Solid fuel use and cooking practices as a major risk factor for ALRI mortality among African children

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ABSTRACT

Background: Almost half of global child deaths due to acute lower respiratory infections (ALRIs) occur in sub-Saharan Africa, where three-quarters of the population cook with solid fuels. This study aims to quantify the impact of fuel type and cooking practices on childhood ALRI mortality in Africa, and to explore implications for public health interventions.

Methods: Early-release World Health Survey data for the year 2003 were pooled for 16 African countries. Among 32 620 children born during the last 10 years, 1455 (4.46%) were reported to have died prior to their fifth birthday. Survival analysis was used to examine the impact of different cooking-related parameters on ALRI mortality, defined as cough accompanied by rapid breathing or chest indrawing based on maternal recall of symptoms prior to death.

Results: Solid fuel use increases the risk of ALRI mortality with an adjusted hazard ratio of 2.35 (95% CI 1.22 to 4.52); this association grows stronger with increasing outcome specificity. Differences between households burning solid fuels on a well-ventilated stove and households relying on cleaner fuels are limited. In contrast, cooking with solid fuels in the absence of a chimney or hood is associated with an adjusted hazard ratio of 2.68 (1.38 to 5.23). Outdoor cooking is less harmful than indoor cooking but, overall, stove ventilation emerges as a more significant determinant of ALRI mortality.

Conclusions: This study shows substantial differences in ALRI mortality risk among African children in relation to cooking practices, and suggests that stove ventilation may be an important means of reducing indoor air pollution.

Acute lower respiratory infections (ALRIs) are responsible for close to two million, or one-fifth of, annual deaths among children under 5, representing a "permanent global emergency".[1] They comprise a set of clinical symptoms of various aetiologies and severities and include pneumonia, bronchitis and bronchiolitis.[2] It is estimated that children under 5 in developing countries suffer 0.29 ALRI episodes per child per year; ALRI incidence and mortality are highest in the neonatal period and decrease with age.[3] Sub-Saharan Africa, home to 46% of global ALRI deaths among children, is the most affected world region.[4]

Less than 20% of children with ALRIs have access to appropriate treatment.[5] Data from the USA show that childhood ALRI deaths fell by two-thirds during the first three decades of the twentieth century prior to the introduction of antibiotics or vaccines.[1] This implies that improved living conditions play a critical role in reducing ALRI morbidity and mortality.[6] Inadequate nutrition, low birth weight, lack of exclusive breastfeeding, HIV status, indoor air pollution (IAP) from solid fuel use, environmental tobacco smoke, overcrowding and lack of adequate handwashing have all been implied as potential risk factors.[7–15]

Daily exposure to IAP from household combustion of solid fuels is a fact of life for half the world's population and has been linked to a wide spectrum of health outcomes.[16 17] In sub-Saharan Africa, 77% of the population meet their basic energy needs using wood, dung, crop residues, charcoal and/or coal.[18] A systematic review by Smith *et al*[19] concluded that there is strong support for a causal link with ALRIs in children under 5 years.[19] Their meta-analysis based on eight studies yielded a relative risk of 2.3 (1.9 to 2.7) for ALRIs among children exposed to cooking with solid fuels.[20–27] A more recent meta-analysis by Dherani *et al*[28] resulted in a pooled odds ratio of 1.78 (1.45 to 2.18).

Only two of the 24 studies reviewed by Dherani *et al* considered ALRI mortality rather than ALRI morbidity as an outcome.[22 29] The World Health Survey (WHS) is the only international survey that includes information on the causes of child deaths and thus provides a unique opportunity to examine the link between fuel use, stove type, cooking location and ALRI mortality. The objective of this study is to quantify the impact of solid fuel use on childhood ALRI mortality in sub-Saharan Africa, and to explore implications for public health interventions.

