22

Environmental Degradation and Environmental Health Policy in Peru

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Abstract

Environmental problems such as poor air and water quality, inadequate water supply and sanitation, and poor hygiene conditions are a significant cause of disease and death in Peru. The cost of environmental damage was estimated at 8.2 billion nuevos soles (S/.) per year, or 3.9 percent of the country's GDP in 2003. Over 70 percent of this, or S/. 5.85 billion per year, is attributable to environmental health impacts. It is the poor—who usually do not have sufficient resources to deal with adverse environmental health impacts and who are most exposed to environmental risks—who bear the greatest burden of this cost. Children under the age of five are the most vulnerable to the health consequences of environmental degradation. It is estimated that every year, there are over 8 million cases of diarrheal morbidity in children under the age of five. Almost 4,000 people die prematurely each year from illnesses associated with poor outdoor air quality. About 1,000 children under the age of five die each year from respiratory illnesses caused by poor indoor air quality. In addition, because lead exposure in early childhood lowers the average IQ by 1 to 2 points, on an annual basis about 2,200 children suffer enough IQ loss to cause mild mental retardation. Due to these environmental risk factors, Peru annually loses an estimated 210,000 disability-adjusted life years, a massive loss for an economy whose human capital is limited. This chapter proposes low-cost interventions to mitigate these negative environmental health outcomes and yield high benefits.

I. Introduction

Environmental quality is an important factor that affects the overall health status and well-being of Peru's growing population (Table 1). Environmental problems, notably urban and indoor air pollution, and inadequate water supply and sanitation account

Table 1. Environmental Pollution and Human Health

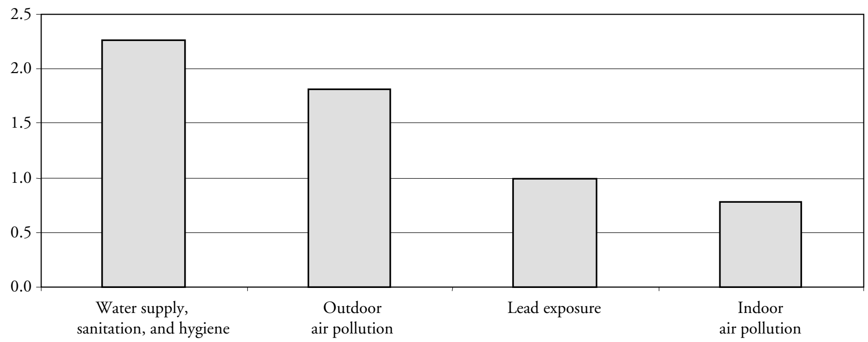
Underlying Determinants	*Adverse Health Consequences*
Exposures to vehicle and industrial air pollution	Respiratory and cardiovascular morbidity and mortality, some cancers, predominantly among elderly
Lead exposure	Loss of IQ, mild mental retardation, gastro-intestinal effects, anemia, high blood pressure morbidity and mortality
Inadequate water (quantity and quality), sanitation, and solid waste disposal	Diarrheas and vector-related diseases, e.g., typhoid/paratyphoid, hepatitis A
Crowded housing and poor ventilation of smoke	Acute and chronic respiratory diseases, including chronic obstructive pulmonary disease and lung cancer, especially among young children and women

for a significant share of the burden of disease and death in Peru. As an illustration, urban air pollution from particulate matter is estimated to cause around 3,900 premature deaths and 3,800 new cases of chronic bronchitis annually. In addition, approximately 9–13 percent of child mortality, or 1,820 deaths could be attributed to diarrheal illness in Peru (WHO 2002). Furthermore, an estimated 1,100 premature deaths are related to exposure to indoor air pollution from burning of solid fuels, such as fuelwood and charcoal, for domestic purposes.

In Peru, the cost of environmental damage is estimated at S/. 8.2 billion per year, or 3.9 percent of the country's GDP in 2003 (Figure 1). Over 70 percent of this cost estimate—or S/. 5.85 billion per year—is attributable to environmental health impacts.[1] Waterborne diseases associated with inadequate water supply, sanitation, and hygiene account for S/. 2.26 billion per year, followed by urban air pollution due to particulate matter (S/. 1.81 billion per year), exposure to lead pollution (S/. 1 billion per year), and indoor air pollution (S/. 0.78 billion per year) (Figure 1). Due to these environmental risk factors, Peru annually loses an estimated 210,000 disability-adjusted life years—a massive loss for an economy whose human capital is limited. There is public recognition of the importance of these priority environmental problems. A survey of public perceptions of environmental problems in the Lima-Callao area, conducted in 2001, found that approximately 80 percent of respondents in a sample of 1,400 Peruvians identified air pollution as the principal environmental problem in the area.

Environmental conditions in Peru continue to increase the burden of poverty. The poor are often disproportionately affected by environmental degradation because they have fewer resources to cope with adverse environmental health effects and losses in income from environmental impacts are often more detrimental to their livelihood than to the livelihood of higher income groups. Often the poor are exposed to higher environmental health risks than the nonpoor. This is especially so, for example, in the

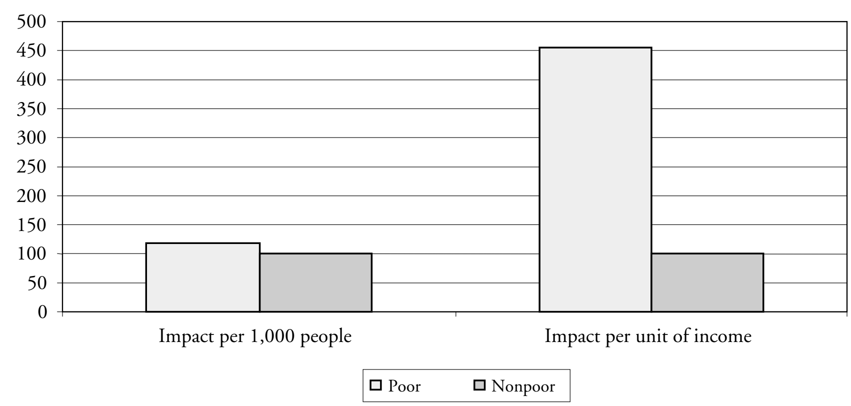
Figure 1. Cost of Environmental Health Damage in Peru
(S/. billion per year)



Source: Larsen and Strukova (2005).

case for risks of respiratory illness and mortality as a result of indoor air pollution, and the risk of diarrheal illness and mortality from inadequate water supply, sanitation, and hygiene (Figure 2). The incidence of health impacts among the poor and the burden on their living standards are higher than for the nonpoor. The combined health impact of environmental degradation per 1,000 people is nearly 20 percent higher for the poor than for the nonpoor, while relative to income, the health impact on the poor is about 4.5 times higher than on the nonpoor population.

Figure 2. Health Impacts per 1,000 People and per Unit of Income



Source: Larsen and Strukova (2005).
Note: Health impacts per 1,000 people and per unit of income are indexed to 100 for the nonpoor population. The health impacts of exposure to lead pollution are not estimated for the poor and nonpoor population because of lack of data on lead exposure for each of these groups.

The cost of environmental degradation in Peru is higher than in other countries that have similar income levels. Studies of the cost of environmental degradation conducted in Colombia, an upper-middle-income country in Latin America, and several lower-middle-income countries in North Africa and the Middle East, show that the monetary value of increased morbidity and mortality typically lies below 2 percent of GDP in these countries, in comparison to a value of 2.8 percent of GDP in Peru (Figure 3).

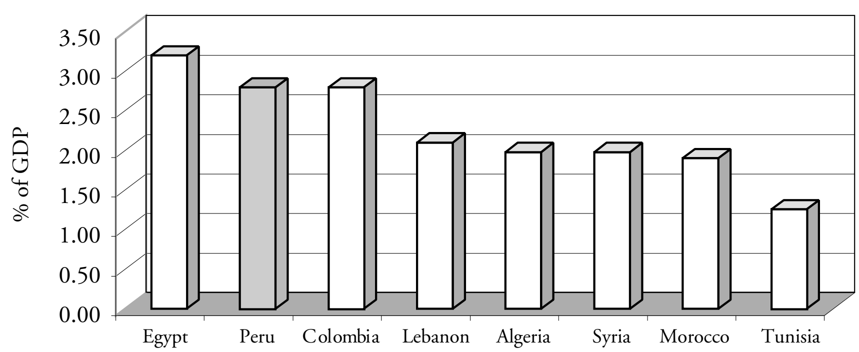
The following three sections of this chapter focus on environmental health consequences linked to identified priority environmental problems—urban air pollution, inadequate water supply, sanitation and hygiene, and indoor air pollution—and provide specific recommendations to address them. Conclusions and more general policy recommendations are outlined in the last section.

II. Diagnosis of Factors and Recommendations

Urban Air Pollution

Air pollution is one of the most widespread and serious environmental problems in Peru's urban centers due to its adverse impacts on health in the form of premature deaths and illnesses. It affects health in a way that depends on the levels and degree of exposure. Although air pollution levels are moderate in most cities, the fact that close to 50 percent of Peru's population lives in cities with more than 100,000 inhabitants creates substantial aggregate health effects. There are two major air pollutants

Figure 3. Costs of Environmental Degradation
(Health and Quality of Life)



Sources: Tunisia and Lebanon: Sarraf, Larsen, and Owaygen 2004. Algeria, Ministry of Territorial Regulation and the Environment 2002; Egypt: World Bank 2002; Morocco: World Bank 2003; Syria: Sarraf, Bolt, and Larsen 2004; Jordan: METAP 2000.
Note: The cost in Peru includes health effects and natural disasters.

of concern to health in Peru, particulate matter (PM) and lead, both of which originate principally from transport and industrial activities.

Health Effects of Particulate Matter Pollution

Particulate matter that has a diameter less than 2.5 microns (PM 2.5) has the most significant effects on health. The literature indicates that mortality increases by 4–6 percent for every 10 μg/m^3 increase in the concentration of PM 2.5 (Pope et al. 2003). Urban air pollution from particulate matter is responsible for almost 3,900 premature deaths annually in Peru. In addition, it accounts for the loss of approximately 66,000 disability-adjusted life years (DALYs[2]) per year, attributable to mortality (44 percent), chronic bronchitis (13 percent), restricted activity days (RADs) (20 percent), and respiratory symptoms (16 percent) (Table 2). The mean annual cost of urban air pollution due to particulate matter is estimated at S/. 1.81 billion. Of this amount, 62 percent is associated with mortality from cardiopulmonary disease and lung cancer, and 38 percent is associated with morbidity from respiratory illnesses (Figure 4). Young children are most affected by acute respiratory infections and death from pneumonia.

The problem of urban air pollution is most critical in the country's industrial corridors, such as Lima-Callao, which bears almost 75 percent of the estimated cost of health impacts of urban air pollution in Peru. The data indicates that pollution levels are highest in the Centro zone (Figure 5). Furthermore, the pollution levels in all zones exceed the concentration threshold of 7.5 μg/m^3 for mortality effects set by the World Health Organization (WHO, 2002). In comparison to other countries in the region, the levels of air pollution in Lima are higher than in Mexico City and Santiago, where air pollution is severe (Figure 6). Furthermore, air pollution levels in Lima are considerably higher than in cities such as Los Angeles, Tokyo, and Rome, which have larger industrial and transportation sectors than Lima and have successfully reduced ambient concentrations of air pollutants.

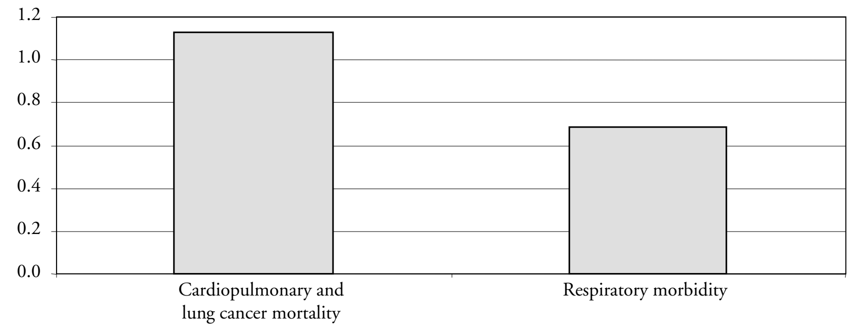
The incidence of health impacts of urban air pollution varies between poor and nonpoor population groups. In the Lima-Callao area, health impacts per 1,000

Table 2. Estimated Annual Health Impact of Urban Air Pollution from Particulate Matter

Health end-points	*Total cases/year*	*Total DALYs/year*
Premature mortality	3,900	29,253
Chronic bronchitis	3,800	8,386
Hospital admissions	12,800	205
Emergency room visits/outpatient hospital visits	252,000	1,133
Restricted activity days	43,350,000	13,004
Lower respiratory illness in children	533	3,467
Respiratory symptoms	137,957	10,347
Total	43,760,990	65,796

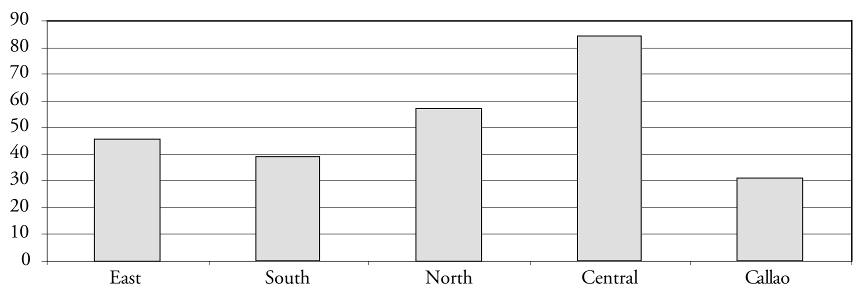
Source: Larsen and Strukova (2005).

Figure 4. Annual Costs of Urban Air Pollution
(S/. billion)



Source: Larsen and Strukova (2005).

Figure 5. Ambient Concentrations of PM 2.5 (µg/m3) in Lima-Callao



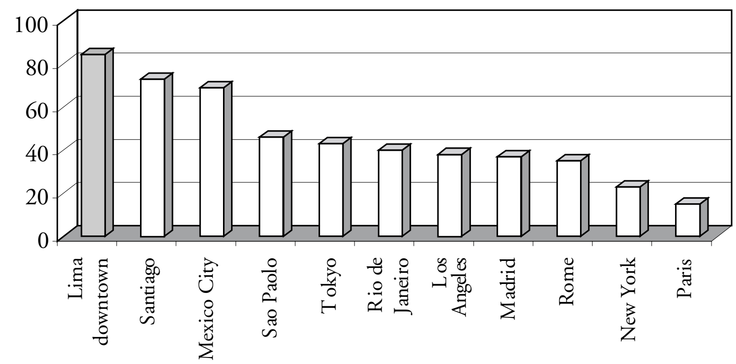
Source: DIGESA (2005).

people are 70 percent and 50 percent higher on the poor than on the nonpoor, for base- and mid-case scenarios respectively.[3] In the high-case scenario, health impacts per 1,000 people are higher among the poor than the nonpoor. When health impacts are compared in relation to income, however, the health impacts range from 75 to 300 percent higher on the poor than on the nonpoor for all three scenarios (Figure 7).

Health Effects of Exposure to Lead Pollution

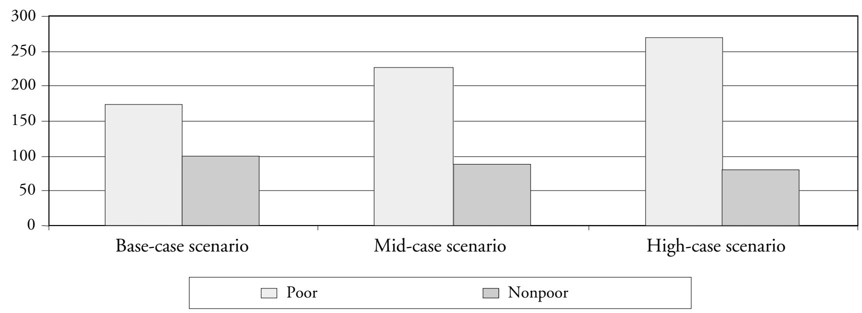
Lead poisoning, the accumulation of lead in the body as a result of continued exposure to lead, is a cause of serious health impacts in children, such as mental retarda-

Figure 6. PM 10 Average Annual Concentrations in Selected Cities
(µg/m³)



Source: World Bank (2005b).

Figure 7. Health Impacts of Urban Air Pollution per Unit of Income in Lima-Callao



Source: Larsen and Strukova (2005).
Note: The health impacts per unit of income are indexed to 100 for the nonpoor in the base-case scenario. Health impact per unit of income is calculated as health impact per person divided by income per person, normalized to 100.

tion, stunted growth, reduced IQ, and learning disabilities, and of fertility problems, nerve disorders, muscle and joint pain, and memory problems in adults.

The use of gasoline with significant amounts of lead content is a major pathway for lead poisoning. Significant amounts of lead, typically around 0.75grams/liter, were found in gasoline in Peru in the 1990s (Lovei, 1998). Similarly high levels of lead in the atmosphere were recorded in the same period. In 1993, the Ministry of

Health reported monthly average lead concentrations in the atmosphere of 1.5–2.18µg/m^3, which were in excess of the annual maximum limit of 0.5µg/m^3 (Jacoby, 1998). In response, the government of Peru adopted a strategy to gradually phase out lead from gasoline, and took a laudable step by eliminating the use of lead-containing additives in gasoline, which took effect from January 1, 2005. As a result, lead in air levels—that had been relatively constant in Lima in the period 2000–04—started to come down after 2005 (Table 3).

Notwithstanding the reductions of atmospheric lead concentrations achieved to date through the government's efforts, there is a need to address lead pollution from remaining point sources such as smelting activities in industry (see Box 1), and diffuse sources such as during the transportation and storage of lead in Lima-Callao. Furthermore, substantial legacies from lead exposure remain as lead tends to accumulate over time in human blood. The main indicator of lead health impacts or lead poisoning in humans is the lead level in the blood or Blood Lead Level (BLL). While there is uncertainty of how much BLL will decline from a lead phase-out program, international experience indicates that a program over a five-year period could lead to a 40 percent reduction in BLL.

The thresholds for BLL differ according to the type of health effects (Table 4). Espinoza et al. (2003) analyzed BBL in children in Lima-Callao and found elevated BBL in young children in the late 1990s. It is important to note that this study was conducted prior to the ban on lead in gasoline. More recent studies suggest that 44–46 percent of the children and 0–11 percent of the adults have BLL greater than 5µg/dl and an estimated 5–14 percent of the children and no adults have BLL greater than 20µg/dl (Larsen and Strukova, 2005). It is pertinent to note that the threshold BLL for reduction of intelligence, measured as the Intelligence Quotient (IQ), in children is 5µg/dl (Fewtrell et al., 2003).

Estimates of the health effects associated with lead poisoning in children under the age of five in Peru are presented in Table 5. Lead poisoning accounts for a loss of about 160,000–235,000 IQ points and 1,750–2,670 cases of mild mental retardation in children under the age of five. Other health effects of lead exposure are gas-

Table 3. Atmospheric Lead Concentration in Lima-Callao
(µg/m3)

Year	*Callao*	*South*	*North*	*East*	*Center*
2000	0.089	0.100	0.290	0.187	0.281
2001	0.072	0.116	0.279	0.170	0.324
2002	—	0.090	0.192	0.186	—
2003	0.193	0.184	—	0.242	0.214
2004	0.180	0.182	0.213	0.208	0.362
Average	**0.134**	**0.134**	**0.244**	**0.199**	**0.295**

Source: DIGESA (2005).

Box 1. Lead Contamination "Hotspots" in Peru

Gasoline is not the only source of lead exposure in Peru. A 2005 analysis conducted in La Oroya by a research team from St. Louis University's School of Public Health confirmed earlier findings by DIGESA. La Oroya, a town of 30,000 inhabitants, has a metal smelter producing gold, silver, lead, zinc and copper that is a major source of lead pollution. About 97 percent of children from six months to six years of age have lead concentrations in the blood (BLL) above 10 µg/dl. About 72 percent of the children have BLL of 20–44 µg/dl and 9 percent in the range of 45–69 µg/dl. Children with BLL in the latter range required urgent medical attention.

There are also other cases of elevated BLL. In 1998, the Ministry of Health confirmed that 5,000 children living near the mining areas in the port city of Callao had a BLL of 20–40 µg/dl, and nearly 100 percent of the 350 students at the María Reich public school had a BLL of more than 40 µg/dl (Osava, 2002).

These incidences are not characteristic of the whole urban population. BLL in most of Lima-Callao metropolitan area and other cities is much lower. Nevertheless, lead contamination "hotspots" should be analyzed and mitigation measures urgently implemented.

Sources: Salazar 2005. Grave Contaminación en La Oroya, 15/12/05, *La República,* 20; http://www.pcusa.org/pcnews/2005/05677.htm; DIGESA, Osava M. (2002). Lead Poisoning Is Not Child's Play, http://www.tierramerica.net/2002/0929/iarticulo.shtml.

trointestinal effects in children, anemia in children and adults, and elevated blood pressure in adults, resulting in higher risk of cardiovascular disease and mortality.

The estