5.2%
92	North East	0.8%	0.4%	1.8%
93	East	0.6%	0.2%	1.6%
94	New Delhi	4.5%	1.6%	12.3%
95	Central	0.5%	0.1%	3.3%
96	West	0.5%	0.1%	1.5%
97	South West	1.5%	0.4%	5.5%
98	South	2.7%	0.9%	7.5%
99	Ganganagar	60.1%	54.4%	65.6%
100	Hanumangarh	74.9%	70.6%	78.7%
101	Bikaner	60.3%	57.1%	63.4%
102	Churu	69.5%	65.7%	73.0%
103	Jhunjhunun	48.9%	42.6%	55.1%
104	Alwar	76.0%	71.5%	79.9%
105	Bharatpur	83.6%	76.8%	88.7%
106	Dhaulpur	78.6%	71.3%	84.4%
107	Karauli	85.3%	81.2%	88.7%
108	Sawai Madhopur	81.9%	76.9%	85.9%
109	Dausa	83.2%	77.9%	87.5%
110	Jaipur	44.7%	40.5%	49.0%
111	Sikar	56.9%	52.2%	61.5%
112	Nagaur	75.6%	69.7%	80.7%
113	Jodhpur	54.8%	51.0%	58.5%
114	Jaisalmer	82.6%	77.6%	86.6%
115	Barmer	85.2%	79.6%	89.4%
116	Jalor	73.0%	66.9%	78.3%
117	Sirohi	59.2%	50.9%	67.1%
118	Pali	58.4%	52.5%	64.0%
119	Ajmer	49.0%	45.3%	52.7%
120	Tonk	78.2%	74.2%	81.8%
121	Bundi	76.9%	71.9%	81.4%
122	Bhilwara	72.3%	67.2%	76.8%
123	Rajsamand	74.3%	69.2%	78.8%
124	Dungarpur	82.8%	77.1%	87.4%
125	Banswara	87.3%	82.7%	90.8%
126	Chittaurgarh	73.9%	68.5%	78.7%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
127	Kota	38.7%	34.1%	43.5%
128	Baran	74.7%	68.7%	80.0%
129	Jhalawar	74.2%	69.3%	78.6%
130	Udaipur	74.8%	70.6%	78.5%
131	Pratapgarh	85.9%	80.3%	90.0%
132	Saharanpur	61.5%	57.4%	65.5%
133	Muzaffarnagar	60.1%	54.0%	65.9%
134	Bijnor	65.9%	60.6%	70.9%
135	Moradabad	55.0%	50.6%	59.4%
136	Rampur	67.7%	62.0%	72.9%
137	Jyotiba Phule Nagar	68.3%	61.3%	74.5%
138	Meerut	34.8%	29.1%	40.9%
139	Baghpat	57.1%	47.3%	66.5%
140	Ghaziabad	20.7%	17.0%	24.9%
141	Gautam Buddha Nagar	23.2%	18.4%	28.8%
142	Bulandshahr	67.4%	61.5%	72.7%
143	Aligarh	59.7%	55.5%	63.8%
144	Mahamaya Nagar	69.3%	64.2%	73.9%
145	Mathura	66.6%	58.7%	73.7%
146	Agra	52.8%	46.9%	58.5%
147	Firozabad	63.1%	60.2%	65.8%
148	Mainpuri	75.1%	70.4%	79.3%
149	Budaun	77.1%	73.4%	80.4%
150	Bareilly	55.6%	51.7%	59.4%
151	Pilibhit	71.3%	66.1%	76.0%
152	Shahjahanpur	73.9%	68.4%	78.7%
153	Kheri	83.4%	78.2%	87.5%
154	Sitapur	80.8%	75.4%	85.2%
155	Hardoi	76.7%	66.6%	84.4%
156	Unnao	76.4%	71.9%	80.4%
157	Lucknow	23.1%	19.9%	26.7%
158	Rae Bareli	76.8%	71.8%	81.0%
159	Farrukhabad	74.8%	68.4%	80.3%
160	Kannauj	80.2%	74.1%	85.1%
161	Etawah	72.2%	66.8%	76.9%
162	Auraiya	72.4%	66.1%	77.8%
163	Kanpur Dehat	82.3%	78.2%	85.7%
164	Kanpur Nagar	28.2%	24.6%	32.1%
165	Jalaun	66.4%	61.2%	71.3%
166	Jhansi	58.6%	54.5%	62.6%
167	Lalitpur	81.7%	75.1%	86.9%
168	Hamirpur	80.3%	75.5%	84.3%
169	Mahoba	83.3%	77.8%	87.6%
170	Banda	84.7%	78.9%	89.1%
171	Chitrakoot	88.3%	83.8%	91.7%
172	Fatehpur	82.2%	78.2%	85.5%
173	Pratapgarh	75.9%	70.1%	80.8%
174	Kaushambi	81.3%	76.6%	85.2%
175	Allahabad	62.3%	54.6%	69.5%
176	Bara Banki	71.8%	67.3%	75.8%
177	Faizabad	75.0%	70.8%	78.7%
178	Ambedkar Nagar	85.1%	80.3%	88.9%
179	Sultanpur	83.2%	78.1%	87.3%
180	Bahraich	84.7%	79.4%	88.8%
181	Shrawasti	90.6%	88.2%	92.6%
182	Balrampur	90.0%	85.9%	93.0%
183	Gonda	79.8%	74.7%	84.0%
184	Siddharth Nagar	79.3%	73.8%	83.9%
