

# Peak Oil and Health in Low- and Middle-Income Countries: Impacts and Potential Responses

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Peak oil refers to the predicted peak and subsequent decline in global production of petroleum products over the coming decades. We describe how peak oil will affect health, nutrition, and health systems in low- and middle-income countries along 5 pathways.

The negative effects of peak oil on health and nutrition will be felt most acutely in the 58 low-income countries experiencing minimal or negative economic growth because of their patterns of sociopolitical, geographic, and economic vulnerability.

The global health community needs to take additional steps to build resilience among the residents of low- and middle-income countries and maintain access to maternal and other health services in the face of predicted changes in availability and price of fossil fuels. (*Am J Public Health*. 2011; 101:1607–1614. doi:10.2105/AJPH.2011.300231)

## LOW AND MIDDLE-INCOME

countries (LMIC) have witnessed remarkable improvement in health and nutrition over the past half century. Between 1970 and 2010, for example, the annual number of deaths in children younger than 5 years worldwide declined by 52%.<sup>1</sup> Although many countries will likely fall short of the fourth United Nations Millennium Development Goal to decrease mortality in children younger than 5 years by two thirds between 1990 and 2015, most countries nevertheless have shown substantial improvement in child mortality indicators.<sup>2</sup>

A range of social, economic, and health systems factors now threaten these and similar gains made by LMIC over the past few decades. A number of challenges facing health systems have recently drawn much attention, such as shortages of trained health workers, insufficient government investments in health, and poor governance.<sup>3,4</sup> Also commonly cited are the 16% increase in the annual number of births between 1970 and 2010,<sup>1</sup> the projected growth in world population from 7 billion people to 8–10 billion people by 2050,<sup>5</sup> and the demands this growth will place on food supplies and health services.<sup>6–8</sup>

These factors clearly could constrain or reverse recent health improvements in LMIC. However, there are 3 more threats that, until recently, have been less prominent in the larger public health and development dialogue. These 3 threats all arise from the earth's limited capacity to sustain unabated

human growth and consumption: (1) global climate change, (2) ecosystem degradation, and (3) peak oil production. Of the 3, climate change has likely received the most attention, with continuing investigation and concern expressed not only about how climate change will affect health<sup>9,10</sup> but also about how continued population growth and economic development may affect production of greenhouse gases.<sup>6</sup> The second threat, ecosystem degradation, was recently characterized in detail by the Millennium Ecosystem Assessment. This assessment examined 24 “ecosystem services” and concluded that 15 were in serious decline and 5 were in a precarious condition.<sup>11</sup> Ecosystem degradation poses threats not only to other species but also to human livelihoods, food production, and health.<sup>12,13</sup>

In this article, we focus exclusively on the third of these threats: peak oil.<sup>14</sup> Peak oil refers to the predicted peak and subsequent decline in global production of petroleum products over the coming decades,<sup>14,15</sup> a trend that is also seen in the supply patterns of other fossil fuels, such as coal.<sup>16</sup> The concept is not new. American geophysicist and petroleum expert M. King Hubbert described the inevitability of decreasing domestic and global fossil fuel production in an article published in *Science* in 1949.<sup>17</sup> Brandt recently confirmed a prediction of Hubbert's peak theory, demonstrating that production of any fossil fuel has followed a bell-shaped curve for 139 oil-producing regions.<sup>18</sup> There is disagreement in the

literature about how to best forecast oil supply and whether the peak of world oil production has already passed, will arrive at some point in the future, or will ever become a real global concern.<sup>19</sup> Notably, the International Energy Agency (IEA) now projects that conventional oil production will peak around 2020, unless governments are more proactive in encouraging energy efficiency and oil alternatives, which could push that date just past 2035.<sup>20</sup>

Regardless of when the peak actually occurs, peak oil has immediate implications for global public health. The IEA has also predicted that if governments promote changes in energy consumption patterns, the price of crude oil per barrel will rise from \$60 in 2009 to \$113 in 2035 (in 2009 dollars).<sup>20</sup> Such increases will severely affect the health of poor people in LMIC, who are extremely sensitive to even minor fluctuations in the prices of fuel, food, and other essentials.<sup>21,22</sup> These price fluctuations will also affect economic growth and health systems, resulting in further health impacts.

