Energy as a key variable in reducing child mortality: A gender and energy perspective on empirical evidence on MDG 4[1]

Discussion Paper

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[1] This report is an output of the Collaborative Research Group on Gender and Energy (CRGGE) with support from the ENERGIA International Network on Gender and Sustainable Energy and the United Kingdom Department for Internati(DfID) KaR research project R8346 on "Gender as a Key Variable in Energy Interventions" For more information and other publications of the CRGGE and the DfID , see www.energia.org/crgge

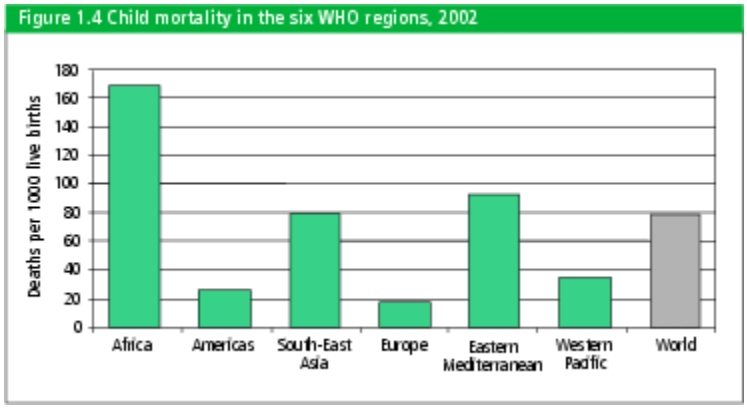
Key words
Biomass, child mortality, energy, gender, health, poverty

1. Introduction

An overview of child mortality in developing countries

The World Health Organisation defines child mortality as deaths of children under the age of five (WHO, 2003). About 10.5 million children under 5 years of age die every year globally (WHO,2003). Of these, 1.5 to 2.5 million infants who die in their first week of life and 4 million infants die in the first four weeks of life. An estimated 88% of these infant and child deaths occur in developing countries, mainly confined to the world's 42 lowest-income countries (WHO, 2003), in Sub-Saharan Africa, Eastern Mediterranean and South Asia (Figure 1). In terms of gender, studies generally indicate that child mortality is higher in males than in females, with a few exceptions such as in China, India, Nepal and Pakistan, where mortality in girls exceeds that of boys because of the preferential treatment of boys in family health care-seeking behaviour and in nutrition (WHO, 2003).

Figure 1: Whose baby is dying? Where? A global picture of child mortality



Source: WHO, 2003

Perinatal conditions, malnutrition, diarrhoea, pneumonia, neonatal conditions (Table 1) and in some areas HIV/AIDS are the most important causes of childhood mortality worldwide (WHO, 2003).

Table 1: Leasing causes of deaths of children in developing countries in 2002

Rank	Cause	Numbers (000)	% of all deaths
1	Perinatal conditions	2 375	23.1
2	Lower respiratory infections	1 856	18.1
3	Diarrhoeal diseases	1 566	15.2
4	Malaria	1 098	10.7
5	Measles	551	5.4
6	Congenital anomalies	386	3.8
7	HIV/AIDS	370	3.6
8	Pertussis	301	2.9
9	Tetanus	185	1.8
10	Protein-energy malnutrition	138	1.3
	Other causes	1 437	14.0
	Total	**10 263**	**100**

Source: WHO, 2003

The millennium development goals (MDGs), agreed upon by 191 countries in September 2000, aim to reduce the child mortality by two-thirds between 1990 and 2015. .

Improving child health and reducing child mortality has been the subject of research and various global initiatives for decades. Past research has concentrated on the various linkages between poverty and child and maternal health. According to the World Health Organisation, the children are most at risk of dying if they are poor and most impressive declines in child mortality have occurred in developed countries, and in low-mortality developing countries whose economic situation has improved (WHO, 2003). This trend suggests that child survival is dependent on, among other things, the availability (access and affordability) of health goods and services, which populations of poor countries are unable to access or afford. Research has particularly focussed on linkages between poverty and health in terms of provision of essential health goods and services such as vaccines, well equipped health clinics and health personnel, health care information, portable and clean water, improving food security and nutrition and improving access to health care facilities. Improving nutrition of mother (and therefore foetus) and child, immunising children against deadly diseases, providing clean water, encouraging breast feeding and providing adequate health care are some of the ways identified as critical to reducing child mortality. In order to provide these required goods and services supporting infrastructure needs to be available, robust and functional. Some studies have also assessed linkages between gender inequalities in communities and child health. Two main streams of gender and child mortality studies are common. On one hand, research has attempted to establish how unequal access to and control over resources between men and women affects child health. On the other hand, research has assessed the gender disparities in child health and mortality, examining whether female and male child morbidity and mortality are affected by their gender, vis-à-vis "Is child mortality higher among male or female children and are these differences due to gender or biological factors?" Results from these various child mortality studies have then informed child health policy at global, national and local levels.

Whilst there are a large number of studies and initiatives on child mortality, there seem to be little being done in the energy sector on gender and child health. Energy policies and programs seem to have made little connection between gender, energy and child mortality. There seems to be little known on whether and how gender and energy relates to child mortality and child health. In particular there is little information on how lack of modern energy products (and services) affects child mortality and health and there is little information on whether and how modern energy services can help reduce child mortality or improve child health. With the development and the pursuance of the MDGs, where goal number 4 is reducing child mortality, it is vital that all aspects of child mortality are explored so that critical enabling factors in the solutions designed to reduce child mortality are maximised. In the two main streams of gender and child mortality research briefly discussed above for example, services provision and infrastructure availability have concentrated on clinics, water and sanitation. Response to the results of such research has then often been to build clinics and train health professionals and to build protected water points for water provision. Whilst these are critical, there is also the question of what makes these basic infrastructures function? Clinics function for example may not function at optimal levels if they have trained health personnel but the health personnel cannot provide various life saving services because the available equipment cannot function without electricity. Neglecting enablers for the functioning of clinics, such as energy services or enablers of healthier environments such as cleaner energy in homes may then create gaps in knowledge and ensuing interventions that may be the bridge to achieving reduced child mortality rates. This research aims therefore at assessing whether gender and energy is a key variable in reducing child mortality. It aims to answer the question: "Does empirical evidence show that the gender perspective of energy is a key variable in reducing child mortality?"

By reviewing empirical evidence on the linkages between gender, energy and child mortality, the study aims to assess whether any linkages between gender, energy and child mortality exist and whether gender and energy is a key variable in reducing child mortality and hence contributing to meeting MDG 4. This would then provide answers as to whether addressing gender and energy issues can significantly contribute to the reduction of child mortality. The linkages between gender, energy and child mortality are explored by reviewing available quantitative and qualitative literature on impacts of energy poverty on child health and mortality as well as the impacts of modern energy services on child mortality and health. Since child mortality and health are intimately intertwined with maternal health, where necessary, the study makes reference to the linkages between gender, energy and maternal health, as it relates to child mortality. Issues dealing with maternal health and combating other diseases (MDGs 5 and 6) are dealt with in separately in the same series on gender, energy and the MDGs[2].

The paper is organised as follows. The first part of the assessment is a brief review of child mortality situation in the world and identifies where the problem is critical and lists key factors in child mortality. The second section further explores the key factors in child mortality, the magnitude of their contribution to child mortality and then assesses the possible linkages between these key determinants and gender and energy. Section three

[2] For more information of CRG, please visit www.energia.org/crgge

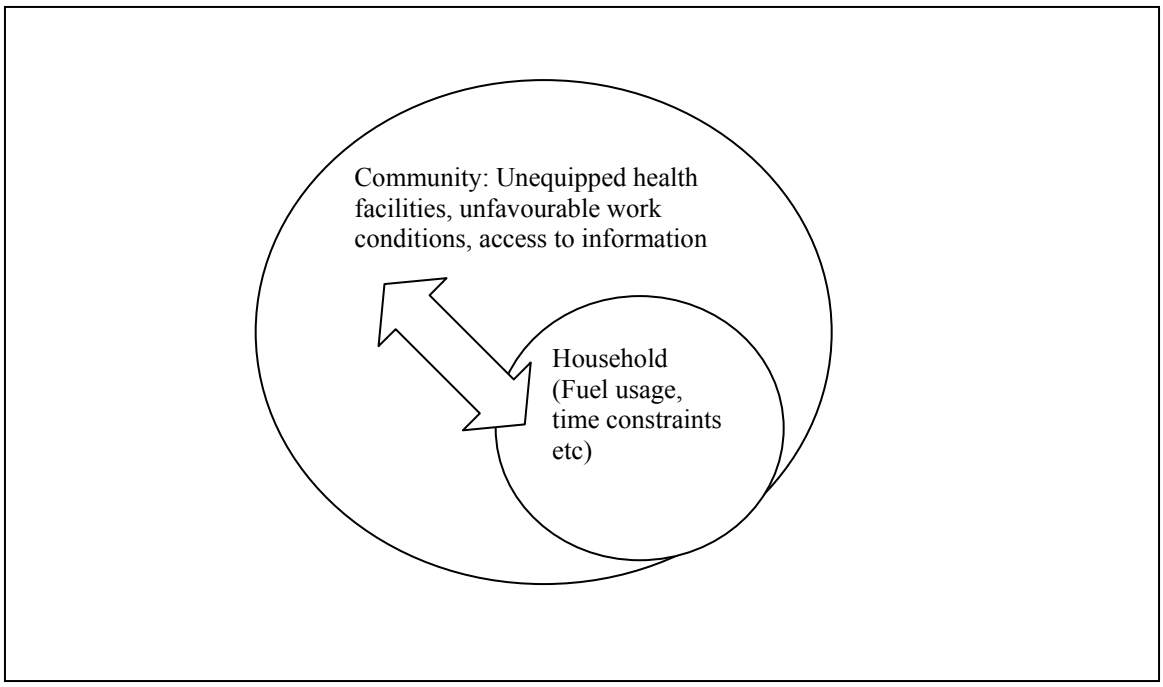
provides the empirical evidence from reviewed literature, on the various linkages discussed in section two. It then discusses their implications within the constraints of the available evidence (for or against the possible linkages) or lack of evidence as well as gaps in knowledge. Section four concludes the paper with a discussion on what the evidence so far shows, identifies the most important connections in the context of the available evidence and provides a summary of the research and actions needed in order to address knowledge gaps identified by the review. Section five is a set of recommendations made in accordance to the findings of the study. The study scope has been limited to developing countries, particularly focusing on Africa, Asia and Latin America where access to modern energy services is lowest and child mortality is high.

2. Background

The UN describes the current global health picture, particularly in low- and middle-income countries, where more than 98 percent of both maternal and child deaths take place under three approaches. These include are epidemiological approach, which describes health status; a structural approach, which focuses on health systems; and a power-mapping approach, which charts patterns of decision-making (UNDP, 2005). The different approaches according to the UN, yield different, vital perspectives on the problem and thus formulates solutions differently. This study then attempts to assess the child health perspective as it relates to gender and energy, from the three perspectives of the global health picture described by the UN. Epidemiology is defined in this study according to Last (2001) as the study of health related states or events in specified population and the application of this study to control health problems. From an epidemiological perspective, the study assesses the linkages between energy usage at various levels, to transmission, occurrence and frequency of disease in children. Where gender disaggregated data is available, details of gender disparities in the linkages are highlighted. From the structural perspective, it attempts to assess the how energy enables or disables the functioning of various health systems related to child health. In terms of power mapping, it assesses how gender constructions in society and access to energy (or lack of) interact to affect child health. These perspectives are thought to exist in two main sphere, community and household vis-à-vis spheres. Community level linkages are mainly related to structural perspectives whilst epidemiological more closely relate to individual groups with the community, in this case children. Power mapping is seen in the intra-household allocation of resources and power and interacts closely with community defined gender roles. [On patial level, the study looks at the linkages at community level, which closely links to the structural perspective, household level in terms of roles of men and women, which corresponds to decision making and power mapping, and individual level, (intra household?), corresponding to health status of children or epidemiological.

The two spheres of gender and energy (i.e. community and household) themselves are highly interactive.

Box 1: Some gender and energy interactions in the face of energy poverty



Child mortality in this research has been defined as per the WHO definition, denoting deaths of persons under the age of fives years (WHO, 2003). Child health and maternal are considered as the nucleus of child mortality and are brought into discussions as necessary. Here, the study makes the assumption that poor health of mothers, and pregnant and breastfeeding mothers in particular can affect that of the foetus, thereby affecting the health of the under five child. It also makes the assumption that unhealthy children are more likely to die than health children and hence its reference to child health where necessary.

3. The study

This study focuses empirical evidence from developing countries on the health impacts of energy poverty as well as modern energy services on child mortality. Evidence is garnered from developing country literature.

It should be noted that this paper is one of several papers on gender, energy and MDGs being compiled as part of a larger research effort of the CRG. Apart from garnering evidence that can support policy in developing countries and developed country policy towards developing countries, the research is also aimed at further building the capacity of developing country researchers, so as to build south-generated knowledge capacities for gender and energy policies for the south.

Scope of the review

The study focuses the review of the linkages between gender, energy and child mortality in developing regions of Africa, Asia, Latin America where child mortality is high and gender and energy are developmental issues. Studies on energy and child health concentrate on those studies aged between 0 and 5 years, defined as under five children.

Women's health is also included under the understanding of women's health as a key determinant of child health. Special attention is focussed on pre-natal and post-natal women. This is because the health of the mother in her life time and particularly during and immediately after pregnancy is critical to child health and survival. Thus gender and energy linkages to child health and maternal health are referred to where necessary. Specific maternal issues are however outside the scope of this paper and so are not addressed in detail in this paper.

Methodology and methodological limitations

In assessing whether gender and energy can contribute to efforts to reduce child mortality, the study examines empirical evidence from studies on gender, energy, child health and related issues. The evidence for or against the linkages is then analysed and presented in this paper, with detailed annexes on the studies that were reviewed.

Literature search was mainly done using the internet based search engine; Google as well as by searching journal articles and reports available on databases on the internet. The search targeted English language publications and grey literature. Some key search words used in the search and key publications and websites used to source data are provided in *Annex 2.* Another limitation was the limited access to a number of journals, which are accessible under user fee arrangements. However, some journals offer open access or limited open access and such opportunities were maximised.

The dependence on internet searches and journal papers was limiting since the study was done from Malawi where internet connection are slow, expensive and electricity is unreliable. In addition, some journal articles are inaccessible and/or expensive to access. To help mitigate this, a number of reports and papers were obtained from colleagues and through email requests to authors, whenever author addresses were available from accessed abstracts.

Another limitation is the fact that the study examined English language publications. This then excludes the bulk of publications in other languages, particularly French, Latin, Portuguese, Chinese and Arabic which are largely used in some parts of the developing world.

The initial units of analysis considered was number of children's lives saved by energy services provided and number of children's lives compromised by lack of modern energy services. However, problems in availability of gender-energy-child mortality specific studies eliminated the validity of these units of analysis. Each linkage is therefore assessed by examining the quantity of studies available to use and the strength of the evidence presented in the study. A large number of studies on an identified possible linkage is used as a proxy indicator that there is adequate information on the subject but does not necessarily mean the link is valid. The strength of the evidence is determined by a combination of the number of studies with consistent findings and whether the studies controlled for confounding factors (rigour) to eliminate error. Thus linkages are proved or disproved based on number of consistent findings and rigour of the studies. A weakness

with this approach is the definition of adequate or large number of studies which is subjective. Moreover, the study is being conducted due to the limited focus on gender, energy and child health and hence almost by definition, there will be a limited number of gender-energy-child mortality studies and initiatives from which linkages may be drawn.

Possible linkages between energy and child mortality

Certain gender norms and the way different gender relate to energy resources have varying impacts on aspects of livelihoods and may therefore have some impact on child mortality. For example, child care is a reproductive role undertaken largely by women. Meanwhile, child health and survival requires various inputs including appropriate nutrition of mother and child, adequate time and resources for child care, a healthy environment, medicines and adequate health care facilities among others. On the other hand, energy drives most functions vital for human survival and development. Thus as energy interacts with child health and women's reproductive and productive roles for survival and development (and later, prosperity), the use of low quality, traditional fuels which is dominant in the developing world, can have various impacts on mother's health and time as well as child health, thereby affecting child health and contributing to consequent mortality. Modern energy services and technologies on the other hand have eased various reproductive and productive functions of women and men and can then play some role in reducing the prevalence or severity of most of the leading causes of deaths as illustrated in Annexe 3 .

In terms of the structural perspective of child health, clinics, health professionals, information, infrastructure and modern equipment, among other things, are important in management of morbidity factors and delivery of vital health services. This is especially vital at community level where modern energy products and services such as electricity can power vital hospital equipment such as operating theatres and incubators for pre-term babies and light up delivery rooms for easier and safer deliveries. Energy, whether conventional electricity or solar power can also be used to power refrigerators, which can then be used to store vaccines (ITDG, undated), enabling children in to be vaccinated against life threatening diseases such as measles and improving health services delivery (Costa and Eck, 2000). In this regard, solar powered refrigerators are of particular importance in remote areas that are not connected to the grid (ITDG, undated). Equipped health facilities in themselves are not adequate for health care services delivery for children. In developing countries, there is an acute shortage of health care professionals, particularly in rural areas. More and adequate training and a conducive work environment which include remuneration and modern social facilities for health care providers may be vital to increasing the number of newborns and sick children attended by health care professionals. Electrified villages and clinics may be an added incentive for health workers and may help increase staff retention rates by providing desirable amenities found in urban centres where health personnel often migrate to (if they are not migrating abroad).

Modern energy services also increase the availability of information sources such as radio, television and telephone which can be vital in helping parents understand and deal with threats to children's health. Radios may be vital for health information broadcasts such as immunisation campaigns, disease outbreaks and points of (specialised) medical

services delivery. This can be especially crucial for poor women in developing countries, most of who are [functionally] illiterate and cannot read posters and newspapers. These communication technologies need to be powered by energy products such as batteries, solar power or conventional electricity.

At the household level, an overwhelming number of households in developing countries depend on fuelwood, charcoal, post harvest materials and dung to meet their thermal energy needs. The traditional biomass fuels used for thermal needs are used in unprocessed or semi-processed forms and often, they are used with inefficient devices such as un-insulated metal stoves or three stone fireplaces. A combination of the form in which they are used and the devices with which they are used, result in high emissions of Carbon Monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), formaldehyde, and polyaromatic hydrocarbons (PAHs) such as benzo(a)pyrene and other chemicals which are harmful to human health(WHO 1992; Smith 1987; Smith 1993) and particularly to the fragile health of children below the age of five. In other developing countries such as China and South Africa, coal is extensively used to meet thermal energy demands of poor households. Coal burning emits various pollutants including arsenic, mercury and other compounds. Such pollutants impede respiratory functions and are particularly harmful to children under the age of five, who inhale high doses of these pollutants because they often spend long periods of time with their mothers, as they cook in the kitchen. Moreover, lungs are not well formed at birth, and development of full functionality does not occur until approximately 6 years of age (Schwartz, 2004). The undeveloped lungs of children, combined with their immature immune system renders the impact of these harmful substances more pronounced in children (Schwartz, 2004). Improved energy services and products can then save lives of millions of children by reducing indoor air pollution which currently kills an estimated 4 million people annually (Bloom et al, 2005), the majority of whom are children below the age of five.

