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Child Health Implications of Plastic Waste Reduction in West Africa

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Abstract

Rapidly growing, unregulated plastic litter has created a multitude of environmental and economic problems in developing countries. The problems are particularly serious for single use plastic (SUP) products that cannot be recycled. While the case for plastic waste reduction is clear, it may conflict with public health and other social objectives. Using Demographic and Health Survey (DHS) data from Ghana and Nigeria, this paper considers the potential for health damage from waste reduction policies that reduce household use of SUP drinking-water containers. The econometric analysis provides strong evidence that SUP containers significantly reduce child mortality and incidence of diarrhea, after controlling for other, widely cited determinants in the literature. By implication, general measures to reduce plastic use may also increase childhood illness and death. The study demonstrates how plastic-waste reduction policies should not be assessed in isolation from their public health implications for poor households and suggests countervailing measures that can be taken to address the SUP waste problem. The study can be replicated in any of the 73 countries where DHS data include the use of plastic containers as household water sources.

Keywords: child mortality and morbidity, clean water policy, Ghana, Nigeria, plastic pollution, single use plastic

1. The Public Health Cost of Plastic Waste Reduction

1.1 Plastic Waste Mismanagement: A Growing International Concern

Global plastic production has experienced tremendous growth over the past 75 years. The recent trend in the rate of global production is about 8% a year (Note 1). By 2040, one can expect annual production to have reached 716 million metric tons (MT), a doubling of the 2019 figure (Geyer, Jambeck, & Law, 2017, Note 2). The durability of plastic, along with its low cost and convenience features, accounts, in large part, for its continued popularity. However, without appropriate waste litter disposal and recycling, plastic waste can have serious environmental, economic, and health-related consequences both locally and globally. The dumping of plastic waste in non-engineered landfills and informal dumpsites and open waste incineration leads to clogged drainage systems, contributing to widespread flooding during the rainy season and contamination of terrestrial and freshwater ecosystems, as well as the degradation of sites with potential tourism value and health hazards. By 2015, the mismanagement of plastic waste had reached 60–99 million tons per year, and, without urgent action, that range could expand to 155–265 million tons per year. The problem is especially serious in developing countries, where available public resources for waste disposal have been overwhelmed by the accelerated growth in plastic use.

1.2 Literature Review

1.2.1 International Focus

The rapid growth of plastic pollution is increasingly recognized as an urgent environmental issue (UNEP, 2018). Recent empirical research recognizes the serious damage of plastic pollution in both terrestrial and marine environments and the resulting adverse effects on human and animal health. Leachate from stockpiles contaminates soil, surface water, and groundwater (Kanmani & Gandhimathi, 2013; Nagarajan, Thirumalaisamy, & Lakshumanan, 2012; Naveen, Sumalatha, & Malik, 2018; Parvin & Tareq, 2021). Toxins in plastics and other chemicals in plastic products disrupt nutrition pathways, inhibit plant growth, choke foraging animals, and bioaccumulate in the food web (Garua & Sharma, 2021; Huerta Lwanga et al., 2017; Ramaswamy & Sharma, 2011; Shaikh & Shaikh, 2021; Toussaint et al., 2019; Wang, Lee, Chiu, Lin, & Chiu, 2020; Waring, Harris, & Mitchell, 2018, Note 3). Plastic incineration releases toxic gases, including dioxins, furans, mercury, and polychlorinated biphenyls (Verma, Vinoda, Papireddy, & Gowda 2016, Note 4). The associated health impacts include cancers, birth defects, impaired immunity, endocrine disruption, and developmental and reproductive damage (Rustagi, Pradhan, & Singh, 2011; Talsness, Andrade, Kuriyama, Taylor, & Vom Saal, 2009, Note 5). Marginalized communities and those living near plastic waste sites are nearly always disproportionately affected, constituting an environmental injustice (UNEP, 2021).

With a potential lifetime of centuries, plastics have become major stressors for marine ecosystems. In the marine environment, plastics slowly degrade into microplastics, which, in turn, accumulate on shorelines, sink to the seabed, or float on the sea surface (Díaz-Mendoza, Mouthon-Bello, Pérez-Herrera, & Escobar-Díaz, 2020; Gallo et al., 2018; Jeftic, Sheavly, Adler, & Meith, 2009; UNEP, 2005). Each year, thousands of fish, sea birds, sea turtles, and other marine life die from ingesting or becoming entangled in plastic debris. Plastic combustion also contributes significantly to global warming through CO_2 and black carbon (BC) emissions (Reyna-Bensusan, 2019; Shen et al., 2020).