We first describe the negative consequences of peak oil on health and nutrition at the household level and on the availability and quality of health services. As an example, we demonstrate how peak oil could affect access to maternal health care in rural areas of LMIC. We then turn our attention to the most vulnerable countries. We borrow the term “bottom billion” from Collier to refer to the approximately 1 billion people

living in the 58 low-income countries that are experiencing minimal or negative economic growth and are stuck in “development traps.”<sup>3</sup> The negative effects of peak oil on health and nutrition will be felt most acutely in these countries because of their patterns of sociopolitical, geographic, and economic vulnerability. Ironically, the residents of these countries have the lowest rates of per capita fossil fuel consumption.

We conclude by describing additional steps that the global health community needs to take to build resilience among the residents of LMIC and maintain access to maternal and other health services in the face of predicted

changes in availability and price of fossil fuels. We do not address several topics of critical importance related to energy and health in LMIC, including energy poverty and exposure to indoor air pollution<sup>23</sup> and the effects of energy generation on climate change and particulate air pollution.<sup>24,25</sup>

**PEAK OIL'S EFFECTS ON HEALTH AND HEALTH SYSTEMS**

Frumkin et al. identified 4 critical pathways through which peak oil or rising energy costs threaten health systems by increasing costs and reducing availability of key goods and services.<sup>15</sup> Although

their analysis focuses on health systems in high-income countries, these pathways are equally applicable to LMIC, and we adapt them here to the contexts of health in these countries. The 4 pathways described by Frumkin et al. are (1) medical supplies and equipment; (2) transportation; (3) energy for heating, cooling, and powering health facilities and operations; and (4) food security and agricultural productivity. To these, we add a fifth pathway: (5) economic growth and employment (Table 1).

**Medical Supplies and Equipment**

Many essential medical supplies, from pharmaceuticals to syringes

and rubber gloves, are manufactured from petroleum, and modern antiseptic practice depends almost entirely on disposable petroleum-based products. Availability and affordability of these products is highly dependent on inexpensive fossil fuel.<sup>15</sup>

In middle-income countries such as China, India, and Brazil, there is a large internal market for these supplies, and local industries have developed to meet both internal and external demand. Fossil fuel scarcity or fluctuations in price will raise the cost of the raw materials to make these supplies, but domestic production in these countries keeps costs related to transportation and importation in

**TABLE 1—Critical Pathways Through Which Energy Scarcity and Peak Oil Affect Health and Nutrition in Low- and Middle-Income Countries**

Critical Pathways	Direct Effects	Household-Level Consequences for Health and Nutrition	Consequences for Health Services
Medical supplies and equipment	Increasing cost and scarcity of medical supplies, equipment, and facilities	Households less able to purchase drugs, eyeglasses, contraceptives, and other health commodities	Shortages of essential drugs and vaccines Inability to maintain infection-control procedures Lack of essential equipment for surgery and other procedures
Transportation	Increased cost and decreased availability of fuel Increased cost of building and maintaining roads, ports, and airports Increased cost of vehicles Increased cost and decreased availability of public transportation	Inability for people living in rural areas to reach medical facilities Increased cost and decreased availability of food, leading to food insecurity Slower response by governments and aid organizations to food shortages, famines, and other humanitarian crises	Breakdown of procurement and supply chains for medical supplies and equipment Breakdown of health care referral system Less mobility of health workers Less direct supervision of health services Health worker shortages in rural areas
Energy generation, heating, and cooling	Increased cost and decreased availability of energy to heat, cool, and light buildings and to operate equipment	Lack of fuel for household cooking, lighting, heating, and cooling	Lack of fuel for health facilities to run heating and cooling systems, equipment, and lighting
Food security and agriculture	Decreased food production Less food for export in traditional exporting countries Increased food prices	Increased cost and decreased availability of food, leading to food insecurity Increased rates of malnutrition Larger and more prolonged famines	Greater demands on health services to respond to famines Greater numbers of malnourished people seeking services
Economic growth and employment	Increased unemployment across all sectors for most countries Less foreign aid provided by rich countries	Lack of money to purchase health services, food, and health-related commodities	Less funding from government and donors for health services and health programs Increased health-sector unemployment

check. By contrast, low-income countries generally import these supplies. Shortages of medical and public health supplies are a chronic problem in LMIC and have limited countries' ability to respond to a range of nutritional and infectious disease problems, including the "neglected tropical diseases,"<sup>26</sup> even when treatments are relatively inexpensive. Shortages of essential medications and supplies stem from lack of foreign exchange reserves to pay for imports, limited government health budgets, and weak procurement, supply chain, and management information systems.<sup>27,28</sup> Each of these problems needs to be addressed in its own right, but the far more fragile supply chains present in many low-income countries mean that these countries could experience far worse shortages of basic medical and public health supplies as fossil fuel costs drive prices higher.