Apart from IAP related diseases, children under the age of five, who spend long periods of time in the kitchen may be vulnerable to accidents such as burns and paraffin poisoning, which can be mitigated by moving up the "energy ladder" to safer fuels and energy devices.

Whilst IAP related diseases may be considered primary epidemiological linkages between energy and child health, there are also secondary epidemiological factors arising from energy poverty at household level. Every year, 1.6 million persons die from diarrhoeal diseases and the majority of these are children in developing countries (UNICEF, 2005). Unsafe water supply and inadequate sanitation and hygiene are the key causes of diarrhoeal diseases (Lenton et al, 2005). From a structural perspective, at a community and household level, access to energy services enables delivery of various survival and developmental services and can help improve delivery of services such as clean water (ENERGIA, 2005). Apart from improving delivery of safe water, boiling (accompanied by hygienic storage) of drinking water has been proven as effective methods of killing pathogens (Oral re-hydration project, 2005). Solar water pumps, wind water pumps, diesel gensets and others can help provide clean water which can then improve hygiene practices such hand washing, bathing of children, provision of clean drinking water and water for domestic hygiene. These hygiene related functions can be especially crucial in preventing diarrhoea, one of the top five killers of children under the age of five. In addition to water delivery, affordable thermal energy such as solar water

disinfection techniques or use of more efficient cookstoves may encourage boiling of drinking water, which may otherwise be neglected due to costs of fuel or time constraints.

Currently, malnutrition causes an estimated 54% to 56% of child mortality. Whilst the causes of malnutrition are wide ranging - from poor policies, politics and security, low education levels, agriculture, climate and others - irrigation can improve food security in most food-insecure areas where water resources are available. Powered irrigation can improve agricultural productivity and may thus improve nutrition, savings lives of millions of children that are at risk of death due to malnutrition. Furthermore, about 95% of staple foods have to be cooked to be eaten and thermal energy provides the energy required to cook food (UNDP, 2004). Apart from palatability, foods benefit from cooking, as this can improve their digestibility and hence their nutritional value to the body. This is because cooking can destroy anti-nutrients such as protease inhibitors, polyphenols (including tannins and saponins), hemagglutinins, phytates, and dietary fiber. Polyphenols and phytates (Tu,1999). This would imply that where food security (i.e. availability of foods) is achieved, affordable thermal energy for cooking the food may play a role in improving nutrition by increasing the digestibility of most foods, thereby making them more nutritionally valuable for children susceptible to malnutrition. If then the scarcity or high costs of fuel results in coping strategies such reduced number of meals cooked per day, excessive consumption of soaked or sprouted foods compared to cooked foods or elimination of certain foods such as dried legumes, because they take a long time to cook, malnutrition may result in spite of food availability. This is especially critical because dried legumes, which take long to cook, are one of the most vital sources of vitamins and proteins for poor families throughout the year. Deductive coping strategies can then deprive children and pregnant mothers, essential nutrients and contribute to malnutrition. Fuelwood scarcity may also result in women increasing walking further and spending more time fetching firewood. This can result in their skipping meals or reducing baby and breast feeding frequencies (and even early weaning) and general reductions in child feeding frequencies because of time constraints. Inadequate feeding and child care may also occur where women are overburdened with household and agricultural activities and therefore reduce child care time. Energy technologies can then reduce the associated drudgery and free up some time which may then be used for child care.

In developing regions, women are responsible for between 80-90% of the arduous household work, including child care. Studies show that women in developing countries work an average of xx hours per day compared to men's xxx hours per day. This means in some cases, trade offs have to be made between providing child care and other work vital for household survival (Personal observations). Young children are often left in the care of their siblings or the elderly, who may not always be able to cope with children. This may render children vulnerable to injuries and children may not receive urgently required medical assistance when they are sick as care takers may want to wait for their mothers' permission before they seek medical assistance.

Men and women in most rural households in developing countries have to travel long distances to basic health clinics (and further for health care facilities with sufficient and

effective or specialised child health care facilities). Apart from the availability of motorised transport, high costs of transport fuel pose a serious challenge to health care access problems. In various countries donor and government programs can provide ambulances to district hospitals yet their services may not be available to rural households due to high costs of transport fuels. Reduced petrol and diesel prices may be vital for reducing transport costs. Blending petroleum fuels such as gasoline with locally produced ethanol or diesel with locally produced biodiesel can reduce fuel prices and consequently, transportation costs.

Apart from targeting the health of children through immunisation, child care, clean environments and water, improving access to health facilities and others, the health of mothers, especially during pregnancy to a large extent, determines the health and wellbeing of children. Malnutrition in women has been cited as one of the causes of low birth weight and malnutrition in children (WHO, 2003). In reducing drudgery of women's work, energy services can help improve nutrient utilisation and improve health and well being of mothers.

Providing improved and affordable energy services and products can also improve incomes, thereby increasing money available for children's health care and nutrition. A summary of the linkages between energy and child mortality are presented in Annex 4. The following section contains subsections, assessing the evidence of linkages between gender, energy and child mortality explored in this section (section 3).

4. Findings of the study: Empirical evidence on the linkage between gender, energy and child mortality

1. Electrified clinics can provide critical care and emergency care for sick children

Energy services enable the provision of emergency health care services which are vital in dealing with life threatening childhood illnesses and injuries. Electricity can power operating theatres, artificial respirators, refrigerators for storing medicines and plasma, and communication systems, which are vital for emergency and critical care. Although we found studies were solar refrigerators enabled vaccine services (Mbaiwa, 2002) and although we know operating theatres need electricity to operate, we found no study quantifying impacts of refrigerators on increased vaccinations and improved child health. There are however anecdotal discussions on the lack of electricity in rural clinics in developing countries (Heartware, 2005; Family Care International, 2005). Pearson and Shoo (2004) cite lack of electricity (and running water), as one of the constraints to provision of emergency obstetric care in Kenya, Rwanda, Southern Sudan and Uganda. This can lead in delayed delivery and result in still birth or death of newborns. The SCI health facility assessment of Ouargaye District Health Facilities for example cites lack of electricity as an infrastructural barrier to (maternal) health services delivery. About 18 out of 20 clinics in the assessment had no had electricity. This situation is repeated in various parts of the developing world, including Asia, Latin America and Africa.

In Tunisia, the rural electrification program instituted by the government has yielded some vital benefits for women's health, which can result in reduced child mortality (Box

1). The program has improved basic health services delivery and family planning Celcelski et al (2001).

Box 1: Rural electrification and improve health services delivery in Tunisia[3]

Basic health and family planning has been the second most important social priority of the Tunisian State, after education, and this is also reflected in the benefits perceived from rural electrification. Rural electrification was provided at the same time as were clean water and well-equipped and staffed health clinics: e.g. a nurse is permanently available even in these remote clinics, a general practitioner visits once a week, and a specialist health team regularly visits. Health clinics have lights, a refrigerator, negatoscope, steriliser, popinel, fans, oil heaters, radio, TV and sometimes video. The majority of drinking water points are equipped with pumping devices, with electricity much in demand to replace diesel.

Beneficiaries and health staff attributed at least part of the responsibility for the reduction in the birth rate in their area to rural electrification, which increased the effectiveness of family planning and other health programs. Clinics report being able to expand the range of their equipment and services: for example, TVs/videos present programs on public health and disease prevention in some waiting rooms; instruments can be sterilized; and vaccines for babies and anti-tetanus shots for pregnant women are more widely available. According to a nurse attached to one clinic, the availability of refrigeration for vaccines and medicines has contributed to a noticeable reduction in childhood diseases, diarrhoea and poisoning.

Women's reproductive health in particular is seen as benefiting from electrification: women with electricity organize their daily tasks so that they have time to watch TV, which passes on many health messages on e.g. reproductive health and contraceptive methods; vaccinations; and the prevention of sexually transmitted diseases; health checks for e.g. breast cancer, colon cancer, etc. …With refrigeration, women are less reluctant to absent themselves from their household tasks, since they can prepare and store meals for their families in advance.

Rural women and children - especially girls - are becoming more demanding about personal hygiene.

Source: Cecelski, 2001

We did not find any studies assessing evidence on linkages or lack of linkages between electrification of clinics and increased provision of critical care and emergency care for sick children. There was however evidence that modern energy services such as electrification contributed to clinics' ability to provide a range of services that could otherwise not be available. However, electrical equipment often posed technical and financial challenges and could be under utilised if not well maintain and in other cases, due to unreliable electricity supply. Electrification of clinics, combined with other vital inputs is however likely to improve child survival.

[3] Edited

2. *Energy can enable the storage of vaccines and the availability of vaccines in remote areas*

According to the WHO organisation (2002) immunisation is an effective way of reducing child death and the WHO estimates that comprehensive immunisation of children could have saved 2.3 million children from dying in the last decade (WHO, 2002). Full coverage of measles vaccination would prevent all deaths due to measles, saving approximately 700 000 child lives per year (WHO, 2003b). To enable immunization there is need for health care professionals and clinics, proper storage and information (to encourage populations to vaccinate their children). Modern energy is especially vital in terms of storage because vaccinations must generally to be stored under well controlled temperatures at between 2^{o}C and 8^{0}C (whilst oral polio vaccine must be kept between -15º C and -25º C) to maintain their effectiveness (INC, 2005). In developing countries, most of which are tropical, the need for refrigeration is even more critical as temperatures can rise sharply yet most rural clinics do not have access to power for refrigerators.

A study by VillageReach in Cabo Delgado, Mozambique in 2002 found that the vaccination rates for DTP were 29%. Among other reasons for the low vaccination rates was the fact that health facilities lacked dependable energy access for vaccines, proper disposal and sterilisation (Judja-Sato, 2004). In addition to lack of energy access, 85% of clinic refrigerators suffered from breakdowns, fuel shortages, and lack fuel of spare parts. Providing solar powered refrigerators in such a case would then sort part of the problem i.e. fuel shortage energy access for vaccine storage but may not solve the problem of refrigerator break downs or lack of spare parts.

Whilst we did not find any study quantifying the effects of lack of powered (electric) vaccine storage facilities on rates of child vaccinations and child mortality, some studies show that energy services, particularly solar powered refrigerators have enabled increased outreach of vaccinations. In Manyana, Botswana, a Pilot Solar Program enabled the installation of a vaccine refrigerator in the area, thereby bringing vaccinations closer to a remote community (Mbaiwa, 2002). In Guatemala, solar electrification of a community clinic also enabled the displaced and remote community of Laj Chimel (USAID, undated) to offer vaccination services. Solar power also enabled the powering of a community health center in Mosoco, Southern Colombia (Cold Chain Program, undated). In Indonesia, a program in 1993 replaced kerosene-powered lighting and refrigeration facilities in rural clinics with PV modules and by 1999 some 5 500 clinics were using solar powered refrigerators, bringing vaccines to the difficult to access areas in the archipelago (WEC, 2001). Globally, the Cold Chain Program has provided solar powered refrigerators for immunization storage in remote areas in almost all countries in the developing world. PV technology has been especially useful in remote areas of Africa and Asia where there were problems in gas supply and there is no grid electricity. In addition, the USAID-implemented program, “Solar Light for Africa” has provided power and light to about 1,500 facilities in rural regions of East Africa, including two large regional hospitals, enabling the carrying out of immunization in rural clinics (USAID, undated). For example in Kakuuto Hospital located in the Rakai District of Uganda in particular, solar power provided by the Solar Light for Africa program enabled medical staff to preserve vaccines and other medicines. This allowed more children to be

vaccinated at greater (required) frequency (USAID, undated). Evidence seems to suggest that availability of modern energy services for refrigeration can be vital for increasing outreach for vaccines, which can then reduce child mortality (Annexe 4) . Solar power in particular, can play a vital role in improving access to life-saving vaccines.

Despite the evidence that solar power enables access to vaccines in remote areas, we did not find any study that correlates the availability of power for refrigeration with increased number of immunised children, hospital attendance, frequency of vaccinations or likelihood of completing vaccine regimes. We also acknowledge that availability of vaccines in refrigerators alone is unlikely to induce increases in desire to have children vaccinated. Public awareness campaigns, staff availability and transportation to health clinics may play a vital role in increasing number of children vaccinated against life threatening diseases. However, it must be noted that the WHO uses the number of children immunised against measles as a proxy indicator of access to basic health services for children under five (UNDESA, 2005). Moreover, it will provide a chance to those that want their children vaccinated access the vaccines. This suggests that availability of powered refrigerators increase vaccinations as well as access to (or patronage of) health services for under five children. Powered refrigerators for vaccine (and medicine) storage can therefore be one of the crucial facilitators for improving child health as WHO (2005) points out:

> "The provision of drugs and vaccines alone cannot build systems nor ensure quality of care, but without the facilities and materials to do their job, health professionals cannot function".

Being able to store the vaccines (at optimal temperatures for effectiveness) is a crucial part of broader efforts in vaccinating children. It is in this respect that solar energy as well as conventionally powered refrigerators can play a crucial role in increasing vaccinations coverage and thereby reducing child mortality.

3. Electrified communities may be more attractive for health professionals and hence increase the availability and quality of health care for children

There have been anecdotal discussions that indicate that lack of equipment that require electric power such as x-rays etc is among factors that cause migration of health professionals from rural areas to urban areas and even abroad. In addition, it is believed that lack of electricity for staff houses may discourage health professionals from taking up positions in unelectrified areas.

According to a report by Physicians for Human Rights (PHRUSA), "deficits including health facilities without adequate supplies of medications, functioning equipment, and constant supplies of clean water and electricity; health care workers without gear to protect them from HIV and other communicable diseases" are some of the issues fuelling brain drain in poor countries (PHRUSA, 2004).

We found no studies that make linkages between electrification and staff retention. An assessment of feedback on a BBC program on brain drain in Africa however indicates that lack of electricity may be a factor as E. Julu Swen puts it:

How can a doctor who is caring for his people earn $50.00 a month and live in a village where there is no electricity and pipe borne water, while government officials run around in big cars?[4]

E. Julu Swen, Monrovia, Liberia

However, browsing through the feedback suggests that low wages and lack of equipment are the main factors encouraging the migration of health staff to "greener pastures" (BBC, 11th March, 2005). In addition, perceived lack of opportunities for children, socio-political and economic factors and political and civil unrest are a significant factor in the migration health professionals.

4. ICTs may enable notification of disease outbreaks, immunisation sensitisation and campaigns notification as well as quick referrals

ICTs are defined in this study as various technologies for creation, storage, processing, communicating and disseminating information (ref). They include radios, televisions, computers, satellites, fibre optic cables, telephones and faxes as well as software and databases. Radio and television have been used extensively in developing countries to transmit vital development information including health information to poor populations. Whilst message content and other elements of communication are critical in relaying messages, there is also need for the energy to power such electrical appliances as radios and television sets. Telecommunications equipment and information technology such as internet and telephones are also being used increasingly to communicate information on disease and disease control as well as self-teaching, for example through open course ware and access to journals, among medical professionals. Telephones are important for calling ambulances which can reduce times for getting critical cases to the attention of medical personnel. ICTs, which include radio, television, internet, computers and telephones not only inform patients and potential patients but also enable medical personnel to access to information vital for their operations and keep them in touch with colleagues internationally. This can improve their ability to provide essential care especially to children in developing countries. This is especially important for developing country practitioners who are often not the main generators or of information but with the bulk of morbidity and mortality in developing countries, are key potential users of health information. In addition, there is increasing need for practitioners in developing countries to generate and share their own knowledge, vital for addressing developing country health issues. Increasing, ICT generated services and products such as databases can improve effectiveness of service delivery, by improving patient history management, record keeping and scheduling as well as information sharing at reduced costs. Software with collaboration function can allow health professionals to collaborate on a range of issues. An interesting development in the health sector e-health, which entails provision of health information and support services electronically.

Two issues have to be noted on the review of use of ICTs and child health. Firstly, there were acute shortage of studies on gender, energy and ICT and health, possibly for

[4] Edited

methodological reasons. Secondly, access to modern energy services does not mean access to health information although this may be aided. However, access to information through radio, TV, internet or the possession electronic databases in most cases means some form of access (group or individual) to modern energy services of one form or another (battery, solar, conventional electricity, diesel generator etc), perhaps with the exception of wind-up radios). The review therefore focused on impacts of products of ICT and the ways in which the enable or disable various health services and products or behaviours.

Perhaps an interesting thing to note initially is that there are gender differences in access to and use various ICTs. Where radios are the main ICT, women have less access to it (Smith et al, 2004; Alamu, undated). However, where radio and newspaper are key sources of information, women are more likely to use radio compared to newspapers as a key source of information. In Mali, a much higher percentage of women and household heads reported listening to the radio than reading a newspaper, mostly because of low literacy levels. Radios therefore play an important role in health information delivery (Smith, 2004). In Bangladesh, BTV is the single largest provider of information on vaccination and other health related issues whilst radio is considered a major provider of child and women's health (Alamu, undated).

The review showed that various ICT are being used improving health services delivery in various ways. A study of safe motherhood knowledge, attitudes and practices in Bla, Mali found that almost 90% of the women interviewed and 97% of household heads reported listening to the radio often or sometimes (Smith et al, 2004). For the women, the radio represents a vital source of health information, especially because literacy levels are low. In Bla, Mali therefore, the largest source of information on safe motherhood was found to be the radio, sited by 49.7% of female respondents (Smith et al, 2004). Radios as a source of information exceeded matrons, community health agents, nurses and midwives and doctors combined (Table 2). It must of course be noted that only 6 % of women cited the radio as a credible source, despite the fact that it is the most frequently cited sources of information.

