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Luciane Lenz, Laura Montenbruck, and Maximiliane Sievert[1]

Accidents Caused by Kerosene Lamps – New Evidence from African Household Data

Abstract

The use of kerosene for lighting, cooking, and heating in developing countries is often considered a major health threat as it can cause accidents like thermal injuries, poisonings, fires or explosions. A number of hospital surveys emphasize this threat but evidence from household data is extremely scarce and mostly outdated. The present paper is one of the first to investigate the link between kerosene-based lighting and accidents at the household level. We use survey data from 3,326 non-electrified households in Burkina Faso, Rwanda, Senegal, and Zambia and observe very heterogeneous kerosene lamp usage rates. In some regions, accidents with kerosene lamps occur in a substantial share of the population, but the absolute incidence is rather low.

JEL Classification: I15, K32, O13

Keywords: Burns; thermal injury; kerosene lamp; traditional lighting; Sub-Sahara Africa

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1. Introduction and literature

Globally around 1.2 billion people without electricity access light their homes with kerosene lamps (WHO, 2014). Kerosene is an easily accessible but highly flammable fuel, often accused of causing poisonings, fires, explosions, and in particular thermal injuries, or so-called burns (see for example The Economist, 2015). The source of accidents are malfunctioning appliances, fuel adulteration, poisoning through accidental ingestion, in particular by children, or generally improper appliance use, such as unstable placement of lamps.

The World Health Organization (WHO, 2011, 2016) argues that "the use of kerosene (paraffin) stoves and lanterns […] are major risk factors for burn injuries" and that "millions of people suffer burns from using kerosene lamps every year". At the same time, the WHO raises concerns, stating that "evidence that household kerosene use presents a substantial safety risk [is of] moderate quality".

Studies to substantiate these risks rely mostly on data from hospitals and health centers. Studies looking at burns find that kerosene related accidents account for a considerable share of thermal injury admissions (Ghaffar et al. 2008, Shanmugakrishnan et al. 2008, Liu et al., 1998, Dongo et al. 2007 and Laloë 2002).[1] Other surveys of health facilities stress a risk of kerosene ingestion (for example Malangu and Ogunbanjo 2009).[2] These results suggest substantial health costs to households and society from accidents related to kerosene use. However, the few studies available that rely on household data provide less alarming results, reporting burn incidences within one year among 2.6 percent of households surveyed in Bangladesh (Mashreky et al. 2009) and 4.2 percent in South-Africa (Matzopoulos et al. 2006). To our best knowledge, there are no additional surveys on the risk of kerosene

[1] Please see Table A1 in the annex for a comprehensive literature review of thermal injuries from kerosene use. Also see Mills (2012, 2016) for literature overviews on the health and safety impacts of fuel-based lighting.

[2] See Table A2 in the annex for an overview of studies on kerosene ingestion, limited to studies that started after 1995.

ingestion or explosions based on household data. [3]

This paper provides a descriptive analysis of cross-country kerosene usage for lighting and the number of accidents it provokes using data from 3,326 rural households in Burkina Faso, Rwanda, Senegal, and Zambia.

2 Data and methods

Our analysis relies on household data from Burkina Faso, Senegal, Rwanda and Zambia, that was collected between 2010 and 2014. The data stems from comprehensive evaluation studies of rural electrification interventions that provide detailed information on households' energy consumption and socio-economic characteristics.[4] None of the surveyed households had access to electricity or other modern lighting sources, such as grid connection, solar home systems, or car batteries. Hence, we observe households that depend on traditional energy – including kerosene - as their main source. A total of 3,326 households has been representatively sampled from two to 50 villages per country.[5]

Our main outcome variable is based on the survey question "How many accidents caused by the fire of kerosene lamps occurred in the last 12 (6) months?"[6] Hence, the data we use is self-reported and the survey question captures different types of fire-related accidents, potentially involving thermal injuries or property damages.[7] For an illustration of kerosene lamps typically used in the areas, see Figure 1.