METHODS

Description of World Health Survey

The WHS was conducted in 70 developing and industrialised countries in 2003 to provide low-cost, valid, reliable and comparable information on health and associated risks, and to monitor whether health systems achieve their desired goals.[30] Based on a stratified multi-stage cluster sampling design, the nationally representative sample population consists of adults over 18 years. Quality assurance procedures were implemented at all stages, ranging from the selection of survey institutions to data analysis.[30]

Early-release data are in the public domain but had to undergo additional cleaning, in particular with respect to missing values or inconsistent information for birth, death and survey dates, current age for living offspring and age at death for dead offspring. Mauritius and South Africa were excluded due to lack of information on cause of death and problems with date variables respectively; the remaining 16 countries in sub-Saharan

Africa were pooled (table 1). To reduce random recall error, all offspring born more than 10 years prior to the survey were eliminated from the sample; this 10-year time window also helps maintain a more plausible temporal relationship between exposure and health outcome. We examined recall bias through a series of logistic regression analyses and did not observe any statistically significant effect of length of recall time on the reporting of individual symptoms or combinations of symptoms, nor was solid fuel use associated with length of recall time.

Determinants of ALRIs assessed in the WHS include socioeconomic circumstances (ie, wealth based on ownership of various household assets, maternal education, urban/rural location), cooking practices (ie, main cooking fuel, stove type, presence of chimney or hood, cooking location) and heating practices (heating versus not heating, main heating fuel, stove type). The relationship between ALRI mortality and heating practices is, however, strongly confounded by geographical and climatic factors, and therefore could not be investigated further. Suitable information on other relevant risk factors is not available.

Health outcome definition

The WHS asks mothers to report on the occurrence of different symptoms prior to their child's death, including fever (768 cases), diarrhoea (330 cases), cough (307 cases), fast breathing (409 cases), chest indrawing (296 cases), convulsions (273 cases) and unconsciousness (189 cases). A priori, an ALRI definition based on cough accompanied by rapid breathing or chest indrawing most closely resembles the ALRI definition in standard verbal autopsy tools and was used throughout the analysis.[31] This combination of symptoms represents an intermediate sensitivity, intermediate specificity definition, that is it includes most but not all deaths associated with ALRIs but relatively few deaths that are primarily due to other causes. A high-sensitivity, low-specificity definition based on cough only and a low-sensitivity, high-specificity definition based on cough accompanied by rapid breathing or chest indrawing but excluding diarrhoea (a major rival cause of death or co-morbidity) were tested in sensitivity analyses.

Statistical analysis

As mortality risk is age dependent, and as the objective of this analysis is to compare children that died from ALRIs with all other children—whether they were still alive on their fifth birthday or whether they had died of other causes—survival analysis represents a suitable method.[32 33] The failure variable was defined as ALRI death prior to a child's fifth birthday; children who died of other causes were censored at their age of death. To limit the impact of digit preference at 60 months (fig 1), child deaths reported to have occurred at this age were treated as under-5 deaths. Children alive contributed their current age or a maximum of 59 months to the analysis time.

Cox proportional hazard models to examine the impact of fuel type, stove ventilation and cooking location were run in Stata Special Edition 9. O'Donnell *et al*[34] recommend not adjusting for survey design effects as a conservative strategy for multivariable analysis of household survey data. We therefore did not adjust for stratification and cluster samples and omitted sample weights. Child mortality rates in the WHS sample are substantially lower than reference rates, and as large differences in under-reporting of child mortality between countries may