Table 2: Source of Safe motherhood Messages Seen/Heard by Respondents

Source of information (multiple responses possible)	Women N= 141	Heads of HH (%) N=126
Matron	21.3	**
Community health agent	13.5	7.1
Nurse/Midwife	11.4	8.7
Doctor	1.4	7.1
Traditional birth attendant	**	2.4
Community education agent (Animatrice)	5.7	3.2
Relative/Friend	7.1	64.3
Radio	49.7	17.5
Television	4.3	11.9
Other	3.6	6.4

Source: Smith et al, 2004

In Zimbabwe, however, word of mouth, mostly from nurses was the most important source of health information. Radio followed by newspaper was second and third most major sources of information (Matewa, 2002). Indonesia, the radio, using a fictional character, Mrs Nutrition, played an important role in persuading pregnant women to

incorporate iron supplements into their diet (Clift, 1997), whilst in Bangladesh, radio and TV were used to promote breast-feeding, making weaning foods from locally available and family foods, proper feeding of sick babies, use of oral rehydration for children with diarrhoea, provision of growth charts for monitoring child development, immunization, improvement of personal and environmental hygiene, and teaching what foods are best for pregnant and lactating women (Rana and Sthapit, 1983)

Box 2: Communicating health, communicating life: Use of radio and television to combat child malnutrition in the Philippines

In the Philippines, a 1978 nationwide survey showed that nearly 70 per cent of pre-school children were underweight. As part of efforts to address malnutrition in pre-school children, a food supplement called Nutri-Pak was introduced and communication initiatives accompanied the introduction of the supplement to change behaviours. A program was initiated on Eastern and Western Visayas (the area with the highest prevalence of malnutrition) to determine the most effective communications medium for changing mothers' child-feeding behaviour as measured by Nutri-Pak sales. One village group used television, another used comics, and the third had no media to support the nutrition campaign. Village level workers visited all villages to promote nutrition and sell Nutri-Pak at subsidized rates. The Nutri-Pak was to provide children between 12 to 36 months. Results of the testing showed that the 5 villages visited by the video-van, where the BNS (village level nutrition workers) had been given one day of communication training sales of Nutri-Pak were nearly three times higher than sales under other conditions.

Source: Solon et al, 1983

In Ubon and Sri Saket provinces in North-East Thailand, 48 villages participated in communication initiave to improve child nutrition with food supplement. The initiative targeted mothers of children between the ages of 0-4. Radio, TV and Radio-TV combinations were used in different villages (Dhanamitta, 1983). Results showed that radio messages were well understood by children but mothers could not elaborate upon the content. On the other hand, interactive video-tape programme had a striking effect on knowledge and attitudes, but not much effect on practices as yet (Dhanamitta et al, 1983).

Media has also been used to support vaccination campaigns world wide although we did not find documentation of comparative impacts for households with “powered” communications and those without energy services, there a number of impacts on radio and TV usage. In Philippines, the Philippine Department of Health conducted national mass media communication campaign during the period March-September 1990 to support routine vaccination services. An exit assessment of the impact of the campaign showed that the percentage of children aged 9-11 months who had all vaccinations increased from 32.2% 1989 (before campaign) to 56.2% 1990 (McDivitt et al, 1997). According to McDivitt et al, factors contributing to the success of the campaign include good public access to the media (radio 73%, television 60%, both 50%) as well as the development of high quality radio and television spot and a routine system ready to serve the increase in demand that the campaign generated. In Jordan, efforts to encourage breast feeding included a two day lactation seminar on lactation management for health

professionals and two intensive radio and television campaigns involving drama, testimonials and advice from a fictitious female doctor from May 15 to July 15 1989 and from mid March - end April 1990. Key messages were to initiate breast feeding within the first hours after birth, to enlighten mothers on benefits of colostrum, and to emphasise that breast milk is all the child needs for the first 4 months of life as well as advice on some common breast feeding problems (McDivitt et al, 1993). Evaluation of the efforts using a systematic random sample of mother before (in 1988, n=800) and after campaigns (in 1990, n=777) using questionnaires administered to women with children under the age of 20 months) showed that the mass media breast feeding campaign reached 73% of mothers (1990). There were significant increases in initiation of breast feeding 90.5% to 97.2% ($p< 0.0001$), timely initiation of breast feeding 40% to 54% (p 0.001commencement of breast feeding within 6 hours of birth 51% to 75% ($p<0.0001$) and increased knowledge in the benefits of colostrum 40% to 70% ($p<0.0001$). There was also a slight, but not significant, decrease in early supplementation of breast feeding before 3 months 50% to 60%. Although mass media had a positive impact, it should be noted that the positive impact of the campaign (on mothers' knowledge and timely initiation of breast feeding) was for mothers at home and in public hospitals but not in private hospitals. This suggests that hospital policy and staff practices have an important role in practices. The information on use of mass media for communicating health issues and initiative behaviour change for health suggest that radio and television (an indicator of access to some form of modern energy services), can play a role in disseminating health information, which can be vital for improving child health and hence child survival. However, evidence on whether radio itself is critical must be taken with caution as there are many factors including message content, format and others come into play. Moreover, in most cases, radio campaigns are conducted along side other efforts to change behaviours. Radio may however play a supportive part in supplementing health campaigns and in reaching larger populations. Message content and support from health professional may be more critical in instituting appropriate health behaviours for child health. Recently in Mozambique, the assessment of the impact of a community radio showed that in areas of Dondo, a town without electricity, after one month of information campaigns through a community radio, the number of deaths caused by cholera during annual flooding in 2004 dropped drastically to zero (ID 21, 2005) This was because the radio broadcast information about, among things, the distribution of chlorine and the importance of putting it in the water.

Apart from radio and television, there is growing use of telephones, VHF radios, to help improve health services delivery. In Uganda, a project by Rural Extended Services and Care for Ultimate Emergency Relief (RESCUER), that aimed to improve maternal health services delivery through communications, and quality health services delivery, found that unavailability of electric power supply in most rural areas was a key factor in selecting ICT to be used (as was lack of telephone infrastructure). Solar powered fixed, mobile and vehicle VHF radios were therefore used to improve health services delivery for mothers and infants. Even where electrical power was available, solar powered radios were used because of the inconsistent power supply (World Bank, 2002). The study did not quantify changes in health services delivery but reported increased number of deliveries under trained personnel and increased referrals to health units, which led to a

reduction of about 50 percent in the maternal mortality rate (MMR) in the Iganga district in three years (RHO,2002) . Although the brief does not quantify impact on child mortality, child delivery by qualified health professionals is a factor in the survival of newborns as is reduced maternal deaths and is therefore on target of MDG 4.

The Pan American Health Organisation (PAHO) states information technologies such as internet can better prepare health professionals and populations for disease outbreaks or natural disasters, share groundbreaking news on emerging health issues and discoveries in vaccines research and development; and empower public health workers at all levels to make timely, well-formed decisions by providing them with access to the crucial data and knowledge they need (Epstein, undated). Whilst the ICTs hardware and software are important in transmitting information, they need to be powered by modern energy sources. In Latin America, PAHO implements the "Health Technology Linking the Americas" initiative, aimed at improving access to health information to persons without telephones and home computer, mainly through the internet. In Peru, where about 95% of the population do not have telephone lines or computers at home, public computing centres are linking poor residents without telephones to distant medical facilities and sources of medical information (Epstein, undated). The computer centres have enabled direct linking of clinics and hospitals, conference proceedings and information on such topics as child health from around the globe for modest fees. In Buenos Aires, Argentina, The University of Buenos Aires in Argentina has connected its academic units to the national and international internet community and physicians and paramedics are increasingly using computers for self-teaching (Epstein, undated). Self-teaching, facilitated by information technology can help health professionals deal with childhood diseases and new procedures for saving lives. In Costa Rica, the Ministry of Health and other partners are setting up a national telemedicine network linking medical and research facilities (Epstein, undated).
Trends suggests that with increasing reliance on ICTs, lack of access to electricity for powering the ICTs may increasingly alienate poor communities as well as the health professionals that serve them from accessing vital health information as articulated by Brandling Bennett cited in Epstein:

> *"We also know, given the nature of the new technologies, that the benefits won't be equitable. They might not reach the 5-year-old indigenous child in Guatemala, the sugarcane cutter in Guyana, or the rural school teacher in Bolivia. As we become more reliant on these technologies, the health status of the poor, those in rural areas and minorities may stagnate if they do not have access to or cannot use the new means of communication or find the information they need. We must ensure that the neediest do benefit from the new technologies."*

The emerging evidence suggests that ICTs can help increase access to health information but not all ICTs are beneficial to all people. Radios for example would be beneficial for wider outreach and seem to be better suited for least developed areas where access to TV and internet are low. Internet can be more useful to professionals, for learning and improving efficiency where it is properly used whilst VHF is best suited for responding to emergencies and

referrals. These sentiments are shared by Musoke of the RESCUER project in Uganda

> *"High-end equipment is fine at district and national level, "but it is impractical to supply internet facilities to traditional birth attendants who can't read or write"*

The use of internet itself may raise controversial issues in low knowledge areas as there is a proliferation of health information on the internet, some of which is unsuitable or unproven. In know knowledge settings, identifying appropriate information may be overwhelming. Moreover, in least developed countries, even literate professionals have been know to under utilise ICTs due to low ICT knowledge levels. This suggests, there are more barriers other that electricity connection that could limit the efficacy of ICTs in contributing to improved health care.

5. Clean energy and energy technologies can reduce ARIs by reducing indoor air pollution from biomass and coal

Reproductive and productive roles of human beings are often dictated by gender roles, particularly in developing countries. In most of the developing countries, women undertake the bulk of reproductive work which includes food preparation, child care, gardening and water and fuelwood collection. Where women do not have the benefit of technologies for labour and time saving, women have developed coping strategies which include carrying children on their backs as they work to help them cope with time demands of their roles. During cooking episodes, young children are exposed to high levels of biomass related pollutants such as smoke and respirable particulates. Such exposure has been linked to acute respiratory diseases caused by irritants, cilia toxic fractions, and mucous coagulating agents, including respirable particulates (PM_{10}), carbon monoxide (CO), nitrogen oxides (NOx), formaldehyde (HCHO), and poly-aromatic hydrocarbons (PAH,) and volatile organic compounds (VOC), which impair the respiratory system and render it more susceptible to infection and damage after extended exposure (Mishra et al, 2000). In children, the impact of polluting fuels on child health is more pronounced due to under developed lungs and immune systems. According to Murray and Lopez (1996), respiratory infections are the most important cause of death among children less than 5 years of age, accounting for approximately 4 million deaths annually in developing countries. Kebede (2004) estimates that prolonged exposure can increase ARIs risk in children by 100% to 400%.

Exposure studies have shown IAP from biomass burning to be several magnitudes higher that levels recommended by USEPA and World Health Organisation (Table 3). Annex 6 shows the exposure levels of various fuels from various technologies used in developing countries, all of which are several times higher than the recommended USEPA and WHO levels.

Table 3: Comparison of typical levels of PM10 and CO in developing country homes with WHO and USEPA guidelines

Pollutant	Range of ambient levels in LDC studies, for simple stoves		WHO guidelines (WHO, 1999)		US EPA guidelines (USEPA. 1997)	
	Period	Level	Period	Level	Period	Level
Particles (PM_{10}) ($\mu g/m^3$)	Annual	Not available, but expect similar to 24 hr	Annual	Guidelines presented as exposure-response relationships. Levels as low as 10 $\mu g/m^3$ associated with excess risk.	Annual	50
	24 hour	300 - 3,000+	24 hour		24 hour	150 (99th per-centile)
	During use of stove	300 - 20,000+ some 30,000+				
Carbon Mon-oxide (ppm)	24 hour	2 - 50+	8 hour	10	8 hour	9
	During stove use	10 - 500+	1 hour	30	1 hour	35
			15 mins	100		
	COHb (%)	1.5 - 13%	COHb (%)	Critical level < 2.5% Typical non-smoker 0.5 - 1.5%. Typical smoker 10%		
	During use of stove	1000+				

Source: Bruce et al, 2002

A number of studies have correlated indoor air pollution from biomass smoke to respiratory infections in children in developing countries and have found strong associations between increased frequency and severity of acute respiratory infections and indoor biomass fuel use (Bloom et al, 2005). In a comprehensive review of 13 studies, where confounding factors were controlled for, conducted in developing countries, Smith et al. (2000) found indoor pollution from biomass fuel use to increase the risk of ARI in children by about 2-10 fold after controlling for confounding factors. In terms of gender differentials, few studies on children and biomass smoke have desegregated data by gender, probably under the assumption that both female and male children are carried by their mothers during cooking episodes. This may however not be an absolutely accurate assumption. One study in the Gambia, by Armstrong and Campbell (1991) found that the risk of pneumonia had an increased association with smoke exposure in girls but not in boys. Armstrong and Campbell (1991) suggest that this gender difference resulted from greater exposure of females, who are kept in kitchen environs with their mothers until older ages compared to boys and not from biological differences between the sexes. In the Armstrong and Campbell (1991) study of 500 Children, they found that children riding on their mothers' backs during cooking episodes, using smoky cookstoves, were six times more likely to develop ARI than unexposed children (Smith, 1993). In a study by Mishra et al (2000) in India, ARI incidences were higher for boys than for girls, as was the effect of biomass fuels on the ARI. In India, one in every five children under age 3 suffered from cough (Mishra et al, 2000) and one in every fifteen suffered from ARI — defined as a cough accompanied by short, rapid breathing—during the two weeks before

the survey (Mishra et al, 2000). This translates into approximately 4.6 million ARI cases among children below age 3 during the two-week period. According to India's 1992/93 National Family Health Survey (NFHS), boys (72 per 1,000 children under age 3) in India are more likely to suffer from acute respiratory infections than girls (49 per 1,000 children under age 3). Mishra suggests that the differences in the Mishra (2000) study and the Armstrong and Campbell (1991) may be attributed to the fact that India are more likely to carry young boys than girls with them or keep them in the kitchen area while they are cooking In addition, there may be under reporting of cases affecting girls because of the culturally low value placed on girls in some communities in India. Not all evidence supports the association between polluting fuels and ARIs. A study of 642 infants dwelling in urban slums of Delhi and using wood and kerosene respectively found that the difference in the prevalence of acute lower respiratory tract infections did not significantly differ by fuel type (Sharma, 1998). In addition, in a study of 400 under five children in South Kerala India, Shah et al (1994) reported no association between use of biomass fuels and severe pneumonia as per WHO criteria. Non-association is also reported by Azizi et al (1991) in a Malaysian study. In a case control study of children between the ages of one month and five years hospitalized for pneumonia (n = 143), acute bronchiolitis (n = 92), acute laryngotracheobronchitis (n = 32) and empyema (n = 4) and compared with 322 children hospitalized during the same 24 hour period for non-respiratory causes. Azizi et al (1991) found that whilst several home environmental factors were significantly associated with ARI, the study did not show that domestic air pollution had an adverse effect. In another study hospital based study of 158 asthma cases versus 201 control children of ages between one months and 5 years, Azizi (1995) found that sharing a bedroom with an adult smoker and exposure to mosquito coil smoke at least three nights in a week were both associated with increased risk for asthma but there was no association between asthma and exposure to kerosene stove, wood stove, aerosol mosquito repellent, type of housing, or crowding. Annex 7. Presents evidence on the health impacts of fuels on child health.

According to Smith (2000), biomass fuels (dung, crop residues, and wood) are substantially more polluting per meal than the liquid and gaseous fuels further up on the ''energy ladder.'' The amount of important health-damaging pollutants breathed by a cook during a typical meal is about 2 orders of magnitude lower when burning bottled gas than burning wood or crop residues. Since children tend to stay with their mothers when they cook, they tend to be exposed to similar levels of pollution. Changing to cleaner forms of energy can also reduce children's exposure to indoor air pollution. A study by Bailis et al (undated) showed that ARIs incidences decreased by 44% in children whose households shifted from open fire to improved cookstoves. Another study in Kiambu District in Kenya demonstrated statistically significant reductions in the prevalence of acute respiratory infections (ARI) (and conjunctivitis) under five children (and women) who used improved stoves compared to those who did not (Wafula et al, 2000). In the study, children in households using improved woodstoves had an ARI prevalence rate of 23.1% whilst those in households using three stone open fires had a 59% ARI prevalence rate. Thus the probability of having ARI within the households with traditional three stone stoves was 2.6 times greater than for households with improved woodstoves for children under five (Wafula et al, 2000). The study by Wafula indicated a 61% reduction in prevalence of ARI among under five children improved stoves compared to those whose households use traditional three stone open-fires. Studies in

Kenya (Ezzati and Kammen, 2001) and Guatemala (Boy, 2002) have also shown improved health among children and women derived from cleaner burning of charcoal and firewood. Annex 8 presents evidence of the correcting impacts of cleaners fuels and/or cleaner cooking technologies on child health.

This sparse but consistent evidence suggests then that using cleaner burning fuels and technology reduces indoor air pollution and subsequently, the related ARIs. The evidence from actual observations is supported by modelling studies. Wang (2003) and Wang and Van der Klauuw (2003) associate improved energy services with improved respiratory health and decreased child mortality (Table 10). An econometric model using data from India shows that providing clean cooking fuels to all households in India can save 26.5 lives per 1000 lives five year old children, 15.7 lives per 1000 of one year olds and 6 one month old children (Wang and Van der Klauuw, 2003).Details of modelling studies on the health impacts of transitions to cleaner fuels are presented on Annex 9 .

Table 4: Effects of improved services on infant and child mortality (Lives saved per 100)

	Affected	One month	One year	Five years
Piped water source	74%	2.8	4.0	4.4
		(2.6)	(3.5)	(4.6)
Piped water source & no purification	84%	3.7	6.1	6.8
		(2.9)	(3.8)	(5.1)
Private piped water & no purification	94%	2.1	10.9	10.4
		(4.3)	(5.1)	(7.0)
Electricity	49%	2.6	4.0	5.5
		(1.5)	(2.0)	(2.6)
Mother's education	67%	6.6	13.7	22.9
		(1.9)	(2.5)	(3.3)
Toilet facility	77%	4.6	6.1	10.7
		(2.8)	(3.8)	(4.9)
Clean cooking fuel	91%	6.1	15.7	26.5
		(4.3)	(5.6)	(6.9)
Separate kitchen & clean cooking fuel	93%	15.7	27.3	33.6
		(4.1)	(5.7)	(9.2)
Doctor in village	50%	0.0	0.0	3.4
		(1.1)	(1.4)	(1.8)
All interventions	99%	25.1	45.2	62.8
		(3.7)	(4.4)	(5.8)

Source: Wang and Van der Klauuw, 2003

Despite other studies showing non-association, the bulk of the evidence suppose positive linkages between indoor air pollution from biomass to ARIs in children. Considering that ARIs are the most important cause of death among children less than 5 years of age and may increase ARI risk in children by 100% to 400% (Kebede, 2002), pursuing correctional interventions to reduce IAP is critical. According to Smith (2000) the evidence from various studies, on linkages between biomass smoke and ARIs in children

(which were controlled for confounding factors) is considered to be casual but the quantitative risk has not been fully characterized (Smith, 2000).

6. *Clean energy and energy technologies can reduce smoke exposure from biomass and coal among women and thus contribute to the reduction of low birth weights and still births*

The World Health Organisation defines low birth weight as babies born less than 2500 grams and identifies low birth weight (LBW) as a major risk factor in child mortality (WHO, 2003). Epidemiological observations indicate that infants weighing less than 2,500 g are approximately 20 times more likely to die than heavier babies (2004). About 20 million low birth-weight babies are born every year, representing 15.5% of all births, and 95.6% of these births are reported in developing countries (WHO, 2003). Low birth weight is a result of premature (37 weeks of gestation) birth and/ or restricted intrauterine growth and has been linked to women's nutritional status, woman's health status during pregnancy and risk factors include poor nutrition, high work load/physical activity and physical environmental factors.