[3] Note that there is some evidence on the effect of kerosene-based cooking or heating on thermal injuries and ingestion. It is not covered by our literature overview, as we cannot provide evidence on accidents from kerosene-based cooking or heating here. Nevertheless, very few households in our sample actually cook with kerosene: rates range between zero percent in Senegal and 2.1 percent in Burkina Faso. No data is available for Zambia. Heating is generally not practiced.

[4] Corresponding more comprehensive analyses of the data sets have been published as shown in Annex Table A3.

[5] Key features of all surveys are summarized in the annex Table A3 and A4.

[6] Only in Senegal people gave their retrospective answers for a 6 months period. To harmonize answers across the studies, we multiply the number of burns per household in Senegal by two.

[7] Note that the survey question does not capture cases of kerosene ingestions.

Figure 1: Lighting devices based on kerosene

Hurricane lamp	Traditional tin lamp
	

Source: Own illustration

3. Results

We observe very heterogeneous ownership rates of kerosene lamps across countries (see Table 1). Kerosene lamps are most common in Rwanda, where almost two thirds of the surveyed households possess a hurricane or a tin lamp. The majority of Senegalese households, by contrast, have abandoned kerosene lamps and use battery driven LED lamps instead (not shown).

Table 1: Kerosene lamp possession, number of lamps per household (conditional on lamp ownership), and daily lighting hours per lamp, by country

Country	N	Share of households with lamp	Mean number of lamps	Mean daily lighting hours
Burkina Faso	799	0.31	2.24	5.60
Rwanda	1,744	0.64	1.31	2.94
Senegal	687	0.05	2.41	4.39
Zambia	96	0.19	1.33	2.69

Note: For details on data source see Annex Table A3.

Among households that possess kerosene lamps, the absolute number of lamps is highest in Burkina Faso and Senegal. This is mainly due to the bigger household size in these countries. Taking into account household size, the number of lamps per household member is more homogenous across countries, ranging between 0.22 and

0.34 (not shown).[8] The lamps are few in absolute numbers but used substantially, as reflected in their daily lighting hours.

The share of kerosene lamp using households that experienced accidents within the last 12 months ranges between zero percent in Zambia and ten percent in Rwanda (see Table 2). However, the absolute number of accidents per households is rather low in all countries, peaking at seven accidents in one household within 12 months (not shown).[9] To further illustrate this: among 1,744 Rwandan households, 1,116 use kerosene lamps and 103 experienced on average 1.8 accidents in one year. Note that these accident numbers refer to the whole household and include accidents involving young children, often suspected as particularly affected. The magnitude of the problem is substantially lower in Burkina Faso and close to zero in Senegal and Zambia.[10]

Table 2: Accident experience and number of accidents (among lamp owners with positive kerosene consumption), and number of accidents conditional on accident, within preceding 12 months, by country

Country	N	Share of households with accident	Mean number of accidents	Conditional mean number of accidents
Burkina Faso	133	0.06	0.05	1.5
Rwanda*	1,062	0.10	0.18	1.8
Senegal	25	0.08	0.07	1.0
Zambia	18	0.00	0.00	-

*Note: *Values for Rwanda exclude one outlier household with 61 accidents within the 12 months preceding the survey. For details on data source see Annex Table A3.*

One might expect the number of accidents to be related to the regularity of using a lamp. Higher usage might create higher risk due to higher exposure, but also less risk due to learning effects from frequent use. These two effects might also cancel each other out. Furthermore, the type of lamp used might affect the number of accidents. Tin lamps, for instance, are often less stable than hurricane lamps. However, we do not observe these correlations in the data.

[8]The average household size is 12.8 in Senegal, 9.3 in Burkina Faso, 5.0 in Rwanda and 3.9 in Zambia.
[9] Excluding one outlier household in Rwanda that states having experienced 61 accidents over the last 12 months.
[10]These numbers are in line with the household surveys by Mashreky et al. (2009) and Matzopoulos et al. (2006).