185	Basti	80.1%	75.4%	84.1%
186	Sant Kabir Nagar	81.5%	75.9%	86.1%
187	Mahrajganj	81.3%	76.1%	85.5%
188	Gorakhpur	59.5%	53.8%	64.9%
189	Kushinagar	75.8%	70.5%	80.4%
190	Deoria	66.9%	58.5%	74.3%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
191	Azamgarh	75.3%	68.0%	81.3%
192	Mau	77.1%	71.4%	82.0%
193	Ballia	75.3%	70.3%	79.7%
194	Jaunpur	78.1%	73.7%	81.9%
195	Ghazipur	82.8%	77.9%	86.8%
196	Chandauli	77.6%	73.2%	81.4%
197	Varanasi	49.7%	45.1%	54.3%
198	Sant Ravidas Nagar (Bhadohi)	73.6%	66.9%	79.4%
199	Mirzapur	81.9%	76.6%	86.2%
200	Sonbhadra	79.4%	74.8%	83.4%
201	Etah	75.4%	69.6%	80.4%
202	Kanshiram Nagar	80.9%	77.0%	84.2%
203	Pashchim Champaran	81.7%	74.2%	87.4%
204	Purba Champaran	85.3%	81.2%	88.6%
205	Sheohar	88.6%	85.8%	90.9%
206	Sitamarhi	87.2%	82.4%	90.9%
207	Madhubani	87.5%	83.0%	90.9%
208	Supaul	93.9%	90.4%	96.1%
209	Araria	94.8%	90.5%	97.2%
210	Kishanganj	94.0%	89.7%	96.6%
211	Purnia	91.4%	84.6%	95.3%
212	Katihar	89.9%	85.5%	93.0%
213	Madhepura	90.9%	88.6%	92.8%
214	Saharsa	86.6%	80.1%	91.2%
215	Darbhanga	81.5%	76.4%	85.7%
216	Muzaffarpur	77.7%	72.2%	82.4%
217	Gopalganj	79.1%	73.6%	83.7%
218	Siwan	77.5%	72.7%	81.6%
219	Saran	81.9%	77.8%	85.3%
220	Vaishali	79.0%	74.0%	83.3%
221	Samastipur	85.6%	82.1%	88.5%
222	Begusarai	83.4%	77.3%	88.1%
223	Khagaria	86.5%	81.1%	90.5%
224	Bhagalpur	76.4%	71.1%	81.1%
225	Banka	90.7%	86.1%	93.9%
226	Munger	73.4%	67.8%	78.3%
227	Lakhisarai	85.0%	79.9%	88.9%
228	Sheikhpura	83.1%	79.9%	85.9%
229	Nalanda	75.8%	70.9%	80.0%
230	Patna	47.8%	42.3%	53.4%
231	Bhojpur	78.9%	73.4%	83.5%
232	Buxar	76.4%	70.1%	81.7%
233	Kaimur (Bhabua)	85.9%	82.0%	89.1%
234	Rohtas	81.9%	77.5%	85.6%
235	Aurangabad	83.3%	78.0%	87.5%
236	Gaya	84.3%	77.3%	89.4%
237	Nawada	78.5%	72.8%	83.3%
238	Jamui	90.5%	87.4%	92.9%
239	Jehanabad	79.8%	74.7%	84.1%
240	Arwal	89.8%	85.7%	92.8%
241	North District	49.5%	43.3%	55.7%
242	West District	58.4%	51.0%	65.4%
243	South District	46.8%	39.9%	53.8%
244	East District	26.5%	23.2%	30.0%
245	Tawang	53.8%	43.3%	63.9%
246	West Kameng	39.6%	34.0%	45.5%
247	East Kameng	63.0%	57.6%	68.1%
248	Papumpare	14.3%	11.0%	18.4%
249	Upper Subansiri	61.5%	52.0%	70.1%
250	West Siang	50.2%	41.6%	58.7%
251	East Siang	54.9%	45.9%	63.6%
252	Upper Siang	77.6%	72.7%	81.9%
253	Changlang	73.2%	64.4%	80.5%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
254	Tirap	78.8%	72.2%	84.2%
255	Lower Subansiri	35.4%	29.5%	41.7%
256	Kurung Kumey	60.5%	51.9%	68.5%
257	Dibang Valley	66.2%	56.8%	74.4%
258	Lower Dibang Valley	57.9%	50.8%	64.6%
259	Lohit	75.2%	68.2%	81.1%
260	Anjaw	74.8%	60.7%	85.1%
261	Mon	94.0%	89.3%	96.8%
262	Mokokchung	61.7%	56.8%	66.4%
263	Zunheboto	87.2%	82.7%	90.7%
264	Wokha	63.9%	57.9%	69.6%
265	Dimapur	31.6%	27.6%	35.9%
266	Phek	90.1%	86.8%	92.7%
267	Tuensang	90.6%	87.1%	93.2%
268	Longleng	95.2%	92.3%	97.0%
269	Kiphire	88.9%	84.7%	92.0%
270	Kohima	43.7%	38.8%	48.7%
271	Peren	83.1%	78.6%	86.8%