### Transportation

Transportation accounts for the majority of petroleum use worldwide. Modern health systems depend heavily on transportation in many ways, such as maintaining the supply chain for drugs and medical equipment, transporting patients between different levels of the health system, moving health workers from home to work, and conducting supervision.<sup>15,29,30</sup> In many rural settings, lack of access to transportation at the community level has been identified as a major barrier to delivering basic care.<sup>29</sup> In a 2006 comprehensive technical study prepared for the World Bank's program on Transport for Social Responsibility, Babinard and Roberts found that high cost and limited availability of transportation, especially in low-density rural areas of low-income countries,

constrains utilization of all the major maternal and child health interventions, weakens referral and procurement systems, and is a major factor holding back progress toward the United Nations Millennium Development Goals for maternal and child mortality.<sup>29</sup> Furthermore, peak oil and resulting energy insecurity can greatly hinder relief organizations' ability to respond rapidly and effectively to humanitarian emergencies.<sup>31</sup>

### Energy Generation and Heating and Cooling

The third pathway is energy generation to support health facilities and operations.<sup>15</sup> Hospitals and health centers are, for the most part, heavily reliant on electricity generated by fossil fuels to run heating and cooling systems, laboratory equipment, sterilization equipment, and lighting. It is common in many LMIC for health facilities to obtain power from diesel generators because of lack of connection to the grid or to cope with frequent blackouts. As energy becomes scarce or more expensive, these facilities will face rising costs of operation and greater challenges in securing the energy needed to operate.

In rural areas, decreased operational capacity caused by energy scarcity could make it more difficult to attract and retain health workers and could exacerbate existing disparities in distribution of the workforce. Sub-Saharan Africa has around 11% of the world's population and more than 24% of the estimated global disease burden but only 3% of the global health workforce.<sup>32</sup> In countries where working conditions in the health sector are already poor, the challenges described above could further degrade these conditions, contributing to even greater shortages of essential personnel.

### Food Security

The fourth pathway linking peak oil and health is agricultural systems' dependence on cheap energy for growing and transporting food.<sup>15</sup> Neff et al. discuss the effects of peak petroleum on the availability and price of foods elsewhere in this issue,<sup>33</sup> so we will cover the topic only briefly. The spectacular increases in agricultural productivity that LMIC have seen since World War II have been built on a foundation of cheap oil and natural gas, allowing for mechanization of agriculture, irrigation of arid lands, and application of fertilizers, pesticides, and other agrochemicals made from petroleum.<sup>15,34</sup> Prices of food produced by large-scale agriculture will increase steadily as the fossil fuel inputs that make this bounty possible become less accessible; the fertilizer price index in the United States alone almost doubled between 2000 and 2007.<sup>35</sup> The projected price increases for inputs necessary to support commercial agriculture will affect the entire global food supply, including food surpluses used for food aid and humanitarian relief.<sup>31</sup>

There is considerable uncertainty regarding the net effects, positive or negative, that the combination of climate change, ecosystem degradation, and peak oil will have on food production. McMichael et al., writing about the potential effects of climate change on food production, offered this reminder:

Assessments of the effects on the quantity and security of food supplies require complex modeling, spatially differentiated across Earth's productive land surface.<sup>36(pl257)</sup>

Some authors have argued that an increase in fossil fuel prices will encourage more local, small-scale farming because increased fuel prices will make it more costly to

transport food over long distances, forcing some degree of reallocation of the food supply.<sup>37</sup>