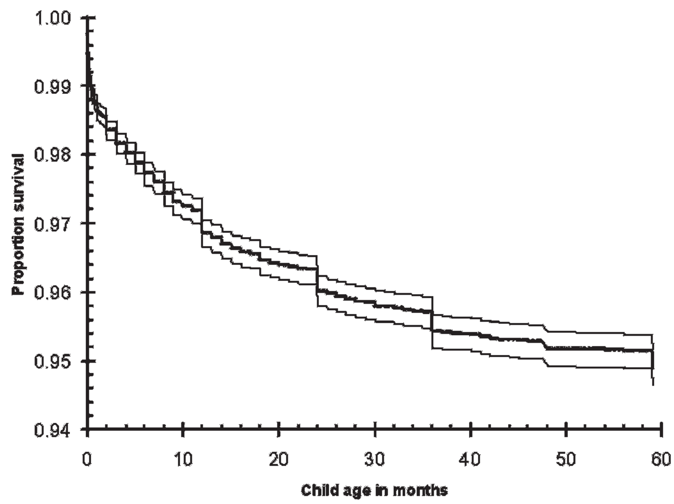

Figure 1 All-cause child mortality: child age at death.

Table 1 Sample sizes by country

Country	No. of households (response rate %)	No. of women aged 18–49 years (response rate)	No. of women aged 18–49 years with children born during last 10 years	No. children born during last 10 years
Burkina Faso	5046 (98)	2122 (99)	1629	602
Chad	5075 (95)	1909 (97)	1054	2346
Comoros	1860 (98)	636 (97)	313	698
Congo	3158 (64)	1193 (98)	553	971
Cote d'Ivoire	3298 (81)	1154 (99)	586	1052
Ethiopia	5131 (96)	2053 (99)	1355	3260
Ghana	5662 (73)	1529 (97)	991	2047
Kenya	5365 (81)	1985 (96)	1447	3197
Malawi	5727 (93(	2396 (96)	1785	3856
Mali	5445 (94)	1270 (85)	351	827
Mauritania	3929 (95)	1754 (99)	767	1656
Namibia	4656 (93)	2025 (99)	1175	2034
Senegal	3649 (69)	1205 (90)	402	809
Swaziland	3122 (54)	1323 (98)	480	956
Zambia	4350 (83)	1794 (94)	1268	2898
Zimbabwe	4343 (89)	2096 (99)	1359	2411
Total	69816	26444	15515	32620

introduce a country-specific bias, we did not weight countries according to population size. In view of non-independence due to children born to the same mother robust logistic regression was used to estimate SEs and CIs. All models were adjusted for child sex as well as wealth and maternal education as at least partly independent socioeconomic confounders; urban–rural differentials failed to be statistically significant once wealth and maternal education variables were included in the model. The impact of country identifiers was examined in a sensitivity analysis.

RESULTS

Out of 32 620 children born during the last 10 years, 1501 were reported dead with 1455 (4.46%) having died prior to their fifth birthday, giving a rate of 1.05 child deaths per 1000 child years (fig 1). Following exclusion of 6.28% of children with missing values in explanatory variables, 207 (15.13%) child deaths can be attributed to ALRIs based on the a priori definition. Table 2 illustrates differences in socioeconomic status and cooking practices between children that died of ALRIs before reaching the age of 5 and children that did not.

In a univariate model, solid fuel compared with cleaner fuel use increases the risk of dying from ALRIs with a hazard ratio of 2.50 (1.40 to 4.49); this decreases to 2.35 (1.22 to 4.52) after adjusting for wealth and education (table 3, model 1). With increasing specificity of the health outcome the effect of solid fuel use grows stronger; the association remains statistically significant when country identifiers are included (table 4).

With an adjusted hazard ratio of 1.25 (0.46 to 3.39), burning solid fuels in a well-ventilated stove is associated with ALRI mortality rates similar to those among children living in households cooking with cleaner fuels. On the other hand, with an adjusted hazard ratio of 2.68 (1.38 to 5.23) relative to cleaner fuels, children are at much greater risk of dying from ALRIs if they reside in households that cook with solid fuels on an open fire or stove in the absence of a chimney or hood