272	Senapati (Excluding 3 Sub-Divisions)	80.9%	74.3%	86.1%
273	Tamenglong	87.3%	79.7%	92.3%
274	Churachandpur	57.6%	47.8%	66.9%
275	Bishnupur	61.1%	56.3%	65.7%
276	Thoubal	62.8%	58.0%	67.4%
277	Imphal West	36.1%	31.0%	41.7%
278	Imphal East	49.3%	44.4%	54.3%
279	Ukhrul	89.1%	85.8%	91.6%
280	Chandel	82.5%	75.7%	87.7%
281	Mamit	58.5%	50.1%	66.5%
282	Kolasib	27.9%	23.3%	33.0%
283	Aizawl	11.7%	8.4%	16.0%
284	Champhai	44.7%	40.1%	49.3%
285	Serchhip	33.0%	29.1%	37.3%
286	Lunglei	45.0%	39.6%	50.5%
287	Lawngtlai	53.8%	45.8%	61.5%
288	Saiha	37.2%	33.1%	41.5%
289	West Tripura	50.9%	45.5%	56.3%
290	South Tripura	70.4%	64.7%	75.5%
291	Dhalai	76.9%	71.3%	81.6%
292	North Tripura	74.7%	69.7%	79.2%
293	West Garo Hills	82.3%	75.3%	87.6%
294	East Garo Hills	92.9%	86.2%	96.5%
295	South Garo Hills	89.9%	84.3%	93.7%
296	West Khasi Hills	92.7%	88.6%	95.4%
297	Ribhoi	88.3%	81.0%	93.1%
298	East Khasi Hills	47.9%	43.2%	52.7%
299	Jaintia Hills	76.9%	70.9%	82.0%
300	Kokrajhar	81.5%	75.0%	86.7%
301	Dhubri	83.2%	79.4%	86.4%
302	Goalpara	78.7%	73.6%	83.1%
303	Barpeta	76.9%	70.0%	82.7%
304	Morigaon	81.7%	75.1%	86.9%
305	Nagaon	80.6%	74.0%	85.9%
306	Sonitpur	76.7%	70.6%	82.0%
307	Lakhimpur	80.8%	73.6%	86.4%
308	Dhemaji	88.8%	82.4%	93.1%
309	Tinsukia	71.1%	64.3%	77.0%
310	Dibrugarh	71.2%	65.4%	76.4%
311	Sivasagar	72.3%	65.6%	78.2%
312	Jorhat	65.0%	56.5%	72.6%
313	Golaghat	84.1%	80.2%	87.3%
314	Karbi Anglong	84.5%	77.8%	89.4%
315	Dima Hasao	72.9%	66.6%	78.3%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
316	Cachar	69.7%	63.2%	75.5%
317	Karimganj	76.9%	70.9%	82.0%
318	Hailakandi	86.1%	83.1%	88.6%
319	Bongaigaon	72.3%	64.9%	78.7%
320	Chirang	81.6%	74.1%	87.3%
321	Kamrup	61.2%	52.3%	69.4%
322	Kamrup Metropolitan	17.4%	12.1%	24.4%
323	Nalbari	64.4%	57.6%	70.7%
324	Baksa	83.4%	76.9%	88.3%
325	Darrang	81.8%	75.5%	86.7%
326	Udalguri	85.9%	81.8%	89.2%
327	Darjiling	43.1%	33.3%	53.4%
328	Jalpaiguri	70.7%	63.8%	76.7%
329	Koch Bihar	85.2%	81.0%	88.6%
330	Uttar Dinajpur	87.6%	81.3%	92.0%
331	Dakshin Dinajpur	87.1%	83.7%	89.9%
332	Maldah	83.5%	76.6%	88.7%
333	Murshidabad	80.0%	71.5%	86.5%
334	Birbhum	82.4%	74.5%	88.3%
335	Barddhaman	69.5%	62.4%	75.7%
336	Nadia	70.8%	63.8%	77.0%
337	North Twenty Four Parganas	46.2%	39.4%	53.0%
338	Hugli	66.7%	59.4%	73.3%
339	Bankura	83.1%	78.7%	86.7%
340	Puruliya	92.1%	88.7%	94.6%
341	Haora	51.0%	40.4%	61.5%
342	Kolkata	5.8%	2.5%	13.0%
343	South Twenty Four Parganas	77.2%	65.6%	85.8%
344	Paschim Medinipur	85.7%	79.4%	90.3%
345	Purba Medinipur	89.1%	84.4%	92.5%
346	Garhwa	94.1%	90.8%	96.3%
347	Chatra	89.2%	82.8%	93.4%
348	Kodarma	68.9%	60.8%	76.1%
349	Giridih	84.8%	79.2%	89.2%
350	Deoghar	79.1%	71.7%	84.9%
351	Godda	93.5%	91.1%	95.3%
352	Sahibganj	87.9%	81.6%	92.3%
353	Pakur	93.4%	88.6%	96.3%
354	Dhanbad	79.2%	73.6%	83.8%
355	Bokaro	73.1%	67.6%	77.9%
356	Lohardaga	84.8%	81.3%	87.8%
357	Purbi Singhbhum	58.3%	53.3%	63.1%
358	Palamu	83.7%	80.0%	86.8%
359	Latehar	94.8%	90.9%	97.1%