### Economic Growth and Employment

Large-scale petroleum production has been a foundation of economic life since only the mid-1800s. This same period has witnessed dramatic declines in mortality rates throughout the world.<sup>38</sup> Although many factors contributed to these declines—which, in Europe, began well before the rise of petroleum—increased fossil fuel consumption has been shown to play a part in health and nutrition improvements<sup>15,39,40</sup> and in population increases.<sup>41,42</sup> One of the major pathways postulated for fossil fuel consumption to contribute to mortality declines is increased economic growth and employment and resultant improvements in standards of living. These factors, in turn, make it more feasible for households to purchase food, health services, and other health-related commodities. Peaks in global fossil fuel production could reduce or reverse economic growth for a variety of reasons: fossil fuels are critical inputs for many industrial processes; they provide power for many factories, offices, and other places of work; and they are used to transport commodities and people around the world.<sup>43</sup>

### PEAK OIL AND MATERNAL EMERGENCIES

To illustrate how peak oil could adversely affect health in LMIC, we examine how these 5 pathways could affect care seeking for maternal emergencies. Maternal mortality is one of the major global causes of preventable mortality, and there were an estimated

342 900 maternal deaths in 2008.<sup>44</sup> Progress toward the United Nations Millennium Development Goal to reduce the maternal mortality ratio by three fourths between 1990 and 2015 is generally considered to be insufficient.<sup>45</sup>

In the highest-mortality countries, the majority of births occur at home, without a skilled birth attendant. It has been estimated that community-based provision of interventions such as contraceptives, antibiotics, and drugs could reduce mortality,<sup>46</sup> but many key interventions for acute life-threatening maternal complications can only be delivered in health facilities, including cesarean delivery, blood transfusion, and intravenous antibiotics.<sup>47</sup> Often these interventions are only effective if women receive them within a few hours of the onset of the emergency. This is especially the case for life-threatening hemorrhage. For this reason, there has long been an emphasis in the

maternal health field on reducing delays in care seeking for maternal complications.<sup>48</sup>

The 3-delays model states that there are 3 stages of possible delay in receiving life-saving maternal care interventions: (1) delay in the decision to seek care at the household level, (2) delay in transportation from the household to the facility, and (3) delay in receipt of life-saving treatment upon arrival at the health facility.<sup>48</sup> As an example, the family of a woman with life-threatening postpartum hemorrhage after a home delivery might take time to recognize the extent of the blood loss and the need to seek care. Once the family decides to take her to the hospital, transportation might be unavailable or too expensive.<sup>29,49</sup> Finally, upon arrival at the hospital there may be no qualified health workers present (especially at night), the power may be turned off, or there may not be blood available for transfusion.<sup>48,49</sup>

Figure 1 illustrates the 3 stages of delay in accessing emergency maternal care, factors affecting utilization and outcomes that affect the 3 stages of delay, and how peak oil affects these factors. The family's economic status and access to cash will affect how quickly they make the decision to take the woman for care, how quickly they can find transportation, and how quickly they are attended to at the health facility.<sup>29,48,50</sup> Availability and cost of transportation, along with real and perceived quality of care at the receiving health facility, affect the decision made in the home to seek care at the health facility.<sup>29,48,50</sup>

The reduced availability of medical supplies and equipment and lack of energy for lighting, heating, and equipment in the health facility directly affect the quality of care. They affect quality of care indirectly by creating more difficult working conditions, making it even harder to fill posts in rural areas with qualified health