Table 2 Socioeconomic factors and household energy practices

n	Children born during last 10 years (n = 30365)	No ALRI death under 5 (n = 30158) n (%)	ALRI death under 5 (n = 207) n (%)
	Geographic location		
9036	Urban	8993 (29.82)	43 (20.77)
21329	Rural	21165 (70.18)	164 (79.23)
	Maternal education		
19418	None	19269 (63.89)	149 (71.98)
7158	Primary	7120 (23.61)	38 (18.36)
3789	Secondary/higher	3769 (12.50)	20 (9.66)
	Wealth		
6030	Quintile 1 (poorest)	5974 (19.81)	56 (27.05)
6074	Quintile 2	6029 (19.99)	45 (21.74)
6062	Quintile 3	6021 (19.96)	41 (19.81)
6099	Quintile 4	6068 (20.12)	31 (14.98)
6100	Quintile 5 (richest)	6066 (20.11)	34 (16.43)
	Main cooking fuel		
3344	Gas, electricity	3332 (11.05)	12 (5.80)
652	Kerosene	652 (2.16)	0 (0.00)
524	Coal	520 (1.72)	4 (1.93)
3369	Charcoal	3343 (11.08)	26 (12.56)
21691	Wood	21530 (71.39)	161 (77.78)
785	Crop residues, dung	781 (2.59)	4 (1.93)
	Cooking with solid fuels*		
3996	Cleaner fuels	3.984 (13.21)	12 (5.80)
26369	Solid fuels	26174 (86.79)	195 (94.20)
	Cooking stove ventilation		
3996	Cleaner fuels	3984 (14.64)	12 (6.25)
2055	Solid fuels with chimney	2047 (7.52)	8 (4.17)
21353	Solid fuels without chimney	21181 (77.84)	172 (89.58)
	Cooking location		
3996	Cleaner fuels	3984 (13.38)	12 (5.85)
8487	Solid fuels outdoors	8435 (28.33)	52 (25.37)
17491	Solid fuels indoors	17350 (58.28)	141 (68.78)

*This binary variable is the dichotomous equivalent of the variable main cooking fuel.
ALRI, acute lower respiratory infection.

Table 3 Cox proportional hazard models of acute lower respiratory infections (ALRIs) mortality: solid fuel use and cooking practices

	Hazard ratio (95% CI)	p Value
Model 1: Cooking with solid fuels		
Univariate model*		
Cleaner fuel use	1.00	–
Solid fuel use	2.50 (1.40 to 4.49)	0.002
Multivariable model†		
Cleaner fuel use	1.00	–
Solid fuel use	2.35 (1.22 to 4.52)	0.011
Model 2: Cooking stove ventilation		
Univariate model*		
Cleaner fuels	1.00	–
Solid fuels with chimney/hood	1.30 (0.50 to 3.40)	0.587
Solid fuels without chimney/hood	2.73 (1.52 to 4.91)	0.001
Multivariable model†		
Cleaner fuels	1.00	–
Solid fuels with chimney/hood	1.25 (0.46 to 3.39)	0.667
Solid fuels without chimney/hood	2.68 (1.38 to 5.23)	0.004
Test for trend across ordered groups	–	<0.001
Model 3: Cooking location		
Univariate model*		
Cleaner fuels	1.00	–
Solid fuels outdoors	2.10 (1.12 to 3.97)	0.022
Solid fuels indoors	2.71 (1.50 to 4.98)	0.001
Multivariable model†		
Cleaner fuels	1.00	–
Solid fuels outdoors	1.96 (0.95 to 4.06)	0.070
Solid fuels indoors	2.48 (1.29 to 4.77)	0.006
Test for trend across ordered groups	–	<0.001
Model 4: Cooking stove ventilation and cooking location		
Univariate model*		
Cleaner fuels	1.00	–
Solid fuels with chimney/hood outdoors	1.42 (0.30 to 6.81)	0.662
Solid fuels with chimney/hood indoors	1.03 (0.33 to 3.17)	0.962
Solid fuels without chimney/hood outdoors	2.25 (1.18 to 4.30)	0.014
Solid fuels without chimney/hood indoors	2.96 (1.63 to 5.36)	<0.001
Multivariable model†		
Cleaner fuels	1.00	–
Solid fuels with chimney/hood outdoors	1.42 (0.27 to 7.31)	0.678
Solid fuels with chimney/hood indoors	0.94 (0.30 to 2.91)	0.911
Solid fuels without chimney/hood outdoors	2.16 (1.03 to 4.56)	0.043
Solid fuels without chimney/hood indoors	2.85 (1.46 to 5.57)	0.002