360	Hazaribagh	81.7%	75.1%	86.8%
361	Ramgarh	81.2%	76.9%	84.9%
362	Dumka	90.6%	87.2%	93.1%
363	Jamtara	95.8%	93.3%	97.4%
364	Ranchi	60.0%	55.8%	64.0%
365	Khunti	92.3%	87.7%	95.3%
366	Gumla	89.3%	85.3%	92.3%
367	Simdega	94.1%	91.1%	96.1%
368	Pashchimi Singhbhum	89.7%	86.7%	92.1%
369	Saraikela Kharsawan	74.2%	64.1%	82.3%
370	Bargarh	86.4%	82.9%	89.3%
371	Jharsuguda	70.9%	66.3%	75.1%
372	Sambalpur	74.1%	68.7%	78.9%
373	Debagarh	92.4%	89.6%	94.4%
374	Sundargarh	72.6%	68.4%	76.5%
375	Kendujhar	82.8%	74.1%	89.1%
376	Mayurbhanj	89.3%	86.6%	91.5%
377	Baleshwar	83.9%	79.5%	87.5%
378	Bhadrak	88.2%	82.7%	92.1%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
379	Kendrapara	85.5%	80.1%	89.6%
380	Jagatsinghapur	85.9%	81.5%	89.4%
381	Cuttack	64.9%	59.7%	69.8%
382	Jajapur	83.1%	78.9%	86.6%
383	Dhenkanal	78.6%	74.0%	82.5%
384	Anugul	78.1%	70.1%	84.4%
385	Nayagarh	77.4%	72.7%	81.5%
386	Khordha	51.6%	46.3%	56.9%
387	Puri	78.7%	73.0%	83.4%
388	Ganjam	65.0%	59.3%	70.3%
389	Gajapati	80.4%	74.7%	85.1%
390	Kandhamal	93.3%	88.0%	96.4%
391	Baudh	88.3%	82.5%	92.4%
392	Subarnapur	86.4%	82.0%	89.9%
393	Balangir	90.2%	87.4%	92.5%
394	Nuapada	91.2%	86.4%	94.4%
395	Kalahandi	92.7%	90.1%	94.6%
396	Rayagada	82.5%	76.8%	87.0%
397	Nabarangapur	90.3%	86.8%	93.0%
398	Koraput	80.3%	75.3%	84.5%
399	Malkangiri	94.1%	91.8%	95.8%
400	Korea (Koriya)	80.8%	77.2%	83.9%
401	Surguja	87.2%	83.2%	90.4%
402	Jashpur	91.8%	88.2%	94.4%
403	Raigarh	80.1%	75.9%	83.8%
404	Korba	72.4%	68.4%	76.1%
405	Janjgir - Champa	81.0%	74.2%	86.3%
406	Bilaspur	71.4%	64.1%	77.7%
407	Kabirdham	89.1%	84.6%	92.4%
408	Rajnandgaon	80.3%	72.9%	86.0%
409	Durg	63.0%	59.3%	66.5%
410	Raipur	64.7%	61.3%	67.9%
411	Mahasamund	86.7%	83.0%	89.8%
412	Dhamtari	78.6%	72.0%	84.0%
413	Uttar Bastar Kanker	84.7%	79.6%	88.6%
414	Bastar	88.4%	84.2%	91.6%
415	Narayanpur	87.9%	85.2%	90.2%
416	Dakshin Bastar Dantewada	83.0%	77.4%	87.5%
417	Bijapur	90.0%	86.4%	92.7%
418	Sheopur	86.1%	82.3%	89.1%
419	Morena	76.2%	68.1%	82.7%
420	Bhind	81.4%	76.4%	85.5%
421	Gwalior	41.4%	37.6%	45.3%
422	Datia	78.2%	74.4%	81.6%
423	Shivpuri	79.9%	77.5%	82.1%
424	Tikamgarh	85.3%	81.2%	88.6%
425	Chhatarpur	86.2%	80.4%	90.5%
426	Panna	88.6%	84.7%	91.6%
427	Sagar	82.0%	75.3%	87.2%
428	Damoh	86.1%	81.8%	89.5%
429	Satna	77.4%	72.4%	81.8%
430	Rewa	86.3%	80.6%	90.5%
431	Umaria	87.2%	78.2%	92.8%
432	Neemuch	64.8%	58.7%	70.5%
433	Mandsaur	70.4%	63.3%	76.6%
434	Ratlam	65.7%	57.7%	72.9%
435	Ujjain	52.4%	48.9%	55.9%
436	Shajapur	74.1%	69.5%	78.1%
437	Dewas	61.6%	55.4%	67.4%
438	Dhar	64.4%	56.1%	72.0%
439	Indore	14.4%	11.0%	18.6%
440	Khargone (West Nimar)	67.0%	60.3%	73.1%
441	Barwani	77.5%	70.0%	83.5%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
442	Rajgarh	81.2%	75.6%	85.8%
443	Vidisha	81.6%	74.6%	86.9%
444	Bhopal	22.1%	16.9%	28.3%
445	Sehore	74.7%	68.7%	79.8%
446	Raisen	72.9%	64.3%	80.0%
447	Betul	71.9%	64.8%	78.0%
448	Harda	68.7%	63.6%	73.4%
449	Hoshangabad	65.0%	60.9%	68.9%