1.2.2 The African Context

Africa has experienced rapid growth of plastic pollution in recent years, and is now the second largest source of ocean plastic pollution from rivers (Lebreton et al., 2017; Ritchie & Roser, 2018, Note 6). It is expected to account for 10.6% of the global total by 2025 (Jambeck et al., 2015), and potentially the largest global share by 2060 (Lebreton & Andrady, 2019).

Recent assessments of West African pollution sources have highlighted the role of SUP containers. These include SUP sachets and bottles, which, in many areas poorly served by public water distribution systems, are major sources of clean drinking water (Note 7). Owing to the absence or poor management of waste disposal systems (Fobil & Hogarh, 2006; Quartey, Tosefa, Danquah, & Obrsalova, 2015), sachets are often disposed of indiscriminately (Note 8). The scant data on litter by type estimate that more than 90% of SUP products are improperly collected or managed (Godfrey et al., 2018; Miezah, Obiri-Danso, Kádár, Fei-Baffoe, & Mensah, 2015).

Despite growing awareness, spatiotemporal monitoring of plastic pollution remains sparse. Jambeck et al. (2015) estimate total annual plastic-waste generation for Ghana and Nigeria at 357,877 MT and 5,961,750 MT, respectively (Note 9) with the share of mismanaged waste at about 81%. Lebreton et al. (2017) estimate annual marine plastic emissions at 2.3 million kg from the Odaw River in Accra and 6.1 million kg from the river systems that discharge waste into Lagos Harbor.

1.3 Potential Social Cost of Plastic Reduction Measures

Some developing countries have responded to the plastic pollution program by banning bags made from single SUPs (Adam, Walker, Bezerra, & Clayton, 2020), while others have implemented or considered programs to reduce plastic use through tariffs, import restrictions on SUPs, or charges on plastic products. While such measures have strong environmental appeal, their implementation may also carry significant social costs. The SUP containers used in many poor countries for drinking water provide a critical example. If the water provided by such containers is cleaner than other sources of drinking water, then the widespread use of SUP containers may offer significant health benefits, including lower child mortality and morbidity. If so, then plastic waste reduction policies should be accompanied by targeted measures to maintain water quality for vulnerable households.

1.4 Child-Health Implications of Reducing Plastic Container Use in West Africa

In Ghana and Nigeria, plastic pollution problems have both international and national dimensions. The rapidly worsening problem of marine plastic pollution results mainly from mismanaged plastic waste transported by rivers that traverse urban areas. Both countries also have significant child-health problems. Despite significant progress made over the past several decades to reduce infant mortality, rates in these two countries remain far above those for high-income countries. Moreover, the current rate of improvement for Nigeria (40.3%) lags that of Ghana (57.5%), which roughly matches that for high-income countries (59.8%) (Table 1).

Table 1. Comparative infant mortality rates (per 1,000 people), showing % changes, 1990–2019

Year	Ghana		Nigeria		High-income countries	
	Rate	% Change	Rate	% Change	Rate	% Change
1990	79.7		124.3		10.7	
2000	64.1	-19.6	110.0	-11.5	6.8	-36.4
2010	47.0	-41.0	84.6	-31.9	5.1	-52.3
2019	33.9	-57.5	74.2	-40.3	4.3	-59.8

Source: World Development Indicators.

Poor households in both Ghana and Nigeria rely heavily on SUP containers as a source of clean drinking water. Thus, without countervailing policy measures in place, reducing the use of SUP containers to achieve environmental objectives is likely to conflict with the social objective of improving infant and child health. This paper assesses the potential conflict by conducting an econometric analysis of the health effects of plastic container use by households in both countries. It is expected that the study's findings will contribute to developing evidence-based strategies for better plastic-waste management and pollution prevention in developing countries.