*Adjusted for sex of child.
†Adjusted for sex of child, wealth and maternal education.

Table 4 Impact of solid fuel use relative to cleaner fuel use on child mortality: sensitivity to different outcome definitions

	Number of deaths	Hazard ratio, adjusted for sex of child (95% CI)	Hazard ratio adjusted for child sex, wealth and maternal education (95% CI)	Hazard ratio adjusted for child sex, wealth, maternal education and country (95% CI)
Child mortality due to cough (high-sensitivity, low-specificity)	307	2.47 (1.53 to 3.99)	2.06 (1.21 to 3.52)	1.94 (1.09 to 3.46)
Child mortality due to ALRI (intermediate sensitivity, intermediate specificity)	207	2.50 (1.40 to 4.49)	2.35 (1.22 to 4.52)	2.44 (1.21 to 4.95)
Child mortality due to ALRI and excluding diarrhoea (low sensitivity, high specificity)	114	3.37 (1.37 to 8.26)	3.23 (1.18 to 8.81)	3.80 (1.24 to 11.61)

(table 3, model 2). The hazard ratios also suggest that outdoor cooking is less harmful than indoor cooking with respect to child mortality (table 3, model 3).

When stove ventilation and cooking location are combined in the same model (table 3, model 4), the presence of a chimney or hood emerges as the more important feature: whether cooking with solid fuels on a well-ventilated stove is undertaken indoors or outdoors it is not substantially different from cooking with cleaner fuels. In contrast, burning solid fuels without a chimney or hood is associated with an adjusted hazard ratio of 2.16 (1.03 to 4.56) when undertaken outdoors and of 2.85 (1.46 to 5.57) when undertaken indoors (table 3, model 4).

DISCUSSION

Key findings

This research suggests that cooking with solid fuels more than doubles the risk of ALRI mortality among children under 5, contributing to the limited literature on this topic. The hazard ratios reported here are roughly similar to an OR of 2.78 (1.79 to 4.33) for ALRI mortality among children that sleep in a room where cooking is done, observed in a Tanzanian case–control study.[29] A matched case–control study in the Gambia found an odds ratio of 5.23 (1.72 to 15.92) for ALRI mortality among children who were always carried on their mother's back during cooking.[22] This substantially higher odds ratio does, however, apply to children who died before their second birthday, the age group with the highest ALRI incidence. The findings reported in this paper are also consistent with the twofold increased relative risk obtained in two meta-analyses of the impact of solid fuel use on ALRI morbidity,[19 28] and are thus in agreement with the large African burden of disease attributable to solid fuel use, as modelled by the World Health Organization's comparative risk assessment.[19]

More important, this research has, for the first time, demonstrated substantial differences in children's ALRI mortality risk profiles in relation to cooking practices. In particular, it implies the lack of a chimney or hood as a critically important and remediable risk factor. Indeed, much of the increased ALRI mortality risk among solid fuel users in general may be attributable to the group burning solid fuels in a poorly ventilated stove. Cooking location, by comparison, appears to play a less important role. Moreover, it is not clear how the term outdoor cooking is defined in time (all year vs seasonal, all vs some meals) and space (outdoor vs semi-open structures). Among solid fuel users, children living in families that cook on a well-ventilated stove indoors show the lowest ALRI mortality risk, being 80% rural and with relatively high wealth and education scores this group appears to represent the rural privileged. In contrast, the urban privileged are more likely to use cleaner fuels than well-ventilated stoves.