450	Katni	80.9%	76.5%	84.7%
451	Jabalpur	49.8%	45.4%	54.2%
452	Narsimhapur	78.5%	69.6%	85.3%
453	Dindori	95.3%	93.3%	96.7%
454	Mandla	84.3%	80.3%	87.6%
455	Chhindwara	73.9%	67.1%	79.7%
456	Seoni	81.5%	75.1%	86.5%
457	Balaghat	82.9%	77.5%	87.2%
458	Guna	76.1%	71.8%	80.0%
459	Ashoknagar	84.1%	78.3%	88.6%
460	Shahdol	86.1%	81.7%	89.6%
461	Anuppur	81.3%	75.1%	86.2%
462	Sidhi	93.0%	86.8%	96.4%
463	Singrauli	82.6%	74.6%	88.4%
464	Jhabua	90.6%	84.8%	94.3%
465	Alirajpur	87.3%	81.7%	91.3%
466	Khandwa (East Nimar)	70.5%	64.6%	75.8%
467	Burhanpur	53.8%	49.3%	58.2%
468	Kachchh	56.7%	46.7%	66.3%
469	Banaskantha	69.6%	61.5%	76.7%
470	Patan	64.9%	57.9%	71.3%
471	Mahesana	41.0%	34.5%	47.8%
472	Sabarkantha	67.4%	57.8%	75.7%
473	Gandhinagar	44.3%	34.8%	54.2%
474	Ahmadabad	11.6%	8.5%	15.6%
475	Surendranagar	61.4%	52.9%	69.2%
476	Rajkot	31.5%	25.0%	38.8%
477	Jamnagar	38.3%	30.8%	46.4%
478	Porbandar	49.5%	42.9%	56.0%
479	Junagadh	50.2%	41.0%	59.2%
480	Amreli	46.2%	38.6%	54.0%
481	Bhavnagar	50.9%	44.0%	57.8%
482	Anand	54.0%	45.4%	62.4%
483	Kheda	68.7%	58.5%	77.4%
484	Panchmahal	73.4%	66.2%	79.6%
485	Dohad	84.2%	76.8%	89.6%
486	Vadodara	43.4%	36.6%	50.5%
487	Narmada	83.4%	72.7%	90.4%
488	Bharuch	46.1%	39.5%	52.9%
489	The Dangs	90.7%	86.9%	93.4%
490	Navsari	45.1%	38.3%	52.1%
491	Valsad	40.1%	30.9%	50.1%
492	Surat	14.2%	10.1%	19.7%
493	Tapi	76.7%	71.7%	81.0%
494	Diu	27.4%	21.8%	33.8%
495	Daman	3.2%	1.5%	6.7%
496	Dadra & Nagar Haveli	37.4%	32.4%	42.7%
497	Nandurbar	77.7%	69.0%	84.4%
498	Dhule	58.0%	51.8%	63.9%
499	Jalgaon	44.7%	38.6%	50.8%
500	Buldana	66.5%	61.2%	71.3%
501	Akola	55.3%	50.2%	60.2%
502	Washim	65.7%	59.4%	71.4%
503	Amravati	49.4%	41.1%	57.7%
504	Wardha	41.1%	35.6%	46.9%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
505	Nagpur	22.6%	17.1%	29.2%
506	Bhandara	52.1%	43.0%	61.1%
507	Gondiya	75.8%	70.1%	80.7%
508	Gadchiroli	77.5%	71.8%	82.4%
509	Chandrapur	52.2%	42.4%	61.7%
510	Yavatmal	62.4%	55.1%	69.3%
511	Nanded	66.9%	61.0%	72.3%
512	Hingoli	74.1%	67.9%	79.5%
513	Parbhani	72.8%	66.1%	78.7%
514	Jalna	77.4%	71.2%	82.5%
515	Aurangabad	42.4%	34.0%	51.4%
516	Nashik	29.0%	20.7%	38.9%
517	Thane	15.2%	12.1%	18.9%
518	Mumbai Suburban	2.2%	1.0%	4.4%
519	Mumbai	1.5%	0.2%	9.8%
520	Raigarh	21.2%	13.0%	32.5%
521	Pune	14.0%	9.7%	19.7%
522	Ahmadnagar	38.1%	31.6%	45.0%
523	Bid	70.7%	63.9%	76.6%
524	Latur	64.7%	58.6%	70.4%
525	Osmanabad	62.1%	55.5%	68.4%
526	Solapur	46.9%	42.2%	51.7%
527	Satara	41.3%	35.3%	47.5%
528	Ratnagiri	64.8%	56.1%	72.6%
529	Sindhudurg	60.4%	53.0%	67.3%
530	Kolhapur	35.1%	27.2%	43.8%
531	Sangli	34.8%	28.9%	41.2%
532	Adilabad	59.3%	52.4%	65.7%
533	Nizamabad	42.1%	35.5%	48.9%
534	Karimnagar	28.0%	23.8%	32.6%
535	Medak	49.9%	42.2%	57.7%
536	Hyderabad	3.4%	1.4%	8.4%
537	Rangareddy	13.0%	8.9%	18.6%
538	Mahbubnagar	51.5%	43.8%	59.3%
539	Nalgonda	38.6%	31.3%	46.4%
540	Warangal	37.4%	31.8%	43.4%
541	Khammam	29.4%	23.9%	35.6%
542	Srikakulam	61.7%	54.3%	68.6%