In areas where modern energy sources are unavailable, women's health before and during pregnancy is affected from collection of primarily biomass [addressed in another section] to usage. At fuel usage level, pregnant women who cook using biomass fuels are exposed to various pollutants. Considering that both passive and active smoking can cause low birth weight and still birth, it seems worth considering the role of polluting fuels in low birth weight and still birth. This consideration also takes into account the fact that incomplete combustion which can occur when burning fuels inefficiently produces Carbon Monoxide (CO), which when inhaled binds with Haemoglobin (Hb) to produce COHb. This can reduce Oxygen (O_2) delivery to key organs and the developing foetus, resulting in low birth weight (Bruce et al, 2002).

There are few studies on fuel and pregnancy outcomes but emerging studies show that the exposure to biomass related IAP may be a factor in low birth weight, which is a significant factor in child mortality and even still birth (Parikh, 2002; Kebede, 2004; Modi, 2005). In Quetzaltenango, a western Guatemalan province, a study of 1,717 mothers using an open fire showed a slightly higher percentage of low birth weight infants, 19.9% versus 16.8% (stove with a chimney) and 16.0% for users of electricity or gas (Boy et al, 2002). According to Boy et al, (2002), the relationship between maternal use of open cook fires during pregnancy and birth weight reduction was statistically significant although it was small. In Zimbabwe 3, 559 infants surveyed from Zimbabwe Demographic Household Survey (ZDHS) over 5 year period showed that as with the Guatemala study, after accounting for confounding factors, mothers who were exposed to biomass smoke had a higher chance of having babies with low birth weight than those that had cleaner energy sources. Mavalankar et al (1991) found that biomass fuel use by pregnant women in India was associated with still birth after multivariate, with an O.R of 1.5 Annex 10 .

Although we found very few studies on the relationship between LBW and fuel usage, it is likely that the impact is vastly underestimated as studies have shown that intrauterine mortality, low birth weight, prematurity, and early infant death have been strongly

associated with urban outdoor pollution, which is often at much lower concentrations than typically found in biomass-using households (Smith, 2ooo). Depending on fuel and stoves used indoor pollution levels from unvented stoves are often 10–50 times greater than the levels studied in most recent urban outdoor studies (Smith, 2000). This would suggest that the magnitude of LBW incidences from indoor air pollution may be significantly higher than documented. Also, despite of the lack of substantial number of studies on linkages between IAP and low birth weight, a review of various studies from both developed and developing countries on linkages between ambient air pollution and LBW by Sram (2005) indicate that there is a causality of the effect of air pollution on birth weight (Sram, 2005). Since the Sram review only looked at ambient pollution which is several magnitudes lower than indoor air pollution in households that use solid fuels and inefficient stoves, it is likely that the impact of IAP on low birth weight from solid fuel use is higher. Similarly, extensive studies have shown that environmental tobacco smoke and smoking itself can result in low birth weight and indoor biomass combustion in absence of ventilation has been known to reach pollution levels of 10,000µg, which is 20-100 times higher than levels produced by smoking two pack of cigarettes per day (Pandey, 1989, cited in Bloom et al, 2005). Whilst some may argue that tobacco smoke may contain other additives such us Benzene, wood smoke itself, contains benzene related compounds and others and although the composition is different from tobacco smoke, its effects are adverse. Moreover, young children are more vulnerable due to their immature respiratory and immune systems, narrower respiratory pathways that can collapse or bloke easily due to due secretions related to respiratory irritation and because during episodes of respiratory infections, they are often unable to feed (Hall 1998; Berman, 1991 in Bloom, 2005).

7. Improved energy devices can reduce incidences of burns and paraffin ingestion among children

As children are often with their mothers, they tend to be within the cooking environment during cooking episodes and are exposed to risks such as burning accidents. Unsafe cooking appliances, fuels and environments leave children exposed to burning accidents and paraffin poisoning. Most available information on burns in the household is dealt with under injury studies do not necessarily address the issue of burns incidences as they relate to energy and gender in the context of under five children. Few studies have dealt with the subject as it relates to gender and energy. South Africa is the only country that seems to have dealt with burns and poisoning as they relate to energy poverty to some extent.

In South Africa alone, accidental paraffin ingestion results in at least 200 deaths a year and 16,000 hospital admissions (Electronic Mail and Guardian, September 25th 1998, Kenny, 2002). The First Annual Report of the National Injury Mortality Surveillance System in South Africa shows that of 1 169 deaths caused by accidents from external factors (i.e. unintentional injuries), 41% were due to burns. Burns were the leading external cause of death in children under one year of age, and second leading cause of death in children aged between 1 and 4 years Butchart (2000). Burns incidences in South Africa are mainly attributed to poorly designed paraffin stoves, which overheat and explode after long period of cooking or tip over. Every year there are an estimated 1,300 deaths from fire, 9,000 hospitalisations and 20,000 dwellings destroyed (Kenny, 2002).

Most of the burns victims are women and children and the causative agent in most cases is paraffin used in poorly designed stoves. Of the 51 369 fire calls were undertaken by Fire departments across South Africa in 1999, 6486 were from formal dwellings, informal dwellings and flats and the most common cause of these fires was open flames (40%) followed by electrical faults, cooking, arson and smoking (Butchart, 2000). These statistics indicate that the first three causes of fire (a risk factor in child death related to unintentional injuries) are energy related (i.e. open fires, electrical faults and cooking). Poor housing also exacerbates burns rates as shacks are build mainly with cardboard and wood and very close together but providing safer energy technologies and energy sources may decrease the risk factors for fires. In Ethiopia, a burn injuries survey of 7, 309 individuals showed that burns had the highest incidence among children under the age of five (Nega and Lindtjorn, 1999). Bruce et al (undated) found that in Guatemala, in a sample of 504 homes with children under the age of four or a pregnant woman, there had been a base line average of 42.2 burns per 1000 children. Twelve months after an intervention which provided the Plancha improved stove, there were about 16 burns incidences in the group using open fire and 8 in the group using the Plancha stove. This translates into 35.2 incidences in the open fire group and 18.1 per 1000 children in the intervention group. The relative risk in the open fire was group was 1.9 (p=0.1). Annex 11 contains details of the studies we found on cooking fuels and childhood burns. We found one study with data on comparative rate of burns incidences between fuel types. Lloyd (2002) reports that annual injury incidents relating to LPG are at least two orders of magnitude lower than paraffin related injuries, for comparable quantities sold (Table 5).

Table 5: Relative incidence rate of paraffin and LGP per 100 000t sold domestically each year

	Homes	Injuries	Deaths
Paraffin	16700	1700	1000
LPG	9	9	5

Source: Lloyd, 2002

Lloyd however does not explore other confounding factors such as education levels of users, awareness campaigns on LPG and paraffin safety, and the number of users of LPG and paraffin which may have significant contribution in this injuries pattern is not provided.

Butchart (2000) also indicates that in infants and children, choking and poisoning by ingestion of paraffin (and other household chemicals) were prominent but does not quantify the prevalence of paraffin poisoning. Incidences of paraffin poisoning however seem to be a substantial threat the health of children under the age of five. A study by Reed and Conradie (2000) found that 111 children admitted for paraffin poisoning under the age of 5 years constituted 9.1% of total ward admissions in this age group. The majority were between 13 and 36 months old. Another retrospective study of 145 children at the Philadelphia hospital in Mpumalanga, South Africa also showed that 91%

of children admitted for paraffin ingestion between January 2000 and June 2001 were under the age of 5 years (Malangu et al, undated). Similarly, a 1990 study of 436 children showed that paraffin poisoning affected children mainly between the ages of 12 and 36 months (de Wet, 1994). In India, a study of families of 70 hospitalised children showed that as is the case with South Africa, paraffin ingestion was a leading cause of poisoning. In terms of gender, boys comprise the highest number of paraffin ingestion victims in all these studies, representing a total 58% of all cases in the Malangu study and 62.5% of the cases in the de Wet study. Although most of the incidences were non-fatal, this could be because this is a hospital based study and fatal incidences were not part of the survey and some fatalities may have occurred at home. It should also be noted that paraffin poisoning can impair lung function and cause pneumonia and even death. According to Lloyd (2002), in 2001, there were an estimated 4000 children deaths from paraffin induced poisoning in South Africa alone (Table 6). Up to 143 000 children are estimated to have drank paraffin (2002). In Zimbabwe Matanhire (1994) found that of burns (16.3%) were preceded by falls (68.8) as most frequent type of injury as the most common form of injury. There were no paraffin poisoning incidences, which the authors suggest is because of availability of storage space. Details on studies found on paraffin poisoning are in Annex 12 .

Table 6: Paraffin-related health and safety incidents in 2001

Children who drank paraffin	143 000
Pneumonia in children from paraffin ingestion	55 000
Deaths in children from paraffin-induced chemical pneumonia	4 000
Paraffin related fires	46 000
Paraffin-related burn injuries from stoves exploding	31 000
Other paraffin-related burn injuries	19 000
Homes destroyed by paraffin-related fires	+ 100 000

Source: Lloyd, 2002

Nriagu et al (1997) also asses risk factors for elevation of lead among 1200 children in two age groups: 3-5 and S-10 years old in informal settlements in South Africa. They found that the burning of solid wastes for heating or cooking was associated with lead poisoning in children. Strong association was found with the type of fuel used in cooking (P = < 0.0001; x' = 17) or heating (P = 0.0024;,yz = 9.3) (wood, gas, paraffin or electricity) and lighting (candles, kerosene or electricity; P = 0.0022; 1' = 9.4)). Whether the child was present while the food was being cooked or slept in the same room where the food was prepared did not appear to affect the lead values. Contamination of food with paraffin during cooking is quite common and since several countries still use leaded fuels, the risk of lead poisoning from cooking fuels may be quite common. Candles also often contain traces of lead.

Whilst one part of the argument is that paraffin poisoning cases are an issue of safety in the home, they are also an issue of poverty. Firstly, most of the paraffin users are using paraffin not as a "fuel of their choice" but as the "second best" within the constraints of poverty. In addition, it should be noted that in both India and South Africa, most poor

families buy paraffin in smaller batches to suit the constraints of their budget. This is then often stored in used and previously discarded soft drink containers. These have by their nature, no childproof caps and yet they are the containers that the families can afford since they are "recycled". In the Indian study for example, paraffin is stored in soft drink containers in 70 % of instances. Hence paraffin ingestion incidences may be related to a combination of inability to use safer fuels, inability to buy paraffin in safer containers and poor safety procedures or low awareness safety procedures with relatively new energy devices. Unfortunately, most developing countries do not have statistics on fuel related burns and paraffin poisoning. It is likely that high numbers of children are at risk every year in poor countries due to high usage of low quality cooking appliances.

8. *Affordable and efficient thermal fuels can enable boiling of water and reduce disease outbreaks, particularly diarrhoea*

Children in developing countries are vulnerable to diarrhoeal and other diseases associated poor water sources and sanitation. An estimated 5, 000 children die every day and millions die every year from water-borne and sanitation related diseases (WHO, 2003). Most of these diseases can be combated by a combination of hygiene practices such as drinking boiled and hygienically stored water and having adequate clean water supplies. However, without adequate fuel resources to boil the water or without a means of obtaining the water in a less strenuous manner (such as pumped water facilities) trade-offs are made. More over, the importance of clean water, which is often as tap water is emphasised by the WHO's statement that "The number of water taps per 1000 persons is a better indicator of health than the number of hospital beds" (cited in Gadjil, 1998)
In areas of acute fuelwood scarcity and where there is shortage of female labour to fetch firewood, women may have to make the choice between boiling water and cooking food in order to conserve fuelwood. The rehydration project, lists difficulty of obtaining fuel and the cost and time required for boiling and cooling (and consequently the delay in commencing of rehydration therapy) as some of barriers to usage of safe drinking water in households (Acra et al, 1984). Providing affordable thermal energy and efficient stoves that reduce water boiling times may therefore be an important part of encouraging life saving drinking water care practices.

There seems to be no studies undertaken to assess the impact of fuelwood scarcity water boiling practices in households.

Insert review Sydney Larson and friend here

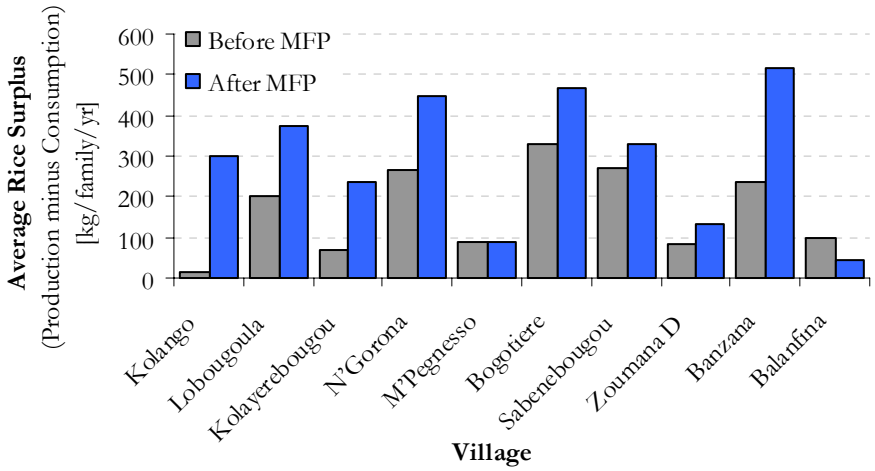
In terms of water usage, studies have shown that availability of clean water sources (pumped water) is one but not the only factor in increasing usage of clean water and improving hygiene practices in households. The availability of clean water, at reasonably short distances, combines with other factors, including hygiene education to reduce diarrhoeal diseases. Details of studies on linkages between water, child health and energy are presented in Annex 13 .

9. *Energy technologies can contribute to food security through irrigation, provision of organic fertilisers and increased labour for agricultural activities*

Energy technology can be used to increase food production by enabling the use of water pumps for irrigation. In addition, energy production through biogas produces slurry which is reach in nitrogen and phosphorous and can be used in gardens as fertiliser or for ponds. According to FAO, substituting slurry for cow dung commonly used in ponds in India for example can double fish yields (FAO, 2001). Finally, solar driers may play a role in reduction of post harvest waste through solar drying. A study in Karnataka, India where 40 households adopted biogas plants found that the households experienced improved agricultural productivity due to the usage of sludge as organic fertiliser (Parikh, 2002). In India, subsidized electricity for farmers has contributed to increased agricultural productivity and food security, allowing the irrigation of 57 million hectares, which contributes two- thirds of food grains output (Bhatia, 2004).

In Mali, the Multi-Functional Platform (MFP) is a powered configuration that provides motive power and electricity for a variety of needs, including water supply, cereal husking, battery charging, welding, carpentry tools, and lighting. In some villages where the MFP was set up reported increased rice, Shea butter and peanuts production and consumed. Of the 10 villages assessed, 6 reported increased rice production and consumption after the introduction of the multifunctional platform. As illustrated in Figure 2, most villages experienced an increase average rice surplus, suggesting that consumption needs were satisfied and there was even excess rice. However, according to the authors, "it is difficult to say with any degree of certainty what exactly caused rice production and consumption to increase".

Figure 2: Rice surplus before and after the Multi Functional Platform



Surplus rice production does not mean malnutrition can be combated by access to modern energy technologies because various foods need to be available for children's balanced diet and other factors affect intra-household food allocation. However, if other confounding factors such as new programs in the area and climatic changes were not significant factors in the change, then the rice production trend before and after MFP suggest that energy technologies may play a role in food production. Households also freed up times previously used for fuelwood collection and collection and processing of

previously used fuels. The study however does not quantify the nutritional gains by women and children which may have had a positive impact on child health and child mortality.

In Uganda, the FAO/UNDP post-harvest programme at Kawanda Research Station in Uganda recommended small scale solar dryers for long-term storage and household consumption of fruit and vegetables. However, the group was more interested in dried fruit as an income generating activity rather that for food preservation (Okalebo and Hankins, 1997).

In Bangladesh[5], rural electrification has led to a number of developmental improvements including increased food production resulting from irrigation and other income generating activities enabled by electrification. In addition, households with electricity spent more on food than households without electricity (Barkat et al, 2002). It must be noted that about 16.4% of the annual income of the electrified households could be attributed to electricity, whilst for non-electrified households in the electrified villages, 12% of the annual income can be attributed to electricity, and only 3.6% of annual incomes for the households in the non-electrified villages could be attributed to electricity (Barkat et al, 2002). In electrified homes, annual per capita expenditure on food in the electrified households (Tk.7,418.6) was 16% higher than that of the households in non-electrified villages. There were also differences in per capita daily intake of food by the members of households with and without electricity in terms of quality as well as quantity (Box 3) .

Box 3: Nutritional intake differences and electricity in Bangladesh

The members in the electrified households, on average, consume daily 46 gms (4.8%) more than their counterparts in the non-electrified villages. In terms of intake of energy (kilo calories), it was 60 K.Cal (2.6%) more. The average daily **protein** intake of the members in the electrified households (182.2 gm) was 34% higher than that of the members in the non-electrified villages. The higher quality is also evident in the fact that while the average K. calorie for the members in the electrified households was only 2.6% higher than that in the non-electrified villages, the money value of food in the electrified household exceeded 15.3%, the money value of food in the non-electrified households.

Source: Barkat et al, 2002

Despite lack of variation in disease patterns, electrified households were more likely to seek assistance from medically competent persons, more likely to have their children delivery by medically competent persons and more likely to have ante-natal and post natal check ups and receive vaccinations. This is likely to have been motivated by TV and radio messages which are available for electrified households. This seems to have affected child mortality rates. Infant mortality rate in the electrified households was found to be 42.7/1000 live births, in the non-electrified households in electrified villages 53.8/1000 live births, and in the non-electrified villages 57.8/1000 live births. Infant mortality rate in the electrified households is 25% less than the national average (57/1000 LB) and 35% less than the national rural average (66/1000 LB). NRECA estimates that if access to electricity is 100% ensured in the rural households, and those electrified

[5] All details on Bangladesh electrification in this section are derived from Barkat et al, 2002

households maintain the same infant mortality rate as the current electrified households, the annual number of infant deaths that could be saved will be around 36,818, i.e., a savings of 101 infant deaths everyday.

Thus in summary, the evidence from Bangladesh shows that households with electricity have higher incomes, spend more on food and eat better in terms of quality and quantity, spend more on health care, have a higher percentage of births attended by qualified personnel, are more likely to use of contraception, have children immunized and are twice as likely to use hygienic latrines than electrified households. These work together, resulting in lower infant mortality rates among electrified households.

Annex 14 presents details of studies on energy production and its role in food security
Despite some evidence of impacts of energy on food production, we found one study that assessed the benefits for children. In addition, the evidence on the impacts of solar pumps on food production was non-existence. There is scanty but supportive evidence on the impact of biogas on increased food production. The most promising impact seems to be the impact of electric and diesel powered irrigation on food production.