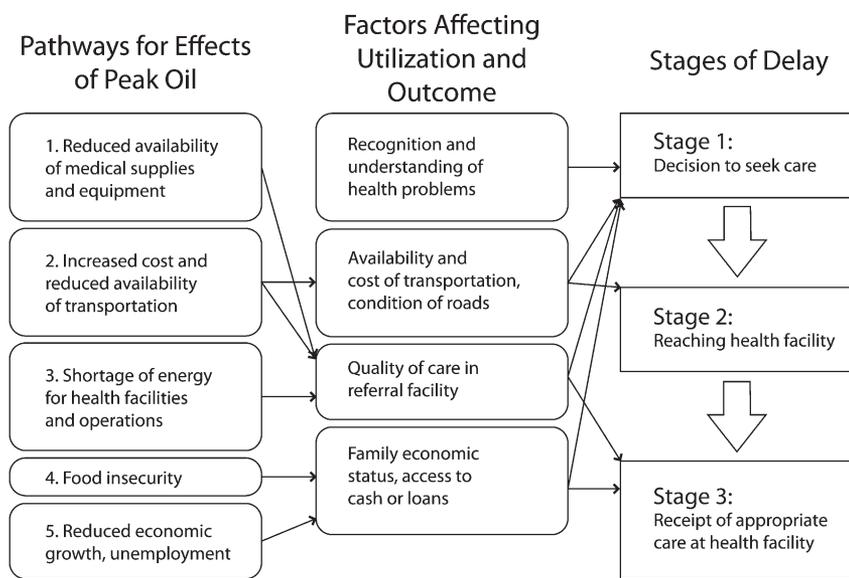
personnel and exacerbating existing disparities in the global distribution of the health workforce.<sup>32</sup> Reduced quality of care in turn makes families less likely or slower to decide to seek outside care.<sup>50,51</sup> Increased cost and reduced availability of transportation can affect the family's economic status, availability of transportation to health facilities, and availability of health workers, supplies, and equipment in facilities, as analyzed in detail by Babinard and Robert.<sup>29</sup> Clearly, energy scarcity could hold back or reverse the global progress toward reduction in the maternal mortality ratio.<sup>44,45</sup>

### VULNERABILITY TO ENERGY SCARCITY IN POORER COUNTRIES

The impacts of peak oil on various phenomena that affect public health (e.g., social and political stability, agriculture and food supply, transportation, health care delivery) are examined in detail elsewhere in this issue.

Here, we focus on the ways in which these processes could affect LMIC disproportionately and could threaten, perhaps severely, the substantial public health gains made in the last half century in these countries. Frumkin et al.,<sup>15</sup> Heinberg,<sup>43</sup> and others have drawn attention to the potential for peak oil to aggravate inequities in health status and access to health care within countries, with the poorest people lacking resources to adapt to drastic social and economic changes.

The particular vulnerabilities many LMIC face related to peak oil, including rapidly expanding populations and dependence on foreign aid, vary widely depending on the country. These vulnerabilities are, however, decidedly more dangerous for countries that



**FIGURE 1—Model of peak oil's effects on delay in receiving care for maternal emergencies, for countries in which most births occur at home.**

make up Collier's bottom billion, which suffer from development traps that have kept economies from growing. We now describe vulnerabilities that increase the impact of peak oil and threaten gains in global health among the 58 countries in the bottom billion.

### Agricultural Productivity and Population Growth

Increased agricultural productivity enabled by cheap fossil fuels has facilitated rapid population growth and made famine a distant memory in many countries. Yet some authors argue that the world population has "overshot" the carrying capacity of world ecosystems.<sup>52</sup> King labeled the phenomenon of a population "exceed[ing] the carrying capacity of its own ecosystem and its 'connectedness' to other ecosystems" as "demographic entrapment."<sup>8</sup> Because this rapid growth in population has been enabled by a temporary period of cheap fossil fuels, some predict that after peak oil we will return to the mortality trends of the early 20th century, whereas others predict that improvements in agricultural technology and more efficient and equitable distribution of food can stave off disaster.<sup>41,53</sup> Petroleum-producing LMIC may be subject to serious food shortages after peak oil, especially if they follow the common pattern of making limited investments in domestic food production and relying heavily on imported food during their years of peak petroleum production. Peak oil will mean that petroleum-producing LMIC have less foreign exchange reserves to pay for food imports, while at the same time food-exporting countries dependent on fossil fuel inputs for their agricultural production will have less surplus food available for

export. Petroleum-producing LMIC may therefore face critical food shortages.

Beyond the challenge of sufficient and equitable distribution of food at the global level, there is the potential of large-scale population displacement. Climate change, rising sea levels, and changes in patterns of disease, compounded by increasing energy prices, could threaten livelihoods and living conditions of people in marginal environments, creating environmental refugees, particularly where there are dense populations living in coastal areas.<sup>54</sup>

### Aid Dependence

Global health practice has long been linked to economic and social development and development aid.<sup>55</sup> The effects of such aid, such as aid dependence, have been debated for decades. Sachs and others contend that foreign aid is needed to ensure that fundamental governing institutions are functional, but others (notably Easterly) have maintained that foreign aid is not necessary for poor countries to succeed and often creates economies that will not survive without it.<sup>56-58</sup>

Many low-income countries, particularly the 58 countries in the bottom billion, rely heavily on development aid and associated technical assistance provided through donors such as the Global Fund for AIDS, Tuberculosis and Malaria to set affordable prices for essential drugs,<sup>59</sup> establish and maintain procurement and supply management systems,<sup>27,60</sup> and to pay for the drugs and supplies themselves.<sup>27,28</sup> The end of cheap fossil fuels could greatly increase the cost of procuring and importing drugs and supplies, particularly in the landlocked countries of sub-Saharan Africa.<sup>3</sup>

In 2006, a review of 17 low-income countries found that 87% of all spending on HIV/AIDS came from international donors.<sup>61</sup> Although it is possible to consider this international HIV/AIDS aid an investment in the health and future productivity of these countries, it is difficult to imagine a scenario in which aid disappears and these countries maintain much of the progress they have made in the fight against HIV/AIDS.

Cheap fossil fuels make foreign aid possible, and foreign aid in turn can foster reliance on fossil fuels in recipient countries. At the time of this writing, the United States is the largest contributor to overseas development aid in the world, followed by Germany, France, the United Kingdom, and Japan. These countries are also among the top 12 petroleum-consuming nations in the world.<sup>62</sup> As costs of energy rise, these countries will face economic strains that will likely reduce the flow of aid to poorer nations.

### Armed Conflict

Collier argues that recurrent armed conflict (and insufficient support for countries recovering from conflict) is already a major contributor to global poverty and an important factor behind the failure of economies in many countries in the bottom billion.<sup>3</sup> Potential effects of energy scarcity on armed conflict are reviewed elsewhere in this issue.<sup>63</sup> Leder and Shapiro predict that energy scarcity will favor armed conflict and a transition away from democratic governments to authoritarian regimes.<sup>64</sup> The effects of armed conflict and natural disasters may be even more damaging because of a decreased capacity of global health organizations to transport human, food, and medical resources during disaster response.<sup>31</sup>

### Landlocked Countries

Collier,<sup>3</sup> Sachs,<sup>58</sup> and Faye et al.<sup>65</sup> identify being landlocked as one of the key development traps for countries in the bottom billion. Of the 12 countries with mortality rates of children younger than 5 years at 160 per 1000 live births or higher in 2009, 7 (Afghanistan, Burkina Faso, Burundi, Central African Republic, Chad, Mali, and Niger) are landlocked, and 5 of the 7 have population densities of less than 60 people per square kilometer.<sup>66</sup> A combination of being landlocked and having a low population density means that many medical supplies are first imported by air and then transported long distances by road. This scenario makes the medical supply chain exquisitely vulnerable to increased fuel prices. It has long been observed that low population densities are associated with less developed road networks,<sup>67</sup> and these countries are no exception. Health systems already face high fuel costs when 4-wheel-drive vehicles are driven long distances on unpaved roads. Referral systems are barely functional in these countries, with significant mortality related to lack of referral.<sup>68</sup> The end of cheap oil will make it difficult for these countries to expand or even maintain their inadequate road networks, pay for vehicles and fuel for health systems, or strengthen referral networks.<sup>29</sup>

### FUTURE DIRECTIONS FOR RESPONDING TO PEAK OIL

The 1978 Declaration of Alma-Ata, adopted at the International Conference on Primary Health Care in Almaty, Kazakhstan, defined a comprehensive approach to the provision of basic health services at the local level and

provided guidance for how to break the links between poverty, ill health, and malnutrition.<sup>55,69,70</sup> Some of the concepts providing the foundation for the Declaration of Alma Ata included “appropriate technology,” opposition to medical elitism, health as a tool for socioeconomic development, self-reliance, and community empowerment, with the seventh statement of the declaration noting that primary health care “requires and promotes maximum community and individual self-reliance and participation.”<sup>42–44</sup> The declaration’s emphasis on appropriate technology, self-reliance, and community empowerment did not arise out of concern about peak oil, energy scarcity, and climate change, but these concepts can help communities identify ways to adapt to a world where energy consumption must be curtailed.