543	Vizianagaram	51.7%	44.8%	58.5%
544	Visakhapatnam	43.6%	38.2%	49.2%
545	East Godavari	48.9%	42.2%	55.7%
546	West Godavari	36.7%	30.7%	43.2%
547	Krishna	26.0%	21.3%	31.4%
548	Guntur	19.2%	14.4%	25.2%
549	Prakasam	33.5%	27.2%	40.4%
550	Sri Potti Sriramulu Nellore	41.7%	34.8%	48.8%
551	Y.S.R.	26.0%	21.1%	31.7%
552	Kurnool	35.1%	27.5%	43.5%
553	Anantapur	33.2%	28.7%	38.1%
554	Chittoor	38.5%	32.7%	44.6%
555	Belgaum	52.5%	46.9%	58.0%
556	Bagalkot	66.2%	59.2%	72.6%
557	Bijapur	70.6%	64.0%	76.4%
558	Bidar	68.3%	61.3%	74.5%
559	Raichur	71.2%	65.2%	76.6%
560	Koppal	65.7%	58.3%	72.4%
561	Gadag	74.5%	69.5%	79.0%
562	Dharwad	41.9%	33.0%	51.4%
563	Uttara Kannada	50.6%	43.1%	58.0%
564	Haveri	63.9%	56.6%	70.5%
565	Bellary	50.2%	40.7%	59.7%
566	Chitradurga	58.8%	52.0%	65.4%
567	Davanagere	43.8%	35.4%	52.6%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
568	Shimoga	37.4%	29.1%	46.5%
569	Udupi	53.8%	48.5%	59.1%
570	Chikmagalur	48.8%	41.5%	56.2%
571	Tumkur	55.6%	48.4%	62.6%
572	Bangalore	3.9%	2.3%	6.5%
573	Mandya	44.2%	37.5%	51.1%
574	Hassan	45.4%	38.9%	52.0%
575	Dakshina Kannada	45.1%	39.8%	50.5%
576	Kodagu	52.1%	45.2%	58.9%
577	Mysore	32.2%	25.3%	39.9%
578	Chamarajanagar	61.4%	54.4%	68.0%
579	Gulbarga	63.5%	56.8%	69.6%
580	Yadgir	81.1%	74.7%	86.2%
581	Kolar	39.1%	32.4%	46.2%
582	Chikkaballapura	50.1%	43.2%	57.0%
583	Bangalore Rural	31.6%	26.4%	37.3%
584	Ramanagara	43.7%	37.0%	50.7%
585	North Goa	15.2%	11.0%	20.8%
586	South Goa	11.6%	8.2%	16.1%
587	Lakshadweep	53.8%	43.9%	63.5%
588	Kasaragod	47.0%	42.8%	51.2%
589	Kannur	43.4%	37.2%	49.9%
590	Wayanad	66.6%	60.3%	72.3%
591	Kozhikode	48.0%	40.5%	55.7%
592	Malappuram	54.1%	46.2%	61.8%
593	Palakkad	49.3%	38.5%	60.2%
594	Thrissur	32.3%	28.0%	37.0%
595	Ernakulam	20.1%	15.4%	25.8%
596	Idukki	52.8%	45.5%	60.0%
597	Kottayam	37.4%	30.5%	44.8%
598	Alappuzha	35.7%	29.5%	42.4%
599	Pathanamthitta	42.0%	37.6%	46.6%
600	Kollam	39.6%	35.2%	44.1%
601	Thiruvananthapuram	47.3%	39.2%	55.6%
602	Thiruvallur	10.9%	7.8%	14.9%
603	Chennai	1.4%	0.6%	3.4%
604	Kancheepuram	11.9%	8.5%	16.3%
605	Vellore	20.9%	15.2%	28.1%
606	Tiruvannamalai	32.8%	25.0%	41.7%
607	Viluppuram	41.2%	34.9%	47.9%
608	Salem	21.0%	14.8%	28.9%
609	Namakkal	12.9%	9.6%	17.2%
610	Erode	9.9%	7.3%	13.3%
611	The Nilgiris	23.7%	18.3%	30.2%
612	Dindigul	31.8%	24.6%	40.1%
613	Karur	19.1%	13.0%	27.2%
614	Tiruchirappalli	25.1%	19.9%	31.2%
615	Perambalur	35.0%	27.8%	43.0%
616	Ariyalur	50.2%	42.8%	57.5%
617	Cuddalore	45.4%	37.6%	53.4%
618	Nagapattinam	38.1%	31.3%	45.5%
619	Thiruvarur	54.9%	47.0%	62.5%
620	Thanjavur	51.3%	44.2%	58.4%
621	Pudukkottai	57.9%	49.9%	65.6%
622	Sivaganga	41.7%	34.1%	49.6%
623	Madurai	20.1%	14.7%	26.8%
624	Theni	21.9%	15.6%	29.7%
625	Virudhunagar	22.3%	16.6%	29.3%
626	Ramanathapuram	40.5%	35.6%	45.6%
627	Thoothukkudi	29.4%	22.3%	37.5%
628	Tirunelveli	22.5%	17.2%	28.9%
629	Kanniyakumari	38.3%	31.6%	45.5%
630	Dharmapuri	23.7%	17.6%	31.3%

Continued...