10. Affordable cooking fuels can enable the diversification (and efficacy) of diets and contribute to reductions in malnutrition

Where there are no alternative fuels, increasing fuelwood scarcity caused by various factors such as land clearing for agriculture and settlements, charcoal production and others often entails increased time spent collecting fuelwood. In most cases, women are the primary fuelwood collectors and increased fuelwood collection times take them away from other roles in and around the household. However, cooking is vital in nutrition it self and inability to cook food can affect child health.

Box 4: Cooked foods – Are they that important?

In general, studies indicate that cooked starchy foods, which are vital for energy are 2 to 12 times more digestible than raw starch. Kataria and Chauhan (1988) measured digestible starch in terms of milligrams (mg) of maltose released per gram of food. They show that starch in cooked mung beans is much more readily digested than the starch in soaked or sprouted beans, and is efficient by a factor ranging from about 1.8 to 12 times, depending on differences in methods of preparing raw compared to cooked starch. Oste (1991) also shows that cooking improved the digestibility of legumes such as African yam beans, moth beans, mucuna seeds, mung beans, sunflower and soybeans. Other foods that benefit from cooking include wheat (Oste, 1991) and rice (Bradbury 1984). The protein digestibility of rice increased from 25% when eaten raw to 65% when cooked (Bradbury 1984). All these are vital foods regularly eaten in developing countries. It should of course be acknowledged that the digestibility of other foods is reduced by cooking but cooking remains a critical process in nutrition.

To maximise times, households devise various coping strategies and these may include the decreasing the frequency cooking of foods that take longer to cook such as beans or encouraging consumption of uncooked or semi cooked foods. Kirubi (1998 cited in

Ballard-Tremeer, 2005) observed that in situations of extreme wood fuel scarcity, some poor households begin conserving energy by altering their diets to include foods that needed less cooking and avoiding indigenous and nutritious foods such as cassava, arrow roots, maize and beans that require much more energy to cook. In fuelwood-stressed areas in rural Malawi, Roth (2005) observed that some households reduced frequency of consumption of beans, a vital source of protein especially among poor households. This seems to resemble Brouwer's findings in another area in Malawi, where women reported that in acute fuelwood scarcity, the first food they would eliminate from their diet would be beans (Brouwer, 1997). However, after introducing energy efficient clay stoves in the area, families reported that they now cooked beans on a regular basis (Roth, 2005). In poor urban slums, women reported that charcoal would prices are increasingly unaffordable and more so in rainy season when roads to charcoal producing areas are impassable. As a result they sometimes miss meals or cook food inadequate food which is often left for children only. During the years of good harvest, the women would use maize bran as fuel (Robinson, 2005).

Bembridge (1990) relates the number of fires made and the number of meals prepared per day and these appear to be closely related. In his study 44% of women made two fires per day and 42% said they prepared two meals per day. Some families made two fires but ate three meals and 12% said they only made one fire per which they kept going all day.

Lund Skar (1982) finds that in Peru, households in the area with the most fuel constraints cook fewer meals than in areas where fuel constraints are not high. The author however also found that the fuel-constrained areas were isolated and had limited access to markets which forces them to depend on the most fuel-demanding foods. Various studies have found several common ways of dealing with fuel wood scarcity (Vermeulen, undated; Mahiri, 2003; Mlambo and Huizing, 2004) which do not include drastic changes in diets. Pant (1935 cited in Dewees, 1989), observed that in the Kumaon Himalayas of Nepal, fodder and fuel were in seriously short supply, and that households had to rely on stalks of amaranth, hemp, and chili for fuel.

Box 5: Coping with fuelwood scarcity

Communal cooking
Soaking foods before cooking
Sealing the sides of pots with maize paste to reduce heat loss
Lowering fire grates
Increased usage of lower quality fuels
Dousing fires after cooking
Moving from cooking outside to indoor cooking
Protecting three stone fire places

Sources: Various

In addition, Dewees (1989) and (Vermeulen, undated) note that assessing whether fuelwood scarcity affects number of meals cooked is complicated by the fact that fuelwood scarcity often occurs together with food scarcity and health care shortages and so it is very difficult to blame any problems on fuelwood shortages alone, especially given that not having enough food is always going to be a far bigger set-back than not being able to cook it. From the reviewed studies, the dominant coping strategies are

changing cooking methods and fuels. Where ash soda is used to accelerate cooking, no review is made on the impact of this on nutritional value. Similarly, where certain foods are avoided, the studies have not related this to changes in child or maternal nutrition or health. Thus there is a gap in knowledge of the nutritional impact on women and children of changes in cooking habits resulting from fuelwood scarcity.

Findings from the available studies also suggest more complex relations in the linkages between fuelwood scarcity and dietary changes. Details on studies on fuel scarcity and coping strategies are presented in Annex 15 .

11. Energy technologies can reduce time taken to undertake household tasks, freeing up time for child care

Studies around the world estimate that women work in both domestic and economic activities, clocking an average 11 to 14 hours per day (Cecelski, 2000). In developed countries women undertake an average of 51% of total work burden whilst in developing countries, women undertake about 53% (Cecelski, 2000 citing UNDP, 1995). Women's work in developing countries entails collecting firewood, fetching water, processing food, carrying out agricultural work, income generating activities and others (Celcelski, 2000). The time constraints faced by women can then result in coping strategies such as taking their children on fuelwood collecting trips or leave them attended at home by fellow children. It is not uncommon for children under the age of five to be left in the care of other children (or men) to help women cope with work burdens. These strategies can reduce child care especially frequency and quality of feeding and even increase children's susceptibility to injury (where they are left in the care of other children) as one woman from Niono puts it:

> "When I work in the fields, my older daughter comes with me to watch the baby. I have them sit at a distance so when the baby cries I am not disturbed. She gives him water to stop the crying" (Mother, Niono District).

In Mali, Tefft et al (2003) found that only 16% of sample children were exclusively breast-fed for the first six months despite recommendations to that effect. Women do not follow these recommendations due to work schedules that make it difficult to meet demanding infant feeding schedules as well as lack of knowledge of the benefits, poor breast-feeding skills and traditional infant feeding practices. The authors also observe that 58% of mothers resumed their normal work within four weeks of delivery because existing social systems failed to provide adequate support for accomplishing household tasks, taking care of other children, and supplying agricultural labor. They highlight that demands on women's time are compounded by the lack of functioning bore wells and cereal mills, which had broken down because there were no arrangements to manage the maintenance of this common property (Tefft et al, 2003).

Time maximizing strategies such as leaving children in the care of their siblings can also increase risk of injury. Reed and Conradie (2000) for example found that one-fifth of the children admitted for paraffin ingestion in Mpumalanga, were in the care of another child at the time of ingestion[6].

[6] The study does not specify what the mothers were doing. However, absence of mother may have same reduced care effect whether the mother is undertaking productive or reproductive activity.

Taking the child on a fuelwood or water collection trip does not however mean the mother will have time to feed the child or watch over it as she may be busy with the task of fuelwood or water collecting. This can therefore still contribute to infrequent feeding and may also put the accompanying child at risk of injury from accidents such as falls. Labour demands placed on women, including fuelwood and water collection which results from lack modern energy services for providing thermal energy and for pumping water, may even force early weaning, leaving children vulnerable to malnutrition and compromising their immune systems which are highly depended on breastfeeding and the mother's good health.

Biran et al (2004) compared behaviours of nursing women in selected Maasai community in Tanzania and Lake Malawi National park community. They found that the Malawi group, nursing women carry their infants strapped to their backs when they went to collect wood and integrate childcare into fuelwood collection by feeding babies during the rest periods that are associated with tying firewood bundles before returning to the village (Biran et al, 2004). In contrast, the Simanjiro Maasai women in the Tanzanian community never carry infants with them when they collect wood. The study focuses on fuelwood collection efficiency rather than health impacts on children and so no conclusions are drawn on the impacts of fuelwood collection on the children's health.

Discussions on the Multifunctional platform in Mali by Burns and Coche (2000) illustrate the trade of that are sometimes made due to the burdens of women, exacerbated by lack of modern energy services;

Box 6: Too little time to eat?

"At this moment it is harvest time, we spend all our time until well after dark in the fields. Tonight the children will go to bed without food, and the men will go back to the fields without breakfast. You see, we do still have cereals in the granary, but we simply do not have time to grind and cook food. We are exhausted. Tomorrow, we will stay behind and find the energy to prepare lunch to take to the men and the other women in the fields. They won't be able to work as they need to on an empty stomach"

-A group of women Maourolo village in Mali, explaining why they needed a platform in 1998.

Source: Burns and Coche, 2000

Although we did not find studies on time spent collecting fuelwood or water and child nutrition, we found a few studies on time spent away from home, on reproductive work and child nutrition. Rabiee and Geissler (1996) assess the nutrition status and related factors of children under the age of 2.5 years old, where mothers undertook light and heavy workloads in fields (defined as being away from home less than or more than three hours a day respectively) in Iran. The study showed that regardless of family income, children of mothers with heavy workloads have lower energy intake and a higher prevalence of diarrhoea, are more likely to be given sedative drugs, and to be thinner during the field work season although not more stunted (Table 7). In the following autumn the relative situation was similar, although the prevalence of thinness was reduced (from 26% to 11%) and of shortness increased (from 51% to 57%).

Table 7: Nutrition status and related factors of young children in relation to mothers' workloads

Workload	Family income[a]	Diarrhoea (%)	Drug (%)	Thin (%)	Short (%)	Energy (% RDI)[b]
Light (N= 18)	3,285	7	0	17	45	69
Heavy (N = 108)	3,690	16	30	35	39	65[c]

a. Tomans per month
b. Only non-breast-fed children over one year old are included.
c. N=76.
Source: Rabiee and Geissler, 1996

There were also differing hygiene practices in the two groups of women and inability to boil water for preparing milk was 59% for those with lighter loads versus 50% with heavier loads. Women with heavy workloads attributed to the lack of time for water boiling (Rabiee and Geissler, 1996). Other differences in hygiene practices could only be explained by lack of knowledge regarding personal hygiene. This would suggest that time saving from energy efficient technologies may increase the ability to boil water for preparing milk. Rabiee and Giessler (1996) suggest that other factors contributing to the higher frequency of diarrhoea may have been poor supervision of the children in an environment highly contaminated with parasites, the use of contaminated drinking water, and the growth of bacteria in foods kept for long periods of time while the mothers were working. The study showed no obvious difference between the formal educational backgrounds of women doing heavy and light work.
In Tanzania, Wandel and Holmboe-Ottesen (1996) found that women spent less time cooking and children were fed less often in the seasons of hard field work (Table 8 and 9). Thus, there appear to be some negative effects of women's work on child feeding practices, especially when the workload is high.

Table 8: Relationship between mothers' field work and average number of child feedings per day

Field work (minutes)	N	Feedings
<90	66	3.3
90-180	69	3.0
>180	40	2.9*

Data based on averages from three surveys.
* Analysis of variance, controlling for Socio-economic score, p = .02.
Source: Wandel and Holmboe-Ottesen, 1996

Table 9: Seasonal variations in cooking and child feeding patterns

Survey	Average cooking time (minutes)	Average child feedings
1	265*	3.6*
2	163	2.7
3	162	3.1

Difference between survey 1 and surveys 2 and 3 significant below the .05 level (paired t test).
Source: Wandel and Holmboe-Ottesen, 1996

Unlike the Iran study, despite reduced cooking and feedings, analysis of the direct relationship between the time mothers spent working in the field and child nutrition status in Tanzania gave no conclusive evidence (not statistically significant) that women's work has negative consequences for the child (Table 10), although weight of child and proportion of malnourished children increased with increasing time spent working in the field.

Table 10: Relationship between mothers' field work and children's nutrition status

Field work (minutes)	N	Average weight for age	Malnourished (%)
<90	137	84.8	16
90- 180	124	83.1	20
>180	105	82.4	22

Data based on averages from three surveys.
The differences are not significant at the .05 level (analysis of variance statistics. controlling for socio-economic score. p = 27).
Source: Wandel and Holmboe-Ottesen, 1996

A USAID study on breast feeding practices in Mali on time constraints and women's agricultural work further illustrates the impact that women's work, can make on child care, frequency and quality of feeding and consequently, child health (Box 4).

Box 7: From the mouths of men- Stories of child health and women's time poverty in Mali

"Already at 4 to 5 months, mothers leave the child with an older sibling, because they have too much work to do. Now, when the mother distances herself from the child, the child will not have the quantity of breast milk he needs and is used to getting, and the type of food that the child could eat is not available to him. In the end, the person caring for the child is obliged to give the child food from the family meal (*toh*), which is not appropriate for the child. This is why children do not grow and develop at the rate they should" (Father, Niono District).

"From the first day of life until the fortieth day a child is treated like a fragile egg. The mother doesn't go anywhere with the child and he is well taken care of by the women of the family. He is well covered so as not to be cold, the sun does not beat down on him, he is often bathed and nurses whenever he demands. During this period you find that the mother is calm and without worries and that she can care for her child. But after the fortieth day, the child is treated like an adult. The mother brings the child to the field and lays him on the millet stalks while she works. The sun beats down on the baby whose skin is not resistant against the sun like adults. At this moment, illness sets in and even if he has been a healthy, plump and well-fed baby he will start to lose weight. Water is given to him and it is not very good quality, because the water should first be boiled to eliminate parasites and kept in a closed bottle to keep it clean until the child needs to

drink. But the reality of it is that the child is exposed to unhygienic conditions, and must even nurse in this environment, only to be left with a child who is barely older than the baby and probably weighs the same, so that the mother can work. How is a child to grow normally under these conditions?" (Father, Niono District).

"Men cannot do the same work as women. Women work from early in the morning until late at night. As soon as they are done with one task, they start another. Men do not do that. How do you expect women to ever rest? Women suffer in a way that men never will"(Father, Macina District)

"I don't think that there is any special preparation for children besides what is prepared in the morning. Children eat this food during the day, and that is because of the enormous amount of work. Here the labor women provide in our fields is very, very important" (Father, Koutiala District).

"If it is the agricultural season, women don't have a moment of rest. From the transplanting to harvesting, women are separated from their children and don't have time to care for them. In the rice fields, they don't have time to approach their children even to nurse them. Often there are children who cry excessively" (Father, Macina District).

"I have noticed that during the months from September to November the ambulance is coming and going. From our fields we hear the siren three or four times a day. And it is never a man in the ambulance, it is always a woman. Everyday we hear of such and such woman who had a difficult delivery, or who died during childbirth and that happens often. But we can't do anything. How can someone who is poor tell his wife to stop working" (Father, Macina District).

Source:

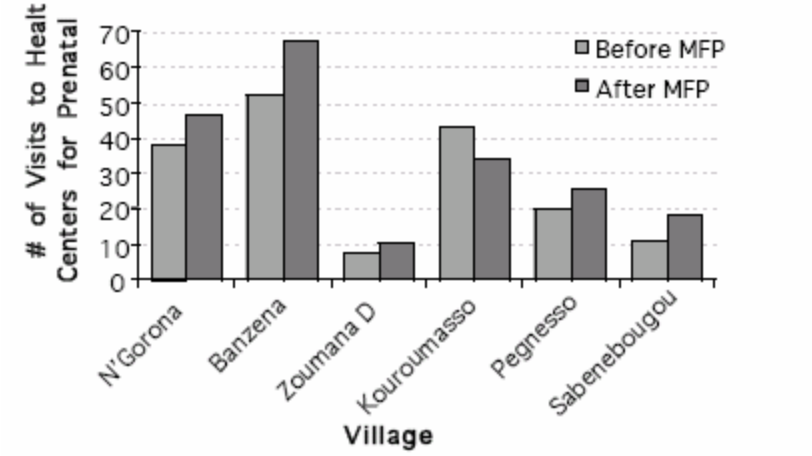
Apart from reducing child care, time constraints and women's heavy workloads during pregnancy can have a negative impact on pregnancy outcomes, resulting in among other things, low birth weight. Shaw (2003) reports that many studies have suggested that strenuous physical activity, including in the workplace during pregnancy, is associated with reduced infant birth weight, lower pregnancy weight gain, shorter gestations, intrauterine growth retardation, spontaneous abortions, fecundity and some congenital malformations. Argarwal et al (2001) assessed the impact of physical activity on pregnancy outcomes in rural undernourished women in India. They classify sitting down, standing still, breast feeding, feeding the child, cutting vegetables, eating and watching as mild activities; cooking, drawing water, shopping, washing utensils and clothes, carrying light load, collecting wood, child care, sweeping and cleaning, walking, weeding rice trans-planting seedlings harvesting, removing husk from rice and wheat by pounding as moderate whilst drawing large buckets of water from the well, carrying heavy load (>20 kg), chopping wood, cleaning land, planting seeds, removing bran from cereals by pounding, digging potatoes, bathing and milking cattle are classified as hard work. Argarwal et al (2001) found that hard physical activity in undernourished rural women in later pregnancy reduced fetal length as well as weight. It also reduced maternal weight gain during pregnancy, which improved with longer hours of rest in later pregnancy.

Reducing women's work time in any area whether agriculture work or fuelwood collection may therefore play a role in improving child health and reducing child mortality.

Energy technologies can reduce the times spent by women working, thereby freeing up time. However, there is the question on what the "saved" time is used for. Gender norms underscoring the roles of women and men may dictate that saved time be used for new work or work that was otherwise carried out by other members of the family. It is therefore important to understand what time gained by women by using labour and time saving energy technologies is used for. Parikh (2002) for example found that whilst some of the time freed for fuelwood collection was used for more work in the field, part of the freed time was used for increased time for nurturing children. In a project by ENSIGN project, time savings were mostly used for childcare as well as recreation, and partaking in social activities (Ramani, 2002 in Panjwani, 2005). Ding 2002 found that whilst electrification reduced time spent tending pigs and grinding corn, the greatest gains were made by men. Women also has increased time to rest but this was offset partly by an increase in the time spent working in the fields. In some households, women's working time even increased with the arrival of electricity, as electricity made it possible for women to move some of the 'domestic' activities into the evening period so that they could work longer in the fields during the day (Ding 2002, in Dutta, 2005). In ….women benefited by having more time for child care, and other household chores but 36% and 49% the respondents in Hill and Terai regions respectively reported that women had to spend more time fetching water after the installation of biogas plants (Eastconsult, 2004).
The evidence on whether women use time savings for child care is scanty. In other studies where women save time from use of energy technologies or improved access to energy, there is no indication whether respondents had children or not. In fact, most studies do not tackle the question of time savings and child care at all, preferring to concentrate of economic benefits of time savings.
Child care can also be viewed in terms of care of unborn child. McCray (2002) found that cooking was the activity rated as number one and most frequently in terms of conflict with pre-natal visits. The study examined 327 households, with children ages 12 to 23 months, to assess the daily activity constraints (environmental and socio-economic factors) that motivate or discourage women from utilizing prenatal care services in rural South Africa. The study found that women sight cooking most frequently, seconded by fetching water as activities that most affected by pre-natal visits to the hospital/clinic (McCray, 2004). Cooking and water fetching take 1.44 hours and 1.39 hours of the women's time. Whilst the study does not examine the health impacts of these activities on child health, it provides some insight in the probable opportunity costs between health care access and energy poverty. Inability to access pre-natal health services can have negative health impacts on both mother and child. Similarly, although to a different degree, as missing meals or opting to reduce hygiene practices to reduce number of water collection trips to make up time for pre-natal visits can both be detrimental to the mother's and child's health. Energy technologies that reduce women's workload can be vital in improving attendance of pre-natal clinics. A study on the impacts of the Multifunctional Platform (MFP) also shows that introduction of the MFP in villages in Mali, which is a diesel operated energy technology for a range of services, resulted in

time savings of between 1 to 3 hours. Among other uses of the time saved was attendance of pre-natal clinics, according to hospital records and information from women themselves. Five out of six villages in the study experienced increases in pre-natal visits (World Bank, xxxx). Only one village experienced a decrease in prenatal visits after MFP (Figure 3). Although the study did not control for other factors and enablers (such as other development programs in the area), the increasing prenatal visit was (partly) because the MFP freed up time for women. Annex 16 presents details of studies on time women's constraints and child health.