2. Data and Methods

2.1 Demographic and Health Surveys

A database was constructed from the Demographic and Health Surveys (DHSs) conducted in Ghana for years 2003, 2008, and 2014 (GSS, NMIMR, & ORC Macro, 2004; GSS, GHS, & ICF Macro, 2009; GSS, GHS, & ICF International, 2015) and in Nigeria for years 2003, 2008, 2013, and 2018 (NPC & ORC Macro, 2004; NPC & ICF Macro, 2009; NPC & ICF International, 2014; NPC & ICF, 2019). These surveys reported caretaker responses for some 12 500 children in Ghana and 99 500 children in Nigeria. For each child, the caretaker reported mortality status; recent incidence of diarrhea; gender; age in months (or age at death for mortality); years of mother's education; household income status; and primary source of drinking water, including plastic drinking containers (sachets and/or bottles).

The measure of household income status was derived from the DHS measure of relative economic status and the World Bank measure of real income per capita. The DHS measure is a factor score derived from a principal component analysis of many dummy variables that record the presence or absence of household possessions. To estimate real household income per capita for each household, its factor score is transformed into a percentile (0–100), which is divided by total household members. The result is divided by its sample mean value, and that result is multiplied by the World Bank estimate of real income per capita in the relevant survey year.

2.2 Probit Probability Model

The study tests the impact of plastic container use on the health of children 0–5 years of age, using a probit probability model fitted to DHS survey data for the period 2003–2018. The dependent variables are dichotomous measures of mortality (1 if child has died; 0 if not) and diarrhea incidence (1 if child had diarrhea recently; 0 otherwise). The independent variables are child gender, years of mother's education, real household income, plastic drinking container use (1 if plastic bottles or sachets are the household's primary drinking-water source; 0 otherwise), and child's age in months (or age at death for mortality). Unobserved spatial and temporal factors are incorporated with dummy variables for DHS years and level-1 administrative regions (9 in Ghana and 36 in Nigeria).

To explore the implications, the probit results are used to predict mortality rates and diarrhea incidences for the sampled children across the full range of incomes in each DHS year, with and without plastic drinking container use.

3. Results

Table 2 presents the probit estimation results for Ghana and Nigeria. (Note 10). For clarity, the dummy variable results for time periods and administrative regions are excluded but are reported in the Appendix (Tables A1 and A2).

Table 2. Plastic drinking-water container use and child health in Ghana and Nigeria

VARIABLE	GHANA[A]		NIGERIA[B]	
	(1)	(2)	(3)	(4)
	DEATH	DIARRHEA	DEATH	DIARRHEA
FEMALE	0.032	-0.001	0.006	0.008
	(0.89)	(0.02)	(0.52)	(0.72)
MOTHER'S EDUCATION	-0.022***	-0.010**	-0.033***	-0.003*
(YEARS)	(4.49)	(2.60)	(21.11)	(2.17)
INCOME PER CAPITA	0.712***	-0.129	0.397***	-0.054*
(US$, 2010)	(8.24)	(1.49)	(19.56)	(2.21)
PLASTIC CONTAINER USE	-0.250**	-0.140*	-0.117**	-0.056
	(2.82)	(2.03)	(2.93)	(1.34)
AGE (MONTHS)	0.007***	-0.008***	0.009***	-0.012***
	(6.63)	(10.00)	(28.50)	(34.66)
CONSTANT	-1.761***	-0.710***	-1.331***	-0.980***
	(23.23)	(10.48)	(26.55)	(17.84)
OBSERVATIONS	12,708	12,541	99,471	98,743

Source: Demographic and Health Surveys.

Note. The dependent variable is the probability of child death or recent diarrhea. Absolute values of t statistics are shown in parentheses; *, **, and *** denote significance levels of 5, 1, and 0.1%, respectively.

As shown, the results are significant in all cases for time periods and in many cases for administrative regions, suggesting that a host of temporal and local factors also have important impacts on child mortality and morbidity. Among the regression variables in Table 2, mother's education and child's age have consistently high significance. Income has a perversely positive, significant association with child mortality, while it has the expected sign for diarrhea and is significant for Nigeria. Among the four results for plastic container use, all have the expected sign (container use reduces the dependent variable probability), and three of the results are statistically significant.

The dynamic implications of these results are explored by estimating the probability of mortality and diarrhea for all children in the sample (about 12,500 for Ghana and 99,500 for Nigeria), for the full range of incomes in each DHS year, with and without plastic drinking container use. The box plots in Figure 1 display the distributions of predicted child mortality (Figure 1a) and diarrhea (Figure 1b), scaled to rates per 1000 children. The figures display notably lower rates for households that use plastic water containers, both within and across years.