These findings are biologically plausible as relatively lower concentrations of key pollutants, such as fine particulates (PM_{10}, $PM_{2.5}$) and carbon monoxide (CO), are associated with fuel types located relatively higher on the "energy ladder", cleaner-burning stoves and better stove ventilation.[35 36] Concentrations of particulate matter in South Asian households were also found to be significantly correlated with kitchen location, fuel quantity and room ventilation practices.[37 38]

Strengths and weaknesses

An inherent limitation of cross-sectional data is their snapshot nature, which makes the establishment of a temporal sequence of events impossible. Furthermore, the WHS sampling strategy is devised to be representative of households but *not* of women of reproductive age and their offspring. Any findings obtained for child mortality can therefore not be considered nationally representative. This is likely to be one of the reasons why the WHS child mortality rates for the 10-year period from 1993 to 2003 (7–79 per 1000 live births for different countries) are much lower than reference rates (77–233 per 1000 live births[39] and 65–220 per 1000 live births[40] for the same countries). Despite high response rates, a birth history truncated at eight children per woman and more complete recall of information about living children than about dead children are likely to introduce selection bias. Yet, the ability to pool large, comparable household survey datasets with cause-of-death information presents a rare opportunity to examine the relationship between cooking practices and ALRI mortality across countries where vital registration systems and health surveillance are either non-existent or patchy. While the results obtained for 16 countries cannot necessarily be generalised to all of sub-Saharan Africa, the pooled sample represents a variety of living conditions and a large percentage of the African population.

Several major risk factors for ALRIs, in particular malnutrition, HIV status and environmental tobacco smoke, could not be adjusted for. Therefore, our results are likely to overestimate the true impact of cooking practices on ALRI mortality. On the other hand, the limited impact of adjustment for wealth and education suggests that factors connected to socioeconomic status do not have a major confounding effect. In addition, the graded effect observed in relation to solid fuel use in the presence or absence of stove ventilation and depending on cooking location supports the notion that our findings are not merely an artefact.

This research has used the combination of a household's primary cooking fuel, stove and cooking location as a relatively imprecise exposure proxy. Moreover, homes in many developing countries use multiple fuels and stoves. On the other hand, the two published ALRI mortality studies and all but two of the ALRI morbidity studies included in two meta-analyses did also not assess concentrations of pollutants or a child's exposure but relied on even more imprecise binary exposure proxies.[19 28] Large random error due to an imprecise exposure measure will underestimate the true strength of the relationship between exposure and health outcome. While the assumption that

What is already known on this subject

- The majority of children suffering from ALRIs, in particular those living in sub-Saharan Africa, do not have access to healthcare.
- This emphasises that preventive measures must complement curative approaches towards reducing disease and death caused by the biggest killer of children under 5.
- Indoor air pollution from solid fuel use is a known risk factor for ALRIs.

What this study adds

- This study represents the first cross-sectional analysis of the impact of cooking practices on ALRI mortality among children in different African countries, contributing to the limited evidence of solid fuel use as a risk factor for child mortality.
- Most importantly, it suggests that stove ventilation may be a critical determinant of risk, and points to chimneys and smoke hoods and, to a lesser extent, outdoor cooking, as potentially effective interventions to reduce ALRI mortality.

household energy practices are stable over a 10-year period does not necessarily hold true, there is no reason to suspect differential misclassification, and the impact of solid fuel use on ALRI mortality is thus likely to be biased towards the null.

The WHS questionnaire includes elements of a verbal autopsy, but the interview may take place up to 10 years after a child's death and cannot draw on open-ended questions to clarify contradictory information. As illustrated by many missing values, a 10-year recall period results in difficulties with remembering a child's age at death, and will make the reliability of reported symptoms questionable. Differential recall, probably exacerbated by a truncated birth history, is likely to produce systematic under-reporting of child mortality by women with more offspring and/or less education. As traditional household energy practices are more widespread among lower socioeconomic groups, this is likely to bias the association between solid fuel use and ALRI mortality towards the null. Even standardised verbal autopsy tools, conducted as an interview with the child's mother or caregiver shortly after death, are not without flaws.[41–43] On the other hand, Williams *et al*[44] estimate that 22% of child deaths in sub-Saharan Africa are caused by ALRIs. Being responsible for approximately 15% of child deaths in the WHS sample, our a priori definition of ALRI mortality neither represents an overestimate of the contribution of ALRIs to total child deaths nor a gross underestimate. Importantly, the sensitivity analysis documents a clear increase in unadjusted and adjusted hazard ratios with greater specificity of the health outcome (table 4). This lends support to the validity of the finding that solid fuel use and cooking practices impact ALRI mortality.

Implications of study

No intervention study has yet analysed the impact of a chimney stove on IAP levels and child health outcomes in Africa. Increasing evidence from other world regions points to such stove ventilation as an effective intervention. In particular, the RESPIRE (Randomised Exposure Study of Pollution Indoors and Respiratory Effects) randomised controlled trial conducted in Guatemala found a 44% average reduction of children's CO exposure and a substantial protective effect of the *plancha* stove on ALRI morbidity among children under 18 months.[45 46] Recent intervention studies have demonstrated reductions in 48-h average kitchen concentrations of $PM_{2.5}$ and CO following the installation of local chimney stoves in India and Mexico.[47–49] In Pune, India, approximately 30% of chimneys were found to be clogged, emphasising the need for regular chimney cleaning and stove maintenance.[48] The only published African intervention study, which measured IAP levels before and after the installation of a smoke hood in Kenyan Masai homes, reported 75% reductions in 24-h averages of $PM_{3.5}$.[50]

This is where the present analysis, although derived from a cross-sectional dataset with reliability and validity problems, adds to the evidence base. Our findings suggest substantial differences in childhood ALRI mortality between homes cooking on a chimney stove and homes cooking on an open fire or stove. They point to the significant potential of chimneys and hoods and, to a lesser extent, outdoor cooking as low-cost technical solutions towards preventing avoidable deaths in Africa—the continent counting the greatest number of childhood ALRI deaths attributable to solid fuel use.[18]

Unanswered questions and future research

IAP from solid fuel use remains a heavily under-researched field. Our analysis highlights the need to improve survey-based assessments. While case–control studies are likely to be the best design for studying ALRI mortality among children, regularly administered cross-sectional surveys, such as the Demographic and Health Surveys or the Multiple Indicator Cluster Survey, could provide a much richer source of information if they assessed causes of death, using standardised tools quantitatively validated in different settings. Similarly, the questionnaire-based assessment of exposure to IAP could be refined, particularly in relation to the use of multiple fuels and stoves, a child's location during cooking and better information on outdoor cooking.

This article also draws attention to how little is known about the role of heating with solid fuels. Future research should investigate this issue based on better exposure measures, such as heating duration per day and over the course of a year. This will be particularly relevant to those populations, where geographical and climatic conditions demand heating for prolonged periods of time and where ventilation is limited.

Finally, it is high time to conduct an intervention trial in sub-Saharan Africa. Efficacy trials represent a logical next step and a means of quantifying how cleaner cooking fuels, improved stoves or smoke hoods affect exposure to IAP and respiratory health among African children. Effectiveness trials, on the other hand, reveal how much health impact an improved stove can achieve under real-life conditions, for example, when a national programme provides incentives for households to purchase an improved stove. If effective interventions were to be implemented through a suitable delivery mechanism and in a sustainable way, they could make a critical contribution to fighting the biggest killer of children under 5 in the world region where it exerts its greatest toll.

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