4. Conclusion

In spite of scarce empirical household evidence, there is a perception that kerosene lamps pose a major risk to health. Statements as "burns, scalds and house fires caused by tipped-over kerosene lamps and heaters are sadly common" (WHO, 2016) raise debates on how to combat this risk. Schwebel et al. (2009), for instance, emphasize the urgent need for interventions to foster safety knowledge and practices.

We call for considering two arguments, before making investments into paraffin safety interventions. First, hospital surveys that are the basis of most evidence cannot quantify the actual size of the problem given the non-representativeness of a hospital population. Our household data analysis is less alerting. We find that kerosene lamp usage varies strongly, but is still substantial among some rural households. We observe heterogeneous accident rates (between zero and ten percent) among kerosene lamp users, most likely being burns, or fire related property damages. The number of total accidents per year is very low, though. Altogether, most people seem to act with caution or to apply safe practices, potentially resulting from households' long-standing experiences in handling kerosene and the appliances it still powers.

Second, African households increasingly replace kerosene lamps with LED lamps without external incentive (Bensch et al. 2015). LED lamps are widely available at reasonable prices, providing less harmful and brighter light than traditional lamps. These developments are likely to futher reduce the size of the problem over time. Such time trends are even more important to note, as the evidence available comes mostly from the 1980s and 1990s – times since which great changes in fuel and appliance use occurred.

Additional to the household surveys used in this paper, we have conducted a wide range of surveys in the past 10 years on energy access in poor and rural Eastern and Western Africa, including in-depth interviews with public health institutions and household focus group discussions on questions related to fuel and lighting use.[11]

[11] For survey examples see Table A3 in the annex.

While households frequently complain about kerosene's bad smell and scorpion bites due to insufficient lighting, accidents have hardly been mentioned. The qualitative, anecdotal evidence confirms that the problem of kerosene-related injuries and damages might be somewhat smaller than widely believed.

Appendix

Table A1: Impact studies on kerosene burns

Author	Country	Type of study	Study period	Sample Size	Share of kerosene lamp burns to total burns
Mashreky et al. 2009	Bangladesh	Household survey	January - December 2003	171366 households, 819429 individuals (1362 burn injuries)	2.6% (≙ 7% of flame burns)
Jayaraman et al. 1993	India	Medical study	May 1987 - April 1988	1368 burns	9.1%
Singh et al. 1998	India	Medical study	1971 - 1996	729 burn deaths (21 - 40 age group)	3.16%
Kumar et al. 2000	India	Medical study	1989 - 1998	309 burn injuries among children	14.6%
Mukerji et al. 2001	India	Medical study	1993 - 1999	110 burns of children aged 0 to 14 years	10.0% (includes fire, matches, candles, kerosene lamps and other non-specifies reasons)
Ahuja and Bhattacharya 2002	India	Medical study	January 1993 - December 2000	11196 burns	2.5% of the over 16 years olds
Shanmugakrishnan et al. 2008	India	Medical study	100 day period	150 burns	6.8% (out of 103 for which the reason is given/known)
Kanchan et al. 2009	India	Medical study	1994 - 2007	75 fatal unintentional injuries of children aged 10 years and below	9.3%
Ghaffar et al. 2008	India	Medical study	July 2005 - July 2007	403 burn cases	14.2%
Gupta et al. 1996	India	Medical study	February - April 1994	303 burn cases, 118 severe ones	all burns due to contaminated kerosene, 37 out of 118 severe burns were followed by death
Soltani et al. 1998	Iran	Medical study	March 1994 - March 1995	1239 burns	most common cause of burns and death was kerosene
Lari et al. 2000	Iran	Medical study	1995 - 1998	3341 burn patients	10.8% (due to kerosene in general)
Barradas 1995	Mozambique	Medical study	1988 - 1991	7985 burn patients	44.7% of 76 deaths (kerosene or petrol lamp, 1989-1990)
Liu et al. 1998	Nepal	Medical study	3 year period	237 burns	20% (lamps, mostly driven by kerosene)
Oduwole et al. 2003	Nigeria	Medical study	October - November 2001	139 kerosene burns (contaminated kerosene)	96.4%
Dongo et al. 2007	Nigeria	Medical study	January 2002 - December 2006	72 burn admissions	31.9% (lanterns and stoves)
Olaitan et al. 2007	Nigeria	Medical study	2000 - 2004	36 burn injuries	19.4% (lamp and stove explosions)
Asuquo et al. 2008	Nigeria	Medical study	February 2005 - January 2008	59 burns	32.2% (lantern and stove explosions)
Oludiran et al. 2009	Nigeria	Medical study	January 2002 - December 2006	62 burns (children aged 0 - 16 years)	51.6% (lantern/ stove explosions)
Matzopoulos et al. 2006	South Africa	Household survey	April 2002	404 households	2.72% reported paraffin-related fires, 4.21% paraffin-related burns
Laloë 2002	Sri Lanka	Medical study	July 1999 - June 2001	345 burn injuries, 221 unintentional	41.18% of unintentional burns

Author	Country	Type of study	Study period	Sample Size	Share of kerosene lamp burns to total burns
Shepherd and Perez 2008	Sri Lanka	Estimation of yearly values	-	-	40% of the burns in Sri Lanka attributed to kerosene bottle lamps, 150 to 200 deaths per year
Peck et al. 2008	Sri Lanka	Personal communication	1998 - 1999	487 burn patients (12 years and older)	31.0% (unintentional)

Table A2: Impact studies on kerosene ingestion

Author	Country	Type of study	Study period	Sample Size	Share of poisonings among admissions
Malangu (2008a)	Botswana	Medical study	January - June 2005	116 admissions due to poisoning to two hospitals	Poisoning by household chemicals, particularly paraffin, affected mainly children under 12
Clarke (2004)	Ghana	Evaluation at Poisoning Center	2002 - Obtober 2003	22 cases of poisoning reported	accidental ingestion of kerosene (paraffin) among children aged 6 years and below which accounted for 17% of enquiries
Gupta et al. (1998)	India	Medical study	1989, 1991, 1993	185 children admitted due to poisonings	47% of poisonings due to kerosene, 6 deaths
Kohli et al. (2008)	India	Medical study	July 2004 - July 2006	111 children with poisonings	27.9% of poisonings due to kerosene
Majeed et al. (2016)	India	Medical study		205 children	all with kerosene poisoning
Raizada (2012)	India	Medical study	3-year period	584 cases of poisoning	
Shotar (2005)	Jordan	Medical study	January 1996 - December 2001	122 children	all with kerosene poisoning
Lang et al. (2008)	Kenya	Medical study	January 2005 - December 2006	48 children admitted with accidental kerosene poisoning	$\triangleq$ 62% of all poisoning cases
Chibwana et al. (2001)	Malawi	Medical study	January - December 1998	144 cases of poisoning (children aged 3 months to 14 years)	16.7% due to paraffin
Khadka and Ale (2005)	Nepal	Medical study	April 2001 - March 2003	67 cases of poisoning	kerosene responsible for 13.4% of child poisonings
Belonwu and Adeleke (2008)	Nigeria	Medical study	January 1999 - December 2005		kerosene poisoning constituted 1.2% (55 cases) of all paediatric admissions
Balme et al. (2012)	South Africa	Medical study	2003 - 2008	2872 children with poisoning	paraffin (kerosene) was the commonest agent (n=692, 24%)
Malangu et al. (2005)	South Africa	Medical study	January 2000 - June 2001	145 children	all admitted with paraffin poisoning
Malangu and Ogunbanjo (2009)	South Africa	Medical study	January - June 2005	424 patients with poisonings in eight different hospitals	Household chemicals were the most commonly implicated poisons (45.7%). Among the household chemical agents, paraffin was the most commonly ingested (26.9%)
Reed and Conradie (1997)	South Africa	Medical study		111 children under 5 years	all with kerosene poisoning, constitutes 9.1% of total ward admissions in this age group
Pillai et al. (2004)	Trinidad	Medical study	January 1998 - December 2000	169 cases of poisoning	Kerosene responsible for 19.5%

Author	Country	Type of study	Study period	Sample Size	Share of poisonings among admissions
Malangu (2008b)	Uganda	Medical study	January - June 2005	276 cases of poisoning	household chemicals responsible for 22.1%
Tagwireyi et al. (2006)	Zimbabwe	Medical study	January 1998 - December 1999	327 admissions over eight different hospitals	all due to kerosene ingestion (≙ 11.8% of poisoning admissions)

Table A3: Evaluation Studies and Related Publications

Study	Publications
Burkina Faso YB	Bensch, G., M. Grimm, J. Langbein, and J. Peters (2013), The provision of solar energy to rural households through a fee-for service system. Public Private partnership GDIS-NUON. Implemented by FRES and the local company Yeelen Ba. Final Report on behalf of the Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs.
Rwanda Peripher y 2012	Grimm, M., A. Munyehirwe, J. Peters, M. Sievert (2014) A First Step up the Energy Ladder? Low Cost Solar Kits and Household's Welfare in Rural Rwanda. IZA Discussion Paper Series. IZA DP No. 8594. IZA, Bonn. Available at [http://ftp.iza.org/dp8594.pdf] Grimm, M., J. Peters, M. Sievert (2013), Impacts if Pico-PV Systems usage using a Randomized Controlled Trial and Qualitative Methods. Final Report on behalf of the Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs. Available at [http://www.iob-evaluatie.nl/resources/impacts-pico-pv-systems-usage-using-randomised-controlled-trial-and-qualitative-methods]
Rwanda 2013	Peters, J., M. Sievert, A. Munyehirwe, and L. Lenz. (2014) The provision of grid electricity to households through the Electricity Access Roll-out Programme. Final Report on behalf of the Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs. Available at [http://www.iob-evaluatie.nl/EARP]
Senegal ERSEN	Bensch, G., J. Peters, and M. Sievert (2011), Report on ERSEN Baseline Study. Baseline report on behalf of the German Technical Cooperation (GTZ).
Senegal ENERSA	Baseline data collection for Impact Evaluation of ENERSA S.A. on behalf of the Dutch Development Company, FMO.
Zambia UNIDO	Neelsen, S., J. Peters, and G. Bensch (2011), Renewable Energy Based Electricity Generation for Isolated Mini-Grids, Zambia. Baseline Report on the GEF project on behalf of the United Nations Industrial Development Organization (UNIDO).

Table A4: Studies and surveys used in this paper

Study[1]	Year of collection	Sample size	Sample Selection	Location
Burkina Faso	2010	799	40 villages representative for Kénédougou province	Rural area with slightly above-average income opportunities due to cotton farming
Rwanda I	2011	307	15 villages, random sample in the country's off-grid periphery	Very remote rural areas
Rwanda II	2011	1437	50 villages, representative sample of rural areas with electrification activities	Nationally representative
Senegal I	2011	375	21 villages in Peanut Basin and Casamance selected by electrification project	Remote rural area, partly above-average soil fertility
Senegal II	2014	312	45 villages in Thiès area and Peanut Basin selected by electrification project	Average to remote rural area, partly relatively well connected
Zambia	2011	96	Two villages [selected by electrification project] located close to planned small hydropower plant	Remote rural area with above-average incomes due to large farming and tourist facilities

[1] Complete references of reports and papers presenting findings of these studies can be found in the Annex.

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