Figure 3: Changes in pre-natal visits before and after the Multifunctional Platform



5. Conclusions

A question that then arises from the above linkages between energy and children's health is: Can improved energy services reduce the infant mortality by reducing their exposure to IAP, injury during fuelwood collection, malnutrition related to fuelwood collection burdens of women and accidents from their proximity to unsafe fuels and appliances in the home? The evidence so far suggests that energy has an important role to play in lives of children under the age of five and may therefore have an important role to play in reducing child mortality. There are various ways in which energy is linked to child health and for each of these there is varying evidence. In some cases, the evidence provides a mixed picture and lack of adequate number of studies mean that most evidence provides remains inclusive.

Although there were a highly limited number of studies, the evidence suggests that availability of modern energy services enables the provision of various important health care facilities. Electricity in particular is important for powering operating theatres and respirators. There is also a linkage in availability of modern energy services, particularly solar refrigerators and geographical expansion of vaccine coverage. Although there were no studies that could be used to test increases in clinic visits and increases number of children vaccinated, increases in geographic coverage would suggest increased access to vaccines and therefore increased number of children vaccinated.

The impact of indoor air pollution on children's life and its casual effect on ARIs in under-five children seems conclusive. In this respect, clean energy technologies can reduce indoor air pollution. However, technologies such as improved stoves, whilst they reduce IAP and in some studies, number of ARIs incidences in children, they do not reduce IAP levels to WHO and USEPA recommended levels. Thus concentrating corrective intervention for indoor air pollution on improved stoves is unlikely to have a significant impact on reducing child mortality. This suggests that to significantly reduce effects of IAP on child health, energy sources higher up the ladder, such as LPG can play a critical role in reducing ARIs. Despite this, the gains made in child lives saved by transition to improved cookstoves are still worth exploiting, particularly for the very poor who will not gain access to cleaner energy in the long term. There are very few studies on low birth weight and still birth and fuel related pollution. However, the evidence from these studies is consistent and importantly, they take into consideration confounding factors. The evidence shows a correlation between women's exposure to IAP and low birth weight. In addition, more comprehensive studies on ambient pollution and environmental tobacco smoke (ETS), are conclusive on the linkages between air pollution and LBW. In almost all cases, indoor air pollution from solid fuel use is several magnitudes higher than ambient pollution and in other cases, is equivalent to smoking 2 packets of cigarettes a day. Using these as proxy indications, there is strong reason to believe that there exists a casual linkage between IAP and birth weights and possibly still births. However, more studies would be required to test the significance of the linkages between fuel related indoor air pollution and low birth weight as well as still birth.

Whilst paraffin poisoning seems to be a risk factor in poisoning and burns, the available evidence provides no in-depth analysis on factors in paraffin ingestion by children, which could include use of additives, lack of safety procedures and other factors. However, it cannot be denied that paraffin poisoning from ingestion and food contamination (And other mechanisms) remains a poverty-energy issue since high income households are unlikely to use paraffin for cooking. The low number of paraffin poisoning studies is another barrier to making any conclusion as is the fact that in most poor countries paraffin remains an expensive commodity and hence is used by fewer households, which may explain the lack of research in impacts of paraffin as a household fuel. The emerging evidence of the health impacts of paraffin usage on child health both in terms of burns, poisoning by ingestion and lead poisoning and linkages indicating fewer deaths in households using LPG raise a debate on whether paraffin, which is considered a transition fuel higher up the ladder should be a targeted as a desirable fuel or whether efforts should be made to help households to "jump the rung" and move to seemingly safer fuels such as LPG and electricity. There is therefore need for increased research in modern fuels such as paraffin, safety of cooking technologies and child health. Although it is scientifically proven that water boiling kills pathogens, it is not clear how and whether availability of modern energy services can improve water boiling habits and therefore help reduce diarrhoeal diseases. This is partly due to lack of studies on this linkage but also due to methodological issues on studies on thermal fuels, water boiling and disease prevention. Various factors play a role and hence issues such as hygiene education and provision of clean water seem to be more critical in water related hygiene for avoidance of risky diseases such as diarrhoea. There are no adequate studies on linkages between energy for food security and child nutrition, yet the strong evidence

from the Bangladesh study that makes direct linkages between electrification and child mortality is overwhelming. This is further supported by modelling studies which also show significant numbers of "child lives saved" due to electrification and use of cleaner fuels. This warrants further research on the impact electrification can make on reducing child mortality. So far, studies on scarcity of fuels, coping strategies and child nutrition suffer from inability to account for confounding factors and inadequate methodologies for separating effects of other factors such as shortage of health care and food shortages. There is however evidence that certain foods may not be adequately consumed although the impact of this is not assessed. Another problem is that under long term fuel shortage (a situation certain areas in developing countries experience) coping mechanisms become knit in everyday life that it may be difficult to single out some mechanism as being a result of fuel shortage. The evidence on fuelwood scarcity and nutrition is therefore inconclusive and research can be conducted to address the gap in knowledge. It is also unlikely that lack of electricity is a key variable in the shortage of professional medical personnel in remote areas. There are several factors at play and we found no study that explored the energy linkage as well as the various factors to allocate the "burden" on the various issues supporting the migration of health care professionals.

6. Recommendations

The review shows that there is a general lack of studies on gender, energy and child health. However, the available evidence suggests that energy has a critical role to play in reducing child mortality. This is especially true for IAP, provision of health care facilities, particularly the role of solar refrigerators in increasing vaccine outreach and possibly lack of access to electricity and child mortality. In view of the finding of this study, we make the following recommendations;

1. There is need to conduct research on the various linkages between gender, energy and child mortality. In particular, the following areas are of interest and need to be investigated:
    - Availability of affordable energy services (or lack there of) and child mortality from a range of factors including access to health information, cleaner environments and income generation for improved quality of life. Here focus should be on identifying conditions under which affordable energy services creates gains in combating child mortality.
    - Impacts of energy technologies on women's ability to allocate time for child care as well as ante-natal and post-natal care.
    - The impacts of paraffin usage must be examined to help policy makers decide the suitability of moving households to paraffin usage as opposed to other fuels.
2. ICTs play various roles especially informing the public about health. These should however be targeted smartly due to costs considerations and illiteracy issues. Radios are best suited to the poorest regions with low literacy levels whilst

lower-middle income areas can be targeted with television. Computers may be best suited for health professional to improve access to information.

3. Gender experts, energy professionals and the health sector in knowledge generation, policy formulation and joint action to ensure that energy services contribute more effectively to the health sector in children and child health in particular.
4. Traditional assessment of energy projects should shift from economic cost-benefits analysis to include gender and socio-economic analysis so as not to miss benefits that cannot be monetised. Gains in reducing child mortality from subsidised electricity for example may offset the "heavy costs" of subsidising electricity access.
5. In resource constrained situations, from donors and aid recipients, improved cookstoves for reducing indoor air pollution should be encouraged. However, the reductions in IAP are well below USEPA and WHO levels and this reality must be recognised. Where possible, households must be helped to jump to energy forms with the largest gains.
6. Energy program design should change focus from providing energy as a commodity to providing energy, focussing on particular developmental issues such as clean energy for child health or water and sanitation.

More studies on time saved or time constraints and child health

Lloyd P, 2002. *The safety of paraffin & LPG appliances for domestic use.* Paper for Energy R&D in Southern Africa. Energy Research Institute, Cape Town.

http://www.who.int/mediacentre/factsheets/fs272/en/

http://www.who.int/mediacentre/factsheets/fs284/en/

Poverty seems to underscore child mortality and so providing services and goods that are essential to child health can play a critical role in reducing child deaths. These services and goods would include well equipped health services and health personnel, dispersing health care information, providing safe environments, providing portable and clean water, improving food security and nutrition and improving access to health care facilities. According to WHO organisation for example, wider vaccination coverage in the past decade could have saved 2.3 million children from dying whilst providing clean water

Annex 1: Tables of contents

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Annex 2: Key search words, publications and websites

Annexe 1: Leading causes of deaths in children in developing countries in 2002

Rank	Cause	% of all child deaths	What causes these deaths?	Possible gender/energy linkage
1	Perinatal conditions	23.1	Most deaths are the result of poor maternal health and nutrition, inadequate care during pregnancy and delivery, lack of essential care for the newborn baby, infections, birth injury, asphyxia, and problems relating to premature births.	1. Maternal health and energy-nutrition balance can be improved with less arduous work during pregnancy 2. Reducing heavy maternal workloads with time saving energy technologies and physical load reducing energy technologies can lead to still birth and incidences of low birth weight infants as well as premature births. 3. Electrifying villages and providing pumped clean water may improve staff retention in rural clinics and offer better child and maternal health services 4. Electrifying clinics may improve delivery services, particularly emergency services provision and reduce still births and birth injury
2	Lower respiratory infections	18.1	In high-mortality developing countries, indoor smoke is responsible for an estimated 3.7% of the overall disease burden, making it the most lethal killer after malnutrition, unsafe sex and lack of safe water and sanitation. There is consistent evidence that exposure to indoor air pollution increases the risk of pneumonia among children under five years. Globally, pneumonia and other acute lower respiratory infections represent the single most important cause of death in children under five years. Exposure to indoor air pollution more than doubles the risk of pneumonia and is thus responsible for more than 900 000 of the 2 million annual deaths from pneumonia. As a result, 56% of all indoor air pollution-attributable deaths occur in children under five years of age.	1. Cleaner energy can reduce IAP and may help reduce child mortality 2. More efficient energy technologies such as improved cookstoves reduce indoor air pollution although not to acceptable levels. Gas and electricity however reduce IAP to recommended levels
3	Diarrhoeal diseases	15.2	Diarrhoea is mainly transmitted due to lack of personal hygiene (in this case, maternal, care-givers and child hygiene) and domestic cleanliness; hygienic food preparation and storage; clean and plentiful water supply; and sanitary excreta and refuse disposal.	1. Clean water can help improve hygiene behaviours such as hand washing, fruit and vegetable washing, bathing, cleaning utensils and surroundings. Energy technologies such as solar water pumps, wind pumps and diesel gensets can improve access to clean water. 2. Affordable energy services can provide thermal energy for boiling water for drinking and for preparation of oral rehydration salts for rehydration therapy for children with diarrhoea. Water boiling is an effective way of killing pathogens 3. Biogas plants and landfill methane plants can help improve waste disposal in areas where this is problematic

				whilst providing clean energy and reduce breeding grounds for disease carrying insects
4	Malaria	10.7	-	-
5	Measles	5.4	Comprehensive immunisations could have saved 2.3 million children in the past decade. Increasing vaccination coverage can therefore save millions of infant and child lives. In addition, acute respiratory infections and pneumonia are the most dangerous complications of measles. Reducing susceptibility to ARIs may save lives of children with measles	1. Solar and conventional refrigerators both of which need electrical power can be used to stock vital vaccines for immunisations and medicines for treatment of measles. Solar powered refrigerators are especially crucial for remote rural areas without grid connection and poor or not existent fossil gas and paraffin networks 2. Cleaner energy could reduce susceptibility to ARIs among children with measles and increase their survival chances.
6	Congenital anomalies	3.8	-	-
7	HIV/AIDS	3.6	-	-
8	Pertussis	2.9	Pertussis, a bacterial disease also known as whooping cough is most effectively controlled by vaccination	1. Solar and conventional refrigerators both of which need electrical power can be used to stock vital vaccines for immunisations and medicines 2. Affordable and convenient transportation can help improve access to health care facilities and reduce the walking burden and encourage vaccination 3. Energy; solar and conventional electricity, can power radios and improve access to health information, including immunisation awareness and campaigns especially in rural areas
9	Tetanus	1.8	-	1. Solar and conventional refrigerators both of which need electrical power can be used to stock vital vaccines for immunisations and medicines 2. Affordable and convenient transportation can help improve access to health care facilities and reduce the walking burden and encourage vaccination 3. Energy; solar and conventional electricity, can power radios and improve access to health information, including immunisation awareness and campaigns especially in rural

				areas
10	Protein-energy malnutrition	1.3	-	-
	Other causes	14.0	-	-

Annexe 2. Some key linkages in energy and child mortality

Contribution towards MDG 4	Child health energy linkages
Harmful effects of low value fuels and energy devices	Improved energy devises and modern energy services can reduce indoor air pollution Safe energy devices and improve energy product delivery can reduce accidents such as burns and poisoning and their related costs
Effects of fuelwood scarcity	Availability of clean and affordable fuels can reduce time spent by women collecting fuels and increase child care time and quality including breast feeding and attendance of pre and post natal clinics Availability of efficient energy devices and affordable fuels can increase household's ability to cook and cook diversified foods and improve nutrition Availability of affordable energy services can enable boiling of drinking water
Health costs of lack of powered facilities	Modern energy products and services such as electricity can power vital hospital equipment Availability of modern facilities such as pumped/piped water and electricity can reduce the migration of health care personnel from rural areas. Availability of pumped water can increase water availability and improve hygiene practices such as washing hands, bathing and general house and utensils care thereby reducing incidences of diarrhoeal diseases in children Electricity enables the powering of emergency facilities at hospitals Availability of power for radio, television and internet can help delivery of improved health care facilities through improved communication among health personnel on emerging disease outbreaks and disease management techniques Telephones can improve response time of ambulance services and reduce mortality caused by delayed responses to emergencies

Annexe 3: Energy and vaccination

Study	Reference type	Location and intervention type	Results
USAID, undated	Project info leaflet	Provision of solar technology in Laj Chimel, In Guatemala	Laj Chimel community in Guatemala is extremely poor and prior to the intervention, did not have access to electricity and telecommunications. USAID, a local NGO; the Funacion Solar and the Local Improvement Community group introduced dolar technology. They ensured women's participation in identifying energy needs of the community and installed 50 solar home systems on homes, clinics, and enabled the availability of solar powered telephones. This reduced IAP associated with kerosene usage, and enabled the community health center to store vaccines and other medicines in solar powered refrigerators as well as long distance learning in lighted classrooms through VCRs
Jimenez and Olson, 1998	NREL Booklet	Provision of PV technologies to rural clinics	Solar powered lighting system installed in October Mosoco, a community of Paez Indians in Southern Colombia enabled the powering of a Community Health Center. During an earth quake and land slide disaster in 1995, it was used as a point for providing disaster relief services by the RedCross, the Colombian Army, and other organizations since it was the only powered building available. The Cold Chain Program has enabled the provision of refrigerators for immunization storage in remote areas in almost all countries. Africa and Asia have especially benefit as temperature controls of gas refrigerators were particularly problematic in its climate. Problems with unreliable gas supplies are also mitigated by the replacement of gas powered refrigerators with solar powered refrigerators. PV technology also enabled the provision of immunization to remote communities in Peru, the Dominican Republic, Mexico, Colombia and others.
			Solar Light for Africa implemented by USAID (sometimes in collaboration with other agencies) has provided power and light to 1,500 facilities in rural regions of East Africa, including two large regional hospitals. Benefits realized include provision of immunization in rural clinics, reduction of polluting toxic fumes of kerosene lanterns.

			In Kakuuto Hospital located in the Rakai District of Uganda in particular, solar power enabled the medical staff to preserve vaccines and other medicines, as well as operate small medical equipment as well as access clean water through a solar powered pumping system with two large storage tanks and 3.2 kilometers of piping supplies the hospital with pure water
SELF Solar Electric Fund	Website www.self.org	Provision of solar lighting and refrigeration to communities in parts of rural northern Nigeria	The solar project improved water supply which before was collected by colleting water from open wells with rope and bucket, hand pumps, diesel-powered pumps which were often too expensive to replace when the broke down. The village health clinics had lights for the first time and for the first time health officers could see patients at night. The clinics were able to store vaccine refrigerators, allowing more people to be vaccinated at greater frequency and fans increase the comfort level of staff and patients alike. Village primary schools had two illuminated classrooms and teachers reported that these were used for adult education classes at night. Each school was provided with a computer and computer instruction for the teachers, with plans for internet connections, street lights made possible night vending and mosque activities possible in the night.
Margolis, Faber et al, 1997	Newsletter	Solar PV for communications, clinics and schools	12,500 PV modules were used for telecommunications systems in polling booths for the general elections; the Independent Development Trust initiated a program for the PV electrification of at least 60 rural clinics in former homeland areas
de Melo Branco, 2002	Newsletter	Solar PV pumps	PV solar pumps were used to provide a community in Northern Brazil (Mamirauá Sustainable Development Reserve*)* with pumped water. Five systems were installed, two of them were submersible pumps, the other three were surface pumps. The pumps enable the provision of clean water in the community and reduced the time spent by women collecting water

Annexe 4: ICTs and health

Table to be made – Will include various aspects of ICT usage and health

Annex 6: Emission levels from various cooking technologies in developing countries energy and vaccination

Reference	Reference type	Location and intervention type	Research methods	Results
Bruce N, Neufeld L, Boy E, Bruce N, Smith K and Hernandez R, September 2000	Journal article Energy for SD. Vol IV No 2	San Juan Ostuncalco Guatemala	This study tested and reported on fuel efficiency of the plancha in western Guatemala, in comparison with the traditional open fire. It tested thermal efficiency, fuel wood consumption and emissions. Up to 20 open fires and 21 plancha (improved cookstoves) were tested	In standard water boiling and cooking tests, the plancha consumed more fuel and took longer than the open fire. A modified plancha combustion chamber improved efficiency by 12%, bringing it up to the value for the open fire. Further modifications to the plancha resulted in the use of 39% less fuel wood than the open fire. The improved thermal efficiency of the final modified plancha would improve health, environmental and poverty outcomes

Abalak R Bruce N McCracken J Smith K De Gellardo T	Journal article Environ. Sci. Technol.2001, 35,2650-2655	La Victoria, San Juan Ostuncalco, Western Guatemala	The study carried out exposure to particulates in 30 households in rural Guatemala, comparing 24 hour particulate concentrations over 8 months for three fuel/cookstove conditions. Comparisons were made between traditional open fire cookstove, an improved cookstove called the plancha mejorada (improved plancha), and a liquefied petroleum gas (LPG) stove/open fire combination	Results show geometric mean $PM_{3.5}$ concentrations were 1560 Ìg/m3 (n) 58 for open fire, 280 Ìg/m3 (n) 59 for plancha and 850 Ìg/m3 (n) 60 for LPG/open fire combination. Results show that Plancha consistently offered the most reductions in $PM_{3.5}$ concentrations, up to 85% reduction compared to open fire whiles the LPG/open fire showed a 45% reduction in $PM_{3.5}$ concentrations compared to the open fire alone. Mothers often spend up to 5 hours in the kitchen with babies on their backs and households use a either the plancha exclusively, an LPG/open fire combination or open fire exclusively.