The most recent results for Ghana (2014) show that plastic water container use reduced the median predicted child mortality rate by 42% (from 45 to 26). The equivalent result for Nigeria in 2018 was a 20% decline (from 90 to 72). For child diarrhea in the most recent survey years (2014 and 2018), using plastic water containers reduced the median predicted rate by 21% for Ghana and 10% for Nigeria. It should be noted that the estimated effects of plastic container use in Ghana are both larger and more significant generally than in Nigeria, suggesting that water contamination issues may be greater in Nigeria.

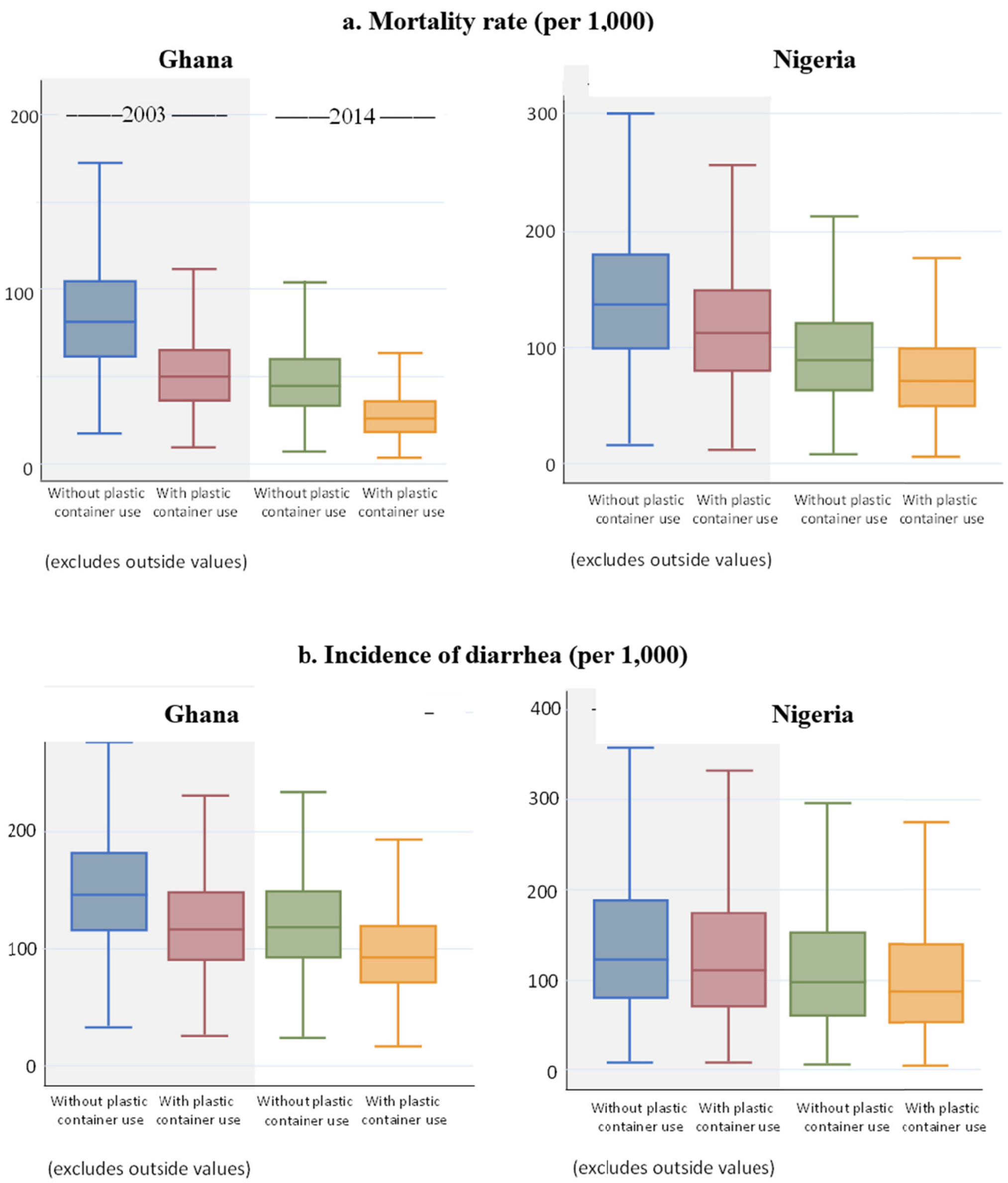

Figure 1. Child-health impacts of plastic water container use in Ghana and Nigeria

Source: Authors' calculations, based on Demographic and Health Survey (DHS) data in Ghana and Nigeria.

Note. In each plot, boxes are bounded by first and third quartile values, medians are identified by interior horizontal lines, and limits for non-outlier values are identified by top and bottom horizontal lines. For further discussion, see Tukey (1977).

Summing up, the results of this econometric analysis found that, after controlling for income, education, and other socioeconomic factors, child mortality rates and incidence of diarrhea are significantly lower for children in households that use plastic water containers (Table 2). The study's results are further corroborated by the differences in regression-predicted rates of mortality and diarrhea (Figure 1).

4. Discussion

4.1 Implications of the Results for Ghana and Nigeria

Like many other countries in Sub-Saharan Africa, Ghana and Nigeria face numerous technical, institutional, and social difficulties with water supply and distribution. These include insufficient infrastructure and human capital, along with weak monitoring and enforcement of laws, rules, and regulations. As a result, clean water supplies are limited in cities, peri-urban, and rural areas. In 2020, approximately 17.6 million Ghanaians (59% of the population, Note 11) and 43 million Nigerians (78% of the population) were living without access to safely managed drinking-water services. Urban access shortfalls affected 40% of the population in Ghana and 75% in

Nigeria, while rural shortfalls affected 84% and 82%, respectively (Note 12).

Ghana and Nigeria, along with other member countries of the Economic Community of West African States (ECOWAS), are adopting policies to reduce SUP pollution (Adam et al., 2020). Both countries have joined the Global Economic Forum's Global Plastic Action Partnership, which works with governments, businesses, and civil society to find concrete solutions to plastic pollution problems. In 2019, Nigeria's House of Representatives (the lower chamber of the National Assembly) considered a bill to ban plastic bags. In 2013, Ghana introduced the Environmental Excise Tax (Act 863), which imposed a 10% tax on the ex-factory price of imported semi-finished and raw plastics, to be paid by importers and manufacturers. Two years later, it failed in an attempt to impose a non-legislative ban on plastics below 20 µm. Since 2017, it has conducted a national consultative process on the possible ban of plastic bags. While such measures may yield clear environmental benefits by significantly reducing plastic consumption and waste, the reduced use of SUP water containers may have adverse health consequences for many households.

This study's econometric results align with the widespread belief among West Africans that water in plastic containers is cleaner and safer than from other sources. This is not to imply that plastic water containers are cleaner and safer in all cases. In those where consistent public testing and certification are absent, the actual quality may be problematic. Some contamination has been revealed by sample-based analysis of water sachets in Accra (Kwakye-Nuako, Borketey, Mensah-Attipoe, Asmah, & Ayeh-Kumi, 2007) and Lagos (Omolade & Zanaib, 2017). The larger estimated benefits for Ghana, shown in Table 2, suggest that the issue of water contamination may be greater in Nigeria. In short, if the sample data include contaminated containers, then the benefits of cleaner water may be underestimated.

This study's results also reflect the influence of unobserved variables that are correlated with plastic container use, but the size of the estimated impacts is certainly cautionary. In Ghana and Nigeria, reducing the use of plastic drinking-water containers may significantly increase childhood illness and death. Thus, policy makers who opt for reducing SUP containers should also consider countervailing health measures, particularly for poor households. These may include subsidized sale or targeted distribution of water disinfection products, promotion of safe water storage in appropriately designed containers, and community hygiene education.

In both Ghana and Nigeria, as in many other developing countries, SUP drinking-water containers account for the bulk of plastic litter, suggesting the need for countries to plan waste management holistically. In 2020, Ghana took an important step in this direction by launching the National Plastics Management Policy, which has four focal areas: (i) behavioral change; (ii) strategic planning and cross-sectoral collaboration; (iii) resource mobilization toward a circular economy; and (iv) good governance, inclusiveness, and shared accountability.

Beyond critical waste-reduction policies, realism also dictates the need for improved waste-collection measures and cleanup. Determining the most cost-effective policy mix for each country should involve location-specific analyses. While the need for improved plastic-waste management has been universally recognized, cost-effective remediation has often been hindered by a lack of information on the spatial distribution and timing of plastic use and waste generation. Given the high cost of field operations and the scarcity of public resources, identification of high-priority cleanup sites is a necessary first step for policy makers. Cleanup measures should target "hotspot" areas where large volumes of plastic litter pose environmental, health, and economic risks. Where feasible, prioritization should be informed by continuous spatial sampling to identify such areas. If continuous spatial sampling is infeasible, data can be gathered by remote sensing and field surveys. High-altitude drone flights can help detect hotspots, and low-altitude flights can assist in more precise identification. In Vietnam, for example, the Ministry of Natural Resources and Environment, in collaboration with the World Bank, identified hotspots for marine plastic pollution and conducted diagnostic studies with information from camera-equipped drones and field surveys along riverbanks. In more resource-constrained contexts, data from crowdsourcing and knowledge sharing via social media should be encouraged.

Solid waste management is costly, often comprising the largest budget item for local administrations. In low-income countries, municipalities spend an average of about 20% of their budgets on waste management—yet more than 90% of their waste is openly dumped or burned (Kaza, Yao, Bhada-Tata, & Van Woerden, 2018). This reality suggests the need for local administrations to (i) conduct a comprehensive assessment of mismanaged plastic waste; (ii) identify the top 10–15 plastic waste items leaking into the environment; (iii) segregate this waste from general waste at the source; and (iv) set goals for reducing, reusing, recycling, recovering, and disposing of plastics. An effective roadmap for plastic pollution management would require enacting laws, formulating policies and regulations, developing institutions for monitoring and enforcement, and investing in infrastructure and service delivery to enable the transition to a circular plastics economy. The analysis presented in this paper highlights the importance of high-resolution local information for customizing the roadmap.

4.2 Additional Policy Dimensions

Beyond the risks to child health, contaminated water has significant health and productivity impacts for adult populations in West Africa (Clasen, Schmidt, Rabie, Roberts, & Cairncross, 2007). Cairncross et al. (2010) estimate that 85% of Africa's burden of disease preventable by water supply is caused by diarrhoeal diseases, which also have large economic costs, including billions of hours each year in lost adult productivity (Ehinomen, Babatunde, & Agu, 2018; Vincent & Rosen, 2001).

Plastic-waste reduction policies cannot be assessed in isolation from their public-health implications. Effective implementation of economic or regulatory measures to reduce demand for SUP containers may negatively impact public health, particularly in poor households, unless recyclable plastic containers are subsidized. In practice, however, fiscally-stressed urban governments may be unable to sustain such programs. By implication, it may be more cost effective to implement several measures that directly address waste reduction. The first is heightened attention to the use of waste plastics as a valuable resource (Hopewell, Dvorak, & Kosior, 2009). In Kenya (Macharia, 2017) and Ethiopia (UNEP, 2017), for example, diverse plastic wastes, including SUP containers, are now utilized by waste-to-energy operations. Second, as previously noted, new technologies for plastic waste "hotspot" detection can increase the cost-effectiveness of municipal programs to remove plastic wastes (Dasgupta, Sarraf, & Wheeler, 2022). Third, recent evidence suggests that targeted environmental education can significantly change plastic waste disposal practices. Nwanaji-Enwerem, Baccarelli, Curwin, Zota and Nwanaji-Enwerem (2022) cite positive results from several efforts to promote environmental awareness-raising and education in poor urban communities. Seidel, Downie, Allen and Diarra (2000) find that environmental education programs have increased conservation activities in Mali, Tanzania, and Zambia. Ifegbesan, Ogunyemi and Rampedi (2017) cite higher recycling rates among environmentally educated students at a Nigerian university. Using household survey data and regression analysis, Amoah and Addoah (2021) find that environmental knowledge has a significant positive impact on pro-environmental behavior in Ghana.

In summary, plentiful evidence from West Africa suggests that numerous measures can address the SUP waste problem without exacting a public health cost. That said, research like the present exercise can play a useful role by quantifying the potential tradeoff between uninformed plastic waste reduction and public health. The study is designed for much broader application by interested researchers, and can be replicated in any of the 73 countries where DHS data include the use of plastic containers as household water sources.

5. Conclusion

The lessons from this research in Ghana and Nigeria are relevant for nearly all developing countries, where management of rapidly growing plastic pollution presents a formidable task. The case for public intervention to reduce plastic waste seems clear. However, effective decision-making requires a comprehensive, multi-sectoral waste management plan. An understanding of the potential conflicts with social objectives is critical for determining optimal policies for plastic pollution reduction. This paper finds significant potential health risks for policies that would reduce household use of SUP drinking-water containers in Ghana and Nigeria. Similar research could be conducted in many other developing countries since DHS data on household water sources and health outcomes are widely available.

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Notes

Note 1. Retrieved February, 2022, from https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/

Note 2. In 2020, the impact of COVID-19 reduced global production by 0.3%.

Note 3. Retrieved February, 2022, from https://www.plasticsoupfoundation.org/en/plastic-problem/plastic-affect-animals/plastic-food-chain/

Note 4. In 2016, approximately 70.2 million tons (29%) of plastic waste was burned without regulation worldwide, leading to 0.92 ± 0.53 million tons of toxic aerosols being released into the air, a majority of which occurred in developing regions (Wu et al., 2021).

Note 5. Retrieved February, 2022, from https://search.nih.gov/search?utf8=%E2%9C%93&affiliate=nih&query=health+effects+of+plastics&commit=Search

Note 6. The largest share has its origin in Asia, which accounts for 86% of the global total.

Note 7. SUP sachets first appeared on the market in the late 1990s, when entrepreneurs in West African cities began using new Chinese machinery that heat-sealed water in plastic sleeves (Stoler et al., 2012).

Note 8. Retrieved February, 2022, from https://qz.com/africa/1229079/ghana-the-worlds-fastest-growing-economy-has-a-trash-problem/

Note 9. Comparable estimates of plastic waste are rare, even at the country level, and estimates from alternative sources vary widely. For example, in 2020, Ghana's Ministry of Environment, Science, Technology and Innovation (MESTI) reported more than 1 million MT of national plastic waste (https://mesti.gov.gh/wp-content/uploads/2021/02/Revised-National-Plastics-Management-Policy_-FINAL.pdf); this figure is much higher than that estimated by Jambeck et al. (2015). An equivalent estimate for Nigeria is not currently available in the public domain.

Note 10. Probit estimation appropriately constrains model-based probability estimates to the range [0–1].

Note 11. See SDG 6 Snapshot and Table 6.1.1. Retrieved February, 2022, from https://www.sdg6data.org/country-or-area/ghana and https://www.sdg6data.org/country-or-area/nigeria

Note 12. In recent years, however, the Government of Nigeria has strengthened its commitment to improved water supply, sanitation, and hygiene (WASH) services. In 2018, President Muhammadu Buhari declared a State of Emergency and launched the National Action Plan (NAP), a 13-year strategy for revitalization of Nigeria's WASH sector. The NAP aims to ensure universal access to sustainable and safely managed WASH services by 2030, commensurate with Nigeria's sustainable development goals. Retrieved February, 2022, from https://wwwworldbank.org/en/news/feature/2021/05/26/nigeria-ensuring-water-sanitation-and-hygiene-for-all

Appendix

Probit Results

Table A1. Probit results for Ghana

Variable	(1) Death	(2) Diarrhea	State	(1) Death	(2) Diarrhea
Female	0.0320	-0.000653	Ashanti	0.110	-0.119*
	(0.89)	(-0.02)		(1.46)	(-2.08)
Mother's Education (Years)	-0.0221***	-0.0103**	Central	0.110	-0.237***
	(-4.49)	(-2.60)		(1.29)	(-3.58)
Income Per Capita	0.712***	-0.129	Eastern	0.109	-0.0509
($US 2010)	(8.24)	(-1.49)		(1.29)	(-0.82)
Plastic Container Use	-0.250**	-0.140*	Greater_Accra	-0.0784	-0.237***
	(-2.82)	(-2.03)		(-0.84)	(-3.32)
Age (Months)	0.00692***	-0.00841***	Northern	0.251***	-0.0568
	(6.63)	(-10.00)		(3.43)	(-1.04)
D2008	-0.126**	0.147***	Upper_East	-0.129	-0.157*
	(-2.69)	(3.95)		(-1.37)	(-2.44)
D2014	-0.292***	-0.132***	Upper_West	0.299***	-0.0469
	(-6.77)	(-3.81)		(3.74)	(-0.76)
Constant	-1.761***	-0.591***	Volta	0.0788	-0.472***
	(-23.23)	(-10.48)		(0.90)	(-6.56)
Observations	12,708	12,541	Western	-0.0303	-0.294***
				(-0.35)	(-4.53)