The stress on “appropriate technology” arose from a desire to move away from investments in large referral hospitals and provision of expensive medical equipment and to move toward investments in a basic package of care at the community level that could be provided to entire populations.<sup>55,69,70</sup> The meaning of “appropriate” now must be expanded to mean technology and technical approaches that are not only affordable and acceptable for end users but that also minimize reliance on use of fossil fuels. It may make sense to resurrect health technologies that were abandoned in the past, such as health facilities that are naturally ventilated and require less power and surgical supplies that can be sterilized and reused.

Models of global health practice will not fall within the Brundtland Commission’s definition of sustainable development as development

that “meets the needs of the present without compromising the ability of future generations to meet their own needs” until project development and practice embrace techniques that are both economically and ecologically sustainable.<sup>71</sup> Global health organizations’ investments in equipment and infrastructure should aim to reduce dependence on fossil fuels through promotion of energy-efficient technologies and renewable sources of energy. Global health meetings and conferences should set an example of careful consumption and energy efficiency by identifying alternatives to air travel, such as teleconferencing, minimizing energy consumption during the meeting, and serving local produce as much as possible.

The stress on self-reliance and community empowerment arose out of concerns about medical elitism and a desire to promote social and economic development.<sup>70,72,73</sup> But self-reliance and community empowerment may also result in reduced consumption of fossil fuels if there is increased reliance on local expertise and resources, rather than on outside expertise and imported commodities produced with fossil fuel inputs.

## CONCLUSIONS

A recent review of primary health care 30 years after the Alma-Ata Declaration concludes with the statement:

In 20 years from now, at the half-century of Alma-Ata, we could see a different world, with basic health care reaching many of the poorest families. However, to achieve this goal we need to revitalize the original revolutionary principles of Alma-Ata, sticking consistently to the core values of universal access for care, equity, community participation, intersectoral collaboration, and appropriate use of resources.<sup>70</sup>

This call to action is entirely compatible with the necessary adaptations to peak oil. “Equity” and “appropriate use of resources” need to be understood as concepts informing efforts to combat the continued energy poverty that undermines both households and health systems.<sup>31</sup>

Returning to the example of care seeking for maternal emergencies, many of the innovative approaches to promoting care seeking could be adapted to conditions of increasing energy insecurity.<sup>29</sup> These include community funds for emergency care seeking,<sup>74</sup> conditional cash transfers to encourage facility births,<sup>75</sup> and community emergency transportation systems.<sup>74,76,77</sup> Such interventions provide good models for building resilience in the face of peak oil, relying as they do on decentralized decision-making and implementation, maximizing use of limited resources, and targeting those who might be most affected by peak oil. These approaches have been shown to increase care seeking and improve access to life-saving interventions, and a recent study suggests that they are sustainable after the end of external funding.<sup>77</sup> However, increases in energy prices will test the limits of their sustainability. Other inputs may be required to sustain such approaches and to strengthen community resilience to projected changes in the cost and availability of fossil fuels.

At the beginning of this article, we listed 3 threats to health that arise from the earth’s limited capacity to sustain unabated human growth and consumption: (1) global climate change, (2) ecosystem degradation, and (3) peak oil. Global health practitioners are beginning to acknowledge the threat posed by climate change, but there is limited awareness of the threats posed by

ecosystem degradation and the rising cost and limited availability of key resources such as petroleum. We need to appreciate the importance of monitoring the local-level effects that peak oil and energy scarcity will have on the poor, and we must aggressively plan for adaptation to peak oil. These efforts should be part of a larger strategy for addressing the critical links between energy and health, including ending energy poverty and ensuring access to electricity for all people; moving toward a low-energy, low-carbon transportation system in middle- and high-income countries; and limiting global greenhouse gas emissions.<sup>78</sup>

Patterns of energy scarcity and rising costs will evolve unpredictably over the coming decades, but the global health community needs to mount a response now. Recent analyses indicate that energy scarcity is already affecting our ability to meet the United Nations Millennium Development Goals for maternal and child health,<sup>29</sup> limiting our ability to adequately respond to humanitarian emergencies,<sup>31</sup> and contributing to food insecurity.<sup>79</sup> Rather than responding on an emergency basis to spikes in prices and acute shortages, we need to develop a long-term strategy to reduce dependence on fossil fuels, end energy poverty, and build communities’ ability to adapt to the coming changes.

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### Contributors

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