			A random sample of 204 households with children less than 18 months in a rural village in the western highlands of Guatemala was examined. Socio-economic and household information was obtained by interview and observation. Carbon monoxide (CO) exposure levels for PM3.5 were examined for 24 hours, using Gastec diffusion tubes. About 50% of the homes used open fires, around 30% used chimney stoves (planchas) and the rest used various combinations including bottled gas and open fires.	The study assesses children's exposure to biomass related indoor air pollution from improved stoves in a rural Guatemalan population reliant on wood fuel. Homes with self-purchased planchas: had the lowest CO of 3.09 ppm (1.87–4.30), open fire homes has CO levels 12.4 ppm (10.2–14.5). The predicted child PM for all 203 children (based on a regression model from the sub-sample) was 375 mg/m3 (270–480) for self-purchased planchas and 536 mg/m3 (488–584) for open fires. Multivariate analysis showed that stove/fuel type was the most important determinant of kitchen CO and child CO exposure with some effect of kitchen volume and eaves. Improved stoves in this community have been effective in reducing indoor air pollution and child exposure, but both measures were still high by international standards.

Visser and Khan, 1996	Journal Article ESD, November 1996 Vol. 3 No. 4	50 CO measurements in 12 households in Dhaka and 24 in Rajshahi	Assesses the emissions exposure for cooks (women) in Bangladesh by taking 50 CO measurements during cooking at breakfast and lunch. Dinner exposure was considered nil because "boiling rice" did not require attendance.	CO concentrations for improved were significantly lower than those for traditional stoves (p-value = 0.012, not assuming equal variance). The average lunch preparation time is calculated to be a little under two hours (1h 51m). Breakfast preparation takes an average 97 minutes. Authors note that preparing lunch with improved stoves does not seem to result in significantly shorter cooking or exposure times (since p = 0.22). This is attributed to the fact that women with improved cookstoves prepare more dishes per meal than those with traditional stoves

Mutere A 1990	World Environmental Library database	Kenya	IAP monitoring in sitting and stirring positions from Mandeleo stove and three stove fire and three different types of wood	The improved, Maendeleo stove again as with the CO and total suspended particulates results (TSP) proved to be emitting at least 50% less of each type of Polycyclic Aromatic Hydrocarbons tested (PAH). TSP levels for the 3 stone stoves were 2.6 times higher on average than for the improved stoves. Nonetheless, the Maendeleo levels are still above the recommended level of 100-150 ug/m3 over 8 hours set by WHO and 260 ug/m3 recommended over 24 hours by the EPA.. Taking the TSP average obtained for the Maendeleo of 1725 ug/m3 and figuring it over 8 and 24 hours, one will get 1300 ug/m3 and 410 ug/m3 respectively. Eucalyptus TSP value for 3-stone stove is 2.3 times higher than the Maendeleo and with Jacaranda it is 1.7, Zanthoxlum is 2.3 times and Cyprus is 2.6 times higher for the 3-stone stove

Balakrishan K, Sambandam el, al, 2004	Journal article	India, Andra Pradesh	The study quantified the daily average concentrations of respirable particulates in 412 rural homes selected through stratified random sampling from three districts of Andhra Pradesh, India. Time activity data for 1400 individuals was recorded for 24-h average exposures. The concentrations were measured using samplers.	The mean 24-h average concentrations ranged from 73 to 732 mg/m3 in gas- versus solid fuel-using households, respectively. Concentrations were significantly correlated with fuel type, kitchen type, and fuel quantity. The mean 24-h average exposures ranged from 80 to 573 mg/m3. Among solid fuel users, the mean 24-h average exposures were the highest for women cooks. These were significantly different for men and children. Among women, exposures were the highest in the age group of 15–40 years who are the primary cooks. Among men, exposures were highest in the age group of 65–80 years (most likely to be indoors).

Balakrishnan, K Parikh, J Sankar, S et al	Journal article Environmental Health Perspectives • Vol 110 No 11 November 2002	Rural Households of Southern India	450 households in 30 villages through systematic random sampling from four districts in Tamil Nadu Villages. A questionnaire was administered to each household to assess prevalence of exposure co-variants such as fuel type, kitchen location, stove type, cooking duration, number of meals cooked, time spent in or near the kitchen while cooking, and presence or absence of chimneys. Personal samplers were attached to cooks while cooking. Concentrations were monitored for the indoor and outdoor microenvironments during cooking and non-cooking times as well as personal exposures of cooks while cooking for each household. A respirable dust sampler was used to assess any contributions from other nearby sources.	Agricultural waste highest levels of respirable particles, followed by wood chips, wood, kerosene, and gas, respectively. The average 24-hr exposure for women cooks when using biomass fuels (231 ± 109 μg/m3) is significantly higher ($p < 0.01$) than for those using clean fuels (82 ± 39 μg/m3) and for non-cooks in homes using solid fuel (179 ± 108 μg/m3). Among non-cooks in households using solid fuel, women not involved in cooking and men with outdoor jobs had the lowest exposures, while women involved in assisting the cook and men staying home had the highest exposures. The 24-hr average exposures for women cooks using biomass fuels in enclosed kitchens (248 ± 117 μg/m3) was significantly ($p < 0.05$) higher than for those that used biomass fuels in outdoor kitchens (171 ± 55 μg/m3). Exposures were not significantly different across women cooks using biomass fuels in various types of indoor kitchens.

Waudo and Muchiri, 2003 (Same as Mathee et al, 2002, I have used the Waudo because its more detailed)	Western Kenya	50 households (25 Kajiado 25 Nyamira- Western Kenya) were assessed for indoor air pollution. Indoor air measurements using samplers	The project used participatory approaches and targeted women to introduce interventions for reducing indoor air pollution in Western Kenya. A baseline assessment prior to the intervention indicated mean 24-hour values for respirable particulates of 5526 micrograms per cubic metre in Kajiado and 1713 micrograms per cubic metre in West Kenya. In some households in Kajiado, pollution was dso high it made monitoring difficult. Interventions included installation of smoke hoods, introduction of improved cookstoves, construction of eaves and installation of windows	Stoves were generally not adopted in Kajiado. In Western Kenya where stoves were adopted, stoves reduced respirable particulates in room by 56%, carbon monoxide in room by 42% and carbon monoxide inhaled by cook was reduced by 5%. All interventions reduced respirable particulates in rooms by 43% whilst smoke hoods reduced respirable particulates by 75%. All interventions reduced carbon monoxide in room by 34% and smoke hoods reduced carbon monoxide by 78%. All intervention reduced carbon monoxide by 16% and smoke hoods reduced this by 35%. Smoke related health burdens that were reported by users to have decreased included; ▪ Coughs, dizziness and chest pains relieved ▪ Reduced sweat and heat, so better sleep ▪ Less headache, malaise ▪ Reduction in aching eyes, tears and running nose ▪ Safer - smoke hood acts as a shield, preventing children and goats falling onto fire ▪ Snakes and rodents cannot hide in the house where there are windows ▪ Food free from soot

Naeher et al, 2000	Journal Article	Queltzanango, Guetamala	The study used samplers to measure indoor and ambient CO and PM2.5 levels during cooking of breakfast, lunch and dinner. Only 10-20% of the population use improved cookstoves (plancha and Lorena), few use gas but the majority use firewood on open fires.	The results showed that gas had the lowest CO and RSP levels. CO ppm averaged 3.5 for the 14 households assessed, Lorena stove had an average ppm of 15.4 for the 13 households assessed, open fires had CO ppm of 22.9 for the 146 households monitored whilst plancha has CO ppm of 10.3 for the 81 households monitored. For PM2.5, gas stoves emitted an average of 0.3 for 13 households monitored, Lorena emissions for 15 households showed an average of 6.03, for the 167 open fire using households indicated average PM2.5 of 5.3 and for the 81 households using plancha stoves, PM2.5 were 1.91. 57 street measurements for ambient PM2.5 levels was 0.23.

Rollin et al, 2004	Journal Article	North West Province, South Africa	The study assesses RSP and CO levels in one electrified and two unelectrified villages in NW province in South Africa in summer 2000. All households selected are away from major roads and have children below 18 months of age. 52 unelectrified and 53 electrified household were monitored for 24 hours using samplers and surveyed using structured questionnaires for time activity and fuel usage. Dwelling structures were similar. The mean number of years with electricity in the electrified households was 3.6 years. 72% of the stoves in the unelectrified households have chimneys but on 32% of stoves in electrified households had chimneys. Of the electrified households, 44% had never used electric stoves. 26% electrified households used electricity as the main source of cooking.	In unelectrified households, both CO and RSP levels were significantly higher than in un-electrified households, (n=25) RSP ranges were between 19 and 1328 µm/m3 with a mean of 162.1µm/m3 whilst unelectrified households (n=13) , the levels were between 18 and 472 µm/m3 with a mean of 82.8 µm/m3. RSP levels were not detectable (RSP=0) in 40 of the electrified households representing 75.5% and in 27 (51.9%) of the unelectrified households. CO levels in unelectrified households ranged from 0.33ppm to 20.95ppm whilst in electrified households CO levels ranged from negligible (undetectable) to 11.18ppm

Guha-Sapir, 1996/7	Newsletter	Delhi, India and Manila, Philippines	The study examines exposure levels to smoke from wood cooking fires in 1200 slum households. 600 of the households had infants less one year old. Medical teams followed uo the homes for 4 months and monitored respiratory illness every two weeks. RSP PM10 levels were monitored in 60 households in Manilla and 80 households in Delhi for 24 hours, using cyclone pumps and filters placed one metre away from the cooking place.	Average PM10 levels were 221 mg/m3 in Manilla and 318 mg/m3 in Delhi. In Delhi, wood burning produced 50% more RSPs than kerosene. The study recorded 17.2 per 1000 episodes of ARIs among infants in Manila, here RSP levels were lower and 34 episodes of ARIs per 1000 infants. The study also found that fuel use and ventilation were the main determinants of indoor air pollution and that mothers did not connent ARIs and IAPs

Zhang J, Smith K.R et al, 1999	Journal paper	Hypothetical village	The paper assesses estimated CO concentrations and exposures, in a hypothetical village kitchen, resulting from use of a range of fuel/stove combinations commonly used in developing countries.	CO emissions for one hour for various fuels were found to be; 562 for charbricquette, 528 for charcoal, 511 for brushwood, 464 for dung etc. Low emit fuels were LPG (4.5), Biogas (1.6), Natural gas (0.083), Coal gas 0.0012. (All CO units in h-mg m¡3)) Carbon Monoxide emissions exposure during cooking was found to be high for women and children and lower for men although for traditional fuels, they were all above acceptable WHO and USEPA recommendations. CO emissions were 1808 for women and children using charcbriqette, and 680 for men, charcoal CO2 was 1698 for women and children and 639 for men, Dung related CO was 1493 for women and children and 562 for men. All CO units in h-mg m¡3)) In comparison, acceptable upper limits for exposures as recommended by the WHO and USEPA were 40 h-mg m3 for 1 hour and 80 h-mg m¡3 for 8 hours. The results suggest that in households that use traditional biomass for cooking, women and children are disproportionately affected by cooking emissions but both women and men are exposed to daily CO exposures that are greater than the exposure equivalents of health-based national standards and WHO guidelines

Zhang J, Smith K.R et al, 1999	Journal paper	Real village in Beijing, China, Simulated village in Sub-urban Beijing, China and Simulated village in Delhi, India	56 fuel/stove combinations were tested in China and India, 28 in each country. In India, all of the fuel/stove combinations were simulated for a village house located in suburban Delhi. In China, the vast majority of the fuel/stove combinations were tested in a simulated village house located in suburban Beijing, while those stoves using piped gas fuels (coal gas and natural gas) were done in actual homes in Beijing. Emission factors were determined using a carbon balance approach. Stove/fuel combinations included various stoves (e.g., traditional, improved, mud, brick, and metal, with and without chimney) using animal dung, different species of crop residues and wood, root fuel, charcoal, kerosene, and several types of coals and gases.	Fuel mass based emissions factors varied but in general biomass fuels and coal had higher CO emission factors than other fossil fuels. Coal gas used with traditional stove showed emission factor of an average of 3×10^{-2} g/kg and for charcoal used on the Angethi stove, the emissions factor was 2.8×10^{-2} g/kg

Saskena, Singh et al, 2003	Journal article	Kathputly and	533 households with infants in Kathputly colony and 545 in Kusumpuri Pahari were assessed. Data was collected on predominant fuel usage; cooking location; mother's employment status; ethnic groups; kitchen walls and roof construction materials; number of rooms in the house; type of family (joint/single); and number of elder children. In each slum 320 households were chosen for the epidemiological survey by first applying certain rejection criteria and then randomly selecting the remaining ones. 40 houses in each area were selected for exposure assessment survey as well. This was done using samplers	Wood smoke RSP exposure ranged from a high average of 1630 for mothers to 987, for infants, it was 1680 to 690. In the case of kerosene users, RSP infant expose range from 730 to 590 whilst for mothers it was 650 to 610. CO exposure for the exposure levels were from 16 to 9 for wood and 4 to 1 for kerosene. In both RSP and CO, exposure was higher for wood compared to kerosene

Annexe 7: Indoor Air pollution and children's health

Reference	Reference type	Location and intervention type	Research methods(anecdotal/ survey), sample size	Results
Morten and Hessen et al, 2004	Journal Article	Guatemala	Interviews were conducted with mothers of 1058 children aged between 4 and 6 years old standardised questionnaires of the International Study of Asthma and Allergies in Childhood questionnaire and procedures	Only 3.3% of the children reported wheezing symptoms in the last 12 months, and 72% wheezing symptoms ever. The prevalence of all the symptoms of asthma was higher in children from households that used open fires compared to improved stoves with chimneys. A

				logistic regression model, showed that the use of open fire for cooking was a significant risk factor for a number of asthma symptoms, with odds ratios varying from 2.0 to 3.5.
T Melsom, L Brinch, et al, 2001	Journal article	Kathmandu, Nepal	The study assessed home environments of 121 schoolchildren with asthma and 126 controls aged 11–17 years. Cases and controls were identified from an ISAAC (International Study of Asthma and Allergy in Childhood) based population study of 2330 schoolchildren in Kathmandu, Nepal.	75 families (34%) used open fire or burning stoves without a flue (with solid fuel such as wood and grass), 43 (18%) used gas stoves, and 106 (43%) kerosene stoves; 63 children (26%) reported that they had been bothered by smoke coming from the cooking place into the sleeping room. The risk for asthma was higher among children exposed to smoky fuels (defined as living in a house with an open fire or burning stove without a flue) than for those not exposed. In 63% of the cases and 60% of the controls one or more family member smoked daily inside the house. Seven children (four cases and three controls) reported being smokers. Smoking by one family member (n=86) did not increase the risk of having asthma, but in families where two or more family members smoked (n=63) the risk of asthma was significantly increased in the index child. Use of smoky fuels increased the risk for asthma in boys 0R 2.4, (95% CI 1.2 to 5.1)) but not in OR 0.8 (95% CI 0.3 to 2.2)) Thus the use of smoky fuels were significantly associated with asthma only in boys. In the rural population indoor biomass smoke was strongly associated with asthma (OR 3.3 (95% CI 1.1 to 9.9)). Overall, asthma was associated with the domestic use of smoky fuels (OR 2.2 (95% CI 1.0 to 4.5)).

Smith K.R, Samet J.M, Romieu I, Bruce N	Journal article Thorax 2000;55:518–532	Selected developing countries	A review of quantitative literature from developing countries (DCs) linking indoor air pollution from household biomass fuel use to acute respiratory diseases in children aged under 2 years of age. Sources from medline, other electronic sources and colleagues from DCs. Most accounted for confounding factors.	The results generally showed a strong significant increase in risk for exposed young children compared with those living in households using cleaner fuels or being otherwise less exposed even in studies where confounding factors such as socio-economic status are taken into account. The study also highlights the fact that acute lower respiratory infection is the chief cause of death in children in less developed countries. The study included 9 control studies, 4 cohort studies and 1 fatality case study. Up to 14 studies from 12 developing countries
Ezzati and Kammen (2001)	Pub: Lancet, Vol 358, August 2002	Mpala Ranch, Kenya	Biomass emissions measurements of 55 Households, taken 200 days, between 1996 and 1999 for 14-15 hours per day at Mpala Ranch, in Kenya.	Differences for ARI between male and female children under 4 years were insignificant. After 5 years, ARI differences were significant. Exposure to high emissions from cooking in adult females resulted in women being twice as likely as men to be diagnosed with ARIs. Total ARIs and ALRIs increased with increased exposure.
Sharma S, Sethi G.R, Rohtagi A, Chaudhary A, Shankar R, et al	Journal articles	Urban slums of Kusumpur Pahari and Kathputly	The study examined 642 children in urban slums of Kusumpur Pahari and Kathputly Colony in Delhi India. The study was undertaken in winter from	Of the 317 children in Kusumpur Pahari, and (142 wood and 175 kerosene), including 64 controls and 78 cases of ALRI in the wood

		Colony in Delhi India	November 1994 to February 1995	fuel group and 81 controls and 94 ALRI cases in the kerosene group (/p/>0.05). Out of 316 children in Kathputly Colony (174 wood and 142 kerosene), there were 33 and 45ALRI cases in the wood and kerosene groups, respectively (/p/<0.05). Bronchiolitis was reported in 22.5% of the wood group and 27.1% of the kerosene group in Kathputly Colony versus 13.7% in the wood group and 12.1% in the kerosene group in Kusumpur Colony. Only one case of croup was reported from Kusumpur Pahari among wood users. The duration of illness was longer in the Kusumpur Pahari due to poor compliance, feeding, and child rearing habits. In conclusion, a higher incidence of ALRI was reported in kerosene users in Kathputly Colony, a high pollution area but according to the authors, the observations need clarification
Jedrychowski W et al, 2005	Journal Article	Krakow, Poland City Centre and outer city area	The study was a retrospective cohort study carried out in a sample of 1036 pre-adolescent children (9 years of age) attending schools in two residential areas of Krakow, Poland. Measurement of health outcomes considered lung	The analysis carried out in the more polluted area found that for children living in households heated with gas or coal, Post natal exposure to indoor pollution was strongly associated with decreased

			function together with height and weight. Indoor air quality was based on environmental tobacco smoke and type of household heating. The number of winter months that occurred during the first 6 months of life was included as a key independent variable. Multivariate linear regression of lung function measured by forced expiratory volume in 1itres and forced vital capacity, and postnatal exposure to indoor pollution in the heating season was adjusted for potential confounders such as maternal smoking during pregnancy and parental education as a proxy of social class.	lung function whereas regression coefficients were not significant in the group of children living in households with central heating. The results suggest that postnatal exposure to indoor pollution has a long-term harmful effect on the lung function of newborns, which extends to pre-adolescence. This suggest that indoor air pollution may be responsible for compromising infant growth.
Sikoka et al, 2002	Journal article	Kibera Lindi, Nairobi Kenya	The study was a retrospective study undertaken to determine the prevalence and the associated risk factors of ARIs in under five children. Factors considered included housing, over crowding, smoke and immunization. Qouta sampling was used and the sample was of 300 children. Data was collected using a questionnaire	Prevalence of ARIs in the group was 69.7%. 49.3% use lanterns for lighting and 69.6% of children from lantern using homes had ARIs. 43% use tin lamps and 70% of their children had ARIs. 85.7% of children from homes that use firewood for cooking had ARIs. Children from 71.2% and 60.4% of kerosene and charcoal using homes respectively had ARIs. 66% of homes cook near the bed and 73.7% of children from these homes had ARIs, 70.8% of children from homes where cooking was done in the home at

				the door had ARIs. 3.7% cooked in kitchen and ARIs among their children was 54.5%.13.7% cook else where and 53.7% of their children had ARIs. 72% of the homes had no smokers and 69% of their children of non-smokers had ARIs. The study suggests that place of cooking (as indicator of level of exposure) and fuel (as indicator of exposure) are associated with ARIs in under five children.

Annex 8 : Corrective impacts of cleaner energy and energy technologies on child health

Annex 9 : Child mortality and modern energy services - Modelling studies

Reference	Reference type	Location and intervention type	Research methods	Results

Wang	Report	Low income country,	Using Demographic and Health Survey (DHS) data from 60 low income country, this study investigates determinants of health outcomes in low- income countries both at the national level, and for rural and urban areas separately. The data is from DH surveys between 1990 and 1999.	At the national level, access to electricity, vaccination in the first year of life and public health expenditure can significantly reduce child mortality. The electricity effect is shown to be independent of income. In urban areas, only access to electricity has a significant health impact while in rural areas, increasing vaccination coverage is important for mortality reduction. Ranked in descending order, access to electricity, asset index, GDP per capita, access to piped water, access to sanitation, and female secondary education are highly correlated with mortality rates at national levels. In the urban data, mortality is highly correlated to access to electricity, asset index and female secondary education. In rural areas, access to piped water, access to electricity, female education, asset index and vaccination coverage are closely related with mortality. In urban areas, access to electricity, in particular, has a large impact on infant mortality rate, although asset index, and health expenditure share are also statistically significant. Female education, access to safe water, access to sanitation, and vaccination coverage have no significant effect on IMR, either individually, or jointly (the joint significance test, $F(6,33)=0.85$). In the rural result, none of the included variables is statistically significant, except that access to electricity is significant only at the 10% level. Findings are almost similar for under-5 mortality rate, at the national level. At the national level, income, health expenditure share of GDP, access to electricity, vaccination coverage in the first year of

Van Der Klauuw and Wang, 2004	Paper	India	Using econometric modeling, the study examines the determinants of infant and child mortality in the rural areas of India. interested in Variables examined include low infant and child mortality include mother's education, source of drinking water, sanitation facility, type of cooking fuels, access to electricity, and availability of medical services. In the sample, slightly over 51% of the households have electricity	The study shows that lower when a separate room is used for cooking and when the house has electricity or when the households use of clean cooking fuels. Child mortality is lower in families that use clean cooking fuel than in families that use wood, crop residues or dung cakes as cooking fuel. Access to electricity to all households reduces neonatal mortality with 2.6 children, infant mortality with 4.0 children and child mortality with 5.5 children. The use of clean fuels to 91% of households reduced neonatal mortality by 6.1children, infant mortality with 15.7 children and child mortality with 26.5 children. The use of clean fuels in a separate kitchen reduces neonatal mortality with 15.7 children, infant mortality with 27.3 children and child mortality with 33.6 children. Drinking water from a piped source decreases neonatal mortality with 2.8 children; infant mortality with 4.0 children and child mortality with 4.4 children The reductions are statistically significant. Providing 1% of the households with access to electricity reduces child mortality with approximately 0.11, which is similar to providing private piped water to 1% of the households.

Annex 10 : Indoor air pollution and low birth weight

Author	**Reference type**	**Location and intervention type**	**Research methods(anecdotal/ survey), sample size**	**Results**
Vinod Mishra, Xiaolei Dai	Journal Article	Zimbabwe	3559 infants from ZDHS over 5 year period. Interviewed mothers showed cards or recalled birth weight	Results suggest the exposure to biomass smoke is associated with low birth weight, independent of child's sex, mom's nutritional status, pregnancy care, education and living standards. Consistent with Guatemala study. Exposure levels of CO between 300 and 1000ppm, of PM10 between 1000 and 4000µg/m3

Annex 11 : Cooking fuels and childhood burns

Reference	**Reference type**	**Location and intervention type**	**Research methods(anecdotal/ survey), sample size**	**Results**
Nega K.E and Lindtjorn 1999	Journal Article	Mekele town in Tigray, Ethiopia.	Cross sectional survey of burn injuries on 7309 individuals in 1390 households. Recall method was used period of 12 months (March 1, 1998 to February 28, 1999).	Burn had the highest incidence among children less than 5 years old (4.8%). Scald (59%) was the leading cause of burn followed by flame (34%). Of these, 17 (48%) were boys and 19 (52%) were girls. All the burn injuries that occurred in the 10 to 14 year old children were seen among girls. There was no

				difference in the incidence of burn injuries between 15-59 old males (12/1655, 9.72%) and females (17/2373, 9.72%). Most burns occurred at home (81%). Crowding and employment were significant risk factors for burn injury. Domestic burn injuries were common among women of reproductive age and work related burns were more common among men. However 14/16 domestic burn injuries (87.5%) and 9/11 (81.8%) work related burn injuries in this age group occurred among women and men respectively (X2=10.2, p=0.0008). There was no age or sex preponderance in the injuries sustained during leisure time. Mortality was 1% for sample
Ahuja, R. B Bhattacharya, S.	Journal article	India	The report examines the management of burns in the developing world. It asserts that	In India, the cooking at floor level in loose fitting clothes

			developing countries have a high incidence of burn injuries compared to developed countries, with India having 700000 to 800 000 burns related admissions annually.	such as "dupatta" places women at increased risk of burn injury. Most burn injuries are sustained by women aged 16-35 years because they are engaged in cooking, and most work at floor level in relatively unsafe kitchens and wear loose fitting clothes such as saris, dupatta, etc. Families use strategies that protect children and elderly people and hence their burns risk us relatively low. The commonest mode of burn injury is a flame burn. Most such incidents are related to malfunctioning kerosene pressure stoves which are favoured because they are cheap yet they are prone to malfunctioning due to poor designs and lack of safety features.
Nigel Bruce et al,	Report, undated	San Marcos, in western Guatemala	The study examined 504 randimsed after baseline assessment homes using an open fire. Eligible homes had a child under four	There were 22 burns and scalds incidences for six months before the study among 1044 children under the

			months or a pregnant woman. Some homes received the *plancha* improved stove and other continued using the open fire until the child was 18 months of age (a *plancha* would then be offered). Information about burns was obtained on two groups of children: older siblings of the study child, at baseline, and at 6 and 12 months after randomisation, by interview survey.	age of 6 years, giving a base line of 42.1 burns per 1000 children. In the 12 months of the study, there were 16 burn incidences in the control (open fire) group) and 8 in the control group (plancha) reported among siblings. These translate to 35.2 per 1000 child years in open fire homes, with a relative risk of 1.9 (p=0.1) and 18.1 per 1000 child years in intervention homes. The plancha use was associated with a 50% reduction in burns incidence reported among siblings (trend; p=0.1). There were 45 burns and scalds incidences after 74 weeks of surveillance, of which 23 occurred in control and 22 in *plancha* homes among the "index" children (less than 18 months). Here there were similar in burns rates in intervention and control groups. Three cases in this

				group were severe and all of them occurred in control for different reasons The location of burns did not differ substantially between control and intervention homes. 38% of the burns and scalds were to the hands, 27% to the face and neck, 13% were to the foot. The results suggest the burns risk associated with open fire use is substantial high.

Annex 12 : Paraffin poisoning in children

Reference	Reference type	Location and intervention type	Research methods(anecdotal/ survey), sample size	Results
Malangu et al	Journal Article	Mpumalanga, South Africa	A retrospective study was undertaken of 145 children admitted with a diagnosis of paraffin poisoning at Philadelphia Hospital, Mpumalanga from January 2000 to June 2001. A pre-tested form was used to collect data from the admission files. Where applicable, the Chi-square test or t-test was used to	Children younger than five years of age were affected significantly more than those older than five years of age (91% vs. 9%, $p<0.001$), and boys were affected more than girls (58% vs. 42%, $p=0.034$). The average length of stay and cost

			determine statistical significance.	of treatment were 2.5±2 days and R617.24 respectively. Prophylactic antibiotics were prescribed in 86% of cases (125/145) and the average number of medications prescribed per child was 3.5±1.8. No mortality was reported.
D. Tagwireyi D. E. Ball and C. F. B. Nhachi (2000)	Journal	Zimbabwe	The study was a retrospective study of the patterns of poisoning cases admitted to eight major urban referral hospitals in Zimbabwe between 1998 and1999 was conducted to describe the pattern of poisoning at these centres.	There were a total of 2764 hospital admissions due to poisoning, involving a total of 2846 toxic agents. Accidental poisoning (AP) accounted for 48.9% of the cases The highest number of cases (45.9%) occurred in children below the age of 5 years, with half of these due to chemicals, mainly paraffin.
Matanhire DN, Nsungu M, Mabhiza ET.	Journal	Mashinaland, Zimbabwe	This community based study utilized responses from questionnaire assisted interviews of mothers and child minders to determine	25.5% of children had had inadvertent injuries in the two weeks before the survey. Both

			background factors to domestic unintentional injuries in children aged five years old and below. The study was done in three wards in a rural communal area of Chivhu District in Mashonaland East Province in Zimbabwe. One hundred and ninety six mothers or child minders were interviewed	recent and lifetime injuries were not significantly different in the 105 boys and 91 girls among whom domestic accidents were reported. Burns made up 16.3% of injuries and scalds made up 4.7% of injuries. The authors suspected that the absence of paraffin poisoning is related to the availability of storage space in the households.
de Wet B, van Schalkwyk D et al	Journal S Afr Med J. 1994 Nov;84(11):735-8.	Cape Peninsula, South Africa	A 12-month retrospective study was undertaken in 1990. Relevant patient data were extracted from the files of 6 major Cape Peninsula hospitals. Treatment costs were calculated based on differential hospital costs per inpatient per day, with outpatient costs at one-third of the costs per day.	Age-specific rates for affected residential areas were calculated to identify high-risk areas. A total of 436 children (62,5% male), mostly between the ages of 12 and 36 months, were treated at an estimated cost of R111 673.
Buchart A, 1999	Report	South Africa	In infants and children choking and poisoning by ingestion (e.g. of paraffin and other household chemicals) were prominent.	9% of accidental deaths were due to burns. In the category of burns, drowning and other accidental

				deaths, there were 1169 deaths of which 41% were due to burns. Burns were the leading external cause of death under one year of age. Burns were the second leading external causes of death from 1 to 4 years of age. There were 1.5 males per female burn death in 52% of the burns deaths among males, blood alcohols concentrations were found. In children, poisoning was mostly due to paraffin (and household chemicals) ingestion
Wani, K. A., M. Ahmad, et al. (2004)	Journal article	Srinagar, Kasmir Valley	Over 4 years, from 1997 to 2000 data on admissions resulting from accidental poisoning was collected. There were 67,59,599 during this period. Maximum number of cases	Of the 650 cases of poisoning, 49.8% were in the age group of 1-5 years and least 4.2% were below I year of age. 46% of case were above 4 years of age group the male female ratio was 1.15:1 where as the rural! urban ratio was 1.6. Kerosene was

				the leading poison, accounting for 40.7% the cases in the study. Kerosene oil ingestion results in toxicity of gastrointestinal, respiratory and central nervous system. Aspiration pneumonia was the commonest complication and central nervous system complications were noted in 25 cases. There was no mortality from kerosene poisoning.

Annex 13 : Water, child health and energy technologies

Annex 14 : Energy and food security for combating malnutrition

Annex 15 : Fuelwood scarcity and nutrition

Reference	Reference type	Location	Coping strategies
M Awumbila and J H Momsen	Journal	Ghana	• Use of bicycles, bullock carts and tractor drawn trailers • Increasing number of male participation (mainly for protection • Decline in resource quantity and quality • Exhaustion of high energy species of trees leads to the substitution with • Fire management – chopping wood in smaller pieces for drying • Closer management – More time by the fire • Moving indoors where it is less windy, increasing exposure to smoke. • Extinguish the fire after cooking and relight the fire every time its needed

			• Not reheating leftover food – may be a health risk after deterioration. • Use of cold water for washing clothes and dishes, or for bathing children and the elderly. • Use of efficient stoves or kerosene stove • Increase of male controlled commercialization of fuel wood
Brouwer I.D et al,	Journal	Malawi	• Increase in time and energy spent on fuelwood collection • Substitution of fuelwood by alternative fuels • Economizing on the consumption of fuelwood and alternative fuels
Mlambo D and Huizing H, 2004	Journal	Zimbabwe	• Fires were extinguished with water soon after cooking • Reducing frequency and duration of cooking and space heating. • Scaling down of large scale operations (pottery, brick burning and beer brewing, scaled down operations- could reduce incomes) Changing from clay pots to metal pots • Use of unfired bricks were used to construct houses Soaking beans and maize seeds in water for about a day before cooking Lowering the fire grate to conserve fuelwood Burning fuelwood together with previously not used material - maize cobs, cattle dung, stump and root wood (lower quality fuels)
Vermuelen	Journal	Various	• Use different types of stoves or different fuels depending on the food being cooked • Burning poorer quality biomass fuels for faster cooking dishes • Simmering food • Use aluminium pots for fast-cooking foods and clay pots for slow cooking • Using tenderisers when cooking grains (e.g. soda ash in west and central Kenya) • Preparing quick cooking porridge and pancakes rather than oven-baked bread

			(common in urban households) • Placing the cooking stove over an inverted sufuria which encloses cooked food to keep it warm while other foods are cooked (mainly urban households) • Cementing the lid on the rim of the sufuria by use of maize porridge paste (in eastern and southern Africa) • use of lids and covers in general • Use of pressure cookers and tea cosies by wealthier households • Use of noxious weeds or trash
Mahiri I.O 2003	Journal	Kenya	• Frying some of the foods that used to be boiled, e.g. small, dried fish and certain • kinds of vegetables • Complementary and simultaneous use of fuelwood with cow dung to cook foods that take so much fuel and time to cook • Use a mixture of cow dung and charcoal dust • Soaking food in water prior to cooking – especially maize and beans • Retrieving half-burned fuelwood, extinguish and reusing them later • Embers remaining from burned fuelwood are used for space heating, warming food, and warming water for washing hand
Brouwer et al, 1997	Journal	Various	Varying distances Switching to poor quality of twigs Stock piling
Dewees (1989)	Journal	Various	• Increasing time for woodfuel collection • Deterioration in the quality, and in the type, of domestic energy used, • Increase in the use of agricultural residues and animal dung for household cooking and heating • Felling more trees to meet demand thereby increase deforestation woodfuel demands; • Changes in cooking and heating habits • Emergence of woodfuel markets and where there are already markets, increases in • Woodfuels prices

Annex 16: Household work, time constraints and child care

Reference	Reference type	Location and intervention type	Research methods(anecdotal/ survey), sample size	Results
McCray Social Science and Medicine 59 2004	Journal article	South Africa,	327 households were examined from June to August to assess the daily activity constraints (environmental and socio-economic factors) that motivate or discourage women from utilizing prenatal care services in rural South Africa. Its uses data from the MRC GIS database to randomly select households with a child between the ages of 12 and 23 months.	The study finds that more often, women sight cooking, which takes 1.44 hours, then seconded by fetching water, which takes 1.39 hours, as activities that most affected by prenatal visits to the hospital/clinic. Fuelwood fetching, which takes about 1.79 hours was rated sixth. Interestingly, time at work, time at school and time spent in gardening, which take up 7.33 hours, 7.46 hours and 4.18 hours respectively are rated eighth, eleventh and seventh respectively. The author suggests that the value placed on the activity itself may affect how and whether it is perceived as disruptive to prenatal care or not. Women, who reported that their ability to fetch water was negatively

				impacted by a need to visit the clinic, were two times more likely to utilize prenatal care services at a low level than other women participating in the study.
Wise et al, 2002 USAID	Report	Mali		Women and men reported that work, particularly gathering wood, fetching water, preparing food which was the responsibility of women and agricultural work, which is a shared workload, limited their ability to breast feed and care for infants. 29 % of the women reported that heavy demands limited their child care time and 10 % of the women said they do not have time to adequately feed their children. 26% said that agricultural activities limited their ability to take care of children. 56% of the men said their spouses did not have time to feed children and 54% said that the daily, time consuming tasks of gathering wood and

				water and preparing meals limited the time mothers need to adequately care for their children. Women stated that cereal mills and community water taps would help free time for child care.Women, especially those in labour also experienced problems reaching hospitals due to lack of transport
Wandel M and Holmboe-Ottesen G	Book	Rukwa region, in western Tanzania	200 households with preschool children were randomly selected and monitored seasonally (three surveys). The three surveys were carried out in April-May, the pre-harvest season with relatively low workload (survey 1), July-August, the main harvest season with high workload (survey 2), and February-March with highwork load in weeding (survey 3). Questionnaires and nutrition survey techniques were used to get more information	The feedings times of women decreased with increasing time spent on household activities. In addition, a longer periods of time spent cooking also related with decreased feeding times. Malnutrition was also more common among children of women who spent more time on work. The differences are not significant at the .05 level and impacts of world load on child's nutrition status were not conclusive

http://www.rho.org/html/ict_progexamples.htm#uganda

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