Note. t statistics are shown in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.2 Probit results for Nigeria

Variable	(1) Death	(2) Diarrhea	State	(1) Death	(2) Diarrhea	State	(1) Death	(2) Diarrhea
Female	0.00572	0.00807	Abia	-0.0535	-0.296***	Kano	0.0826	0.350***
	(0.52)	(0.72)		(-0.85)	(-3.76)		(1.70)	(6.52)
Mother's Education Years)	-0.0326***	-0.00337*	Adamawa	0.0689	0.299***	Katsina	-0.0108	0.339***
	(-21.11)	(-2.17)		(1.30)	(5.14)		(-0.21)	(6.15)
Income Per Capita ($US 2010)	0.397***	-0.0542*	Anambra	-0.178**	-0.163*	Kebbi	0.120*	0.222***
	(19.56)	(-2.21)		(-2.89)	(-2.32)		(2.34)	(3.84)
Plastic Container Use	-0.117**	-0.0555	Bauchi	0.0895	0.898***	Kogi	-0.0690	-0.121
	(-2.93)	(-1.34)		(1.79)	(16.80)		(-1.16)	(-1.73)
Age (Months)	0.00926***	-0.0116***	Bayelsa	-0.106	-0.502***	Kwara	-0.329***	-0.0854
	(28.50)	(-34.66)		(-1.76)	(-6.09)		(-5.24)	(-1.25)
D2008	-0.140***	-0.290***	Benue	-0.0357	0.179**	Lagos	-0.254***	0.000763
	(-6.11)	(-12.48)		(-0.65)	(3.01)		(-4.33)	(0.01)
D2013	-0.279***	-0.262***	Borno	-0.171**	0.461***	Nassarawa	-0.0644	-0.00965
	(-12.05)	(-11.33)		(-3.11)	(8.04)		(-1.13)	(-0.15)
D2018	-0.246***	-0.136***	Cross River	-0.175**	0.0157	Niger	-0.0776	0.271***
	(-10.73)	(-5.97)		(-2.71)	(0.23)		(-1.48)	(4.71)
Constant	-1.331***	-0.980***	Delta	-0.152*	-0.383***	Ogun	-0.323***	-0.173*
	(-26.55)	(-17.84)		(-2.50)	(-4.89)		(-4.89)	(-2.31)
Observations	99,471	98,743	Ebonyi	0.0600	0.217***	Ondo	-0.138*	0.0473
				(1.09)	(3.59)		(-2.20)	(0.69)
			Edo	-0.210**	-0.400***	Osun	-0.409***	-0.0237
				(-3.28)	(-4.89)		(-5.92)	(-0.34)
			Ekiti	-0.0783	0.136*	Oyo	-0.361***	-0.00535
				(-1.22)	(1.97)		(-5.72)	(-0.08)
			Enugu	-0.0342	0.109	Plateau	-0.000370	0.147*
				(-0.55)	(1.62)		(-0.01)	(2.41)
			Federal	-0.224***	-0.0176	Rivers	-0.0692	0.0185
				(-3.59)	(-0.26)		(-1.12)	(0.27)
			Gombe	0.0725	0.719***	Sokoto	0.0952	0.267***
				(1.42)	(13.23)		(1.87)	(4.69)
			Imo	0.100	0.108	Taraba	0.0591	0.616***
				(1.67)	(1.60)		(1.15)	(11.22)
			Jigawa	0.148**	0.391***	Yobe	-0.0500	0.833***
				(2.95)	(7.08)		(-0.95)	(15.15)
			Kaduna	0.0160	0.190***	Zamfara	0.126*	-0.0356
				(0.31)	(3.37)		(2.45)	(-0.60)

Note. t statistics are shown in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.