Appendix Table A.7—*Continued*

District ID	District name	Estimate	Lower	Upper
631	Krishnagiri	35.2%	28.7%	42.4%
632	Coimbatore	12.0%	8.7%	16.3%
633	Tiruppur	7.4%	5.1%	10.5%
634	Yanam	6.9%	4.0%	11.7%
635	Puducherry	12.2%	9.0%	16.3%
636	Mahe	12.3%	9.1%	16.5%
637	Karaikal	24.3%	19.4%	29.9%
638	Nicobars	43.5%	35.1%	52.3%
639	North & Middle Andaman	51.2%	43.7%	58.7%
640	South Andaman	9.1%	6.2%	13.0%

Appendix Table A.8 District-level estimates of household use of solid fuel for cooking, Nepal DHS 2016

Province	District name	Estimate	Lower	Upper
Central	Bagmati	33.3%	28.8%	37.6%
Central	Janakpur	88.3%	82.0%	92.3%
Central	Narayani	66.1%	57.4%	73.7%
Eastern	Koshi	61.0%	53.6%	67.2%
Eastern	Mechi	66.7%	56.4%	75.6%
Eastern	Sagarmatha	91.8%	85.0%	96.0%
Far Western	Mahakali	80.9%	73.4%	86.6%
Far Western	Seti	85.4%	78.6%	89.9%
Mid Western	Karnali	92.6%	85.8%	95.9%
Mid Western	Rapti	81.0%	71.6%	87.9%
Mid Western	Bheri	80.0%	71.1%	86.5%
Western	Dhawalagiri	92.9%	87.5%	95.8%
Western	Gandaki	54.3%	47.2%	60.9%
Western	Lumbini	65.2%	56.8%	72.2%

Appendix Table A.9 Province-level estimates of household use of solid fuel for cooking, the Philippines NDHS 2017

Region	Province ID	Province name	Estimate	Lower	Upper
Autonomous region in Muslim Mindanao (ARMM)	1	Lanao Del Sur	88.3%	77.8%	94.6%
Autonomous region in Muslim Mindanao (ARMM)	2	Sulu	94.6%	86.8%	98.5%
Autonomous region in Muslim Mindanao (ARMM)	3	Tawi-tawi	89.6%	76.0%	96.8%
Cordillera Administrative region (CAR)	4	Abra	73.3%	63.1%	81.5%
Cordillera Administrative region (CAR)	5	Apayao	82.9%	73.6%	89.5%
Cordillera Administrative region (CAR)	6	Benguet	11.0%	6.9%	16.0%
Cordillera Administrative region (CAR)	7	Ifugao	61.1%	53.0%	68.8%
Cordillera Administrative region (CAR)	8	Kalinga	69.2%	61.5%	75.9%
Cordillera Administrative region (CAR)	9	Mountain Province	44.1%	36.2%	52.1%
National Capital region (NCR)	10	Metropolitan Manila	4.0%	2.9%	5.2%
Region I (Ilocos region)	11	Ilocos Norte	47.4%	33.8%	60.5%
Region I (Ilocos region)	12	Ilocos Sur	47.1%	36.5%	57.5%
Region I (Ilocos region)	13	La Union	51.9%	38.8%	66.1%
Region I (Ilocos region)	14	Pangasinan	56.7%	45.2%	67.3%
Region II (Cagayan Valley)	15	Cagayan	66.5%	50.3%	78.9%
Region II (Cagayan Valley)	16	Isabela	59.0%	46.1%	70.4%
Region II (Cagayan Valley)	17	Nueva Vizcaya	61.8%	52.7%	69.9%
Region II (Cagayan Valley)	18	Quirino	68.2%	59.0%	76.3%
Region III (Central Luzon)	19	Bataan	19.2%	11.3%	29.1%
Region III (Central Luzon)	20	Bulacan	15.6%	10.7%	21.5%
Region III (Central Luzon)	21	Nueva Ecija	41.0%	29.1%	53.8%
Region III (Central Luzon)	22	Pampanga	10.5%	7.3%	14.6%
Region III (Central Luzon)	23	Tarlac	48.5%	40.5%	56.4%
Region III (Central Luzon)	24	Zambales	43.6%	31.0%	56.1%
Region III (Central Luzon)	25	Aurora	66.5%	49.3%	80.0%
Region IV-A (Calabarzon)	26	Batangas	46.6%	21.6%	71.3%
Region IV-A (Calabarzon)	27	Cavite	9.8%	6.5%	14.0%
Region IV-A (Calabarzon)	28	Laguna	15.0%	9.9%	21.2%
Region IV (Southern Tagalog)	29	Marinduque	74.2%	64.6%	82.3%
Region IV (Southern Tagalog)	30	Mindoro Occidental	86.4%	73.6%	94.3%
Region IV (Southern Tagalog)	31	Mindoro Oriental	66.8%	52.6%	78.3%
Region IV (Southern Tagalog)	32	Palawan	84.9%	65.2%	95.0%
Region IV-A (Calabarzon)	33	Quezon	61.9%	42.8%	76.6%
Region IV-A (Calabarzon)	34	Rizal	12.3%	8.5%	16.9%
Region IV (Southern Tagalog)	35	Romblon	80.0%	66.9%	89.5%
Autonomous region in Muslim Mindanao (ARMM)	36	Basilan	94.9%	90.1%	97.7%
Region IX (Zamboanga Peninsula)	37	Zamboanga Del Norte	90.2%	80.9%	95.3%
Region V (Bicol region)	38	Albay	70.4%	60.2%	79.1%
Region V (Bicol region)	39	Camarines Norte	72.5%	61.9%	80.7%
Region V (Bicol region)	40	Camarines Sur	61.1%	47.1%	72.8%
Region V (Bicol region)	41	Catanduanes	72.3%	60.6%	82.0%
Region V (Bicol region)	42	Masbate	89.9%	77.9%	96.6%
Region V (Bicol region)	43	Sorsogon	77.0%	66.6%	85.2%
Region VI (Western Visayas)	44	Aklan	82.7%	73.8%	89.4%
Region VI (Western Visayas)	45	Antique	91.5%	83.8%	96.3%
Region VI (Western Visayas)	46	Capiz	86.9%	79.8%	92.2%
Region VI (Western Visayas)	47	Guimaras	90.6%	84.5%	94.6%
Region VI (Western Visayas)	48	Iloilo	84.8%	77.0%	90.3%
Region VI (Western Visayas)	49	Negros Occidental	78.1%	64.4%	86.4%
Region VII (Central Visayas)	50	Bohol	86.7%	69.2%	95.8%
Region VII (Central Visayas)	51	Cebu	55.6%	45.2%	64.0%
Region VII (Central Visayas)	52	Negros Oriental	77.7%	62.3%	88.0%
Region VII (Central Visayas)	53	Siquijor	85.6%	80.1%	90.3%
Region VIII (Eastern Visayas)	54	Biliran	65.2%	51.3%	76.8%
Region VIII (Eastern Visayas)	55	Eastern Samar	83.1%	68.5%	92.3%
Region VIII (Eastern Visayas)	56	Leyte	71.7%	58.0%	81.7%
Region VIII (Eastern Visayas)	57	Northern Samar	79.2%	67.5%	87.7%
Region VIII (Eastern Visayas)	58	Southern Leyte	84.2%	72.6%	92.3%
Region VIII (Eastern Visayas)	59	Samar	81.8%	67.9%	91.0%
Region X (Northern Mindanao)	60	Bukidnon	77.8%	65.9%	86.6%
Region X (Northern Mindanao)	61	Camiguin	83.0%	76.7%	88.0%
Region X (Northern Mindanao)	62	Misamis Occidental	89.5%	81.1%	94.9%
Region X (Northern Mindanao)	63	Misamis Oriental	71.8%	61.3%	80.4%

Continued...

Appendix Table A.9—*Continued*

Region	Province ID	Province name	Estimate	Lower	Upper
Region XI (Davao Region)	64	Compostela	82.5%	73.3%	88.9%
Region XI (Davao Region)	65	Davao del Norte	68.8%	60.7%	76.1%
Region XI (Davao Region)	66	Davao Del Sur	69.1%	61.0%	76.2%
Region XI (Davao Region)	67	Davao Oriental	89.1%	76.9%	95.8%
Region XII (Soccsksargen)	68	Saranggani	88.2%	79.9%	93.8%
Region XII (Soccsksargen)	69	South Cotabato	80.8%	73.1%	86.7%
Region X (Northern Mindanao)	70	Lanao Del Norte	78.8%	69.8%	86.4%
Region XII (Soccsksargen)	71	North Cotabato	91.8%	85.2%	96.0%
Region XII (Soccsksargen)	72	Sultan Kudarat	89.6%	82.5%	94.3%
Region XIII (Caraga)	73	Agusan Del Norte	66.9%	58.1%	74.5%
Region XIII (Caraga)	74	Agusan Del Sur	87.5%	79.3%	93.2%
Region XIII (Caraga)	75	Surigao Del Sur	80.1%	68.0%	89.1%
Region IX (Zamboanga Peninsula)	76	Zamboanga Sibugay	92.7%	85.8%	96.8%
Region IX (Zamboanga Peninsula)	77	Zamboanga Del Sur	77.6%	63.6%	87.8%
Region XIII (Caraga)	78	Dinagat	78.3%	70.0%	85.2%
Region XIII (Caraga)	79	Surigao Del Norte	84.4%	70.6%	93.1%
Autonomous region in Muslim Mindanao (ARMM)	80	Maguindanao	93.2%	88.0%	96.6%
Autonomous region in Muslim Mindanao (ARMM)	81	Shariff Kabunsuan	83.4%	75.1%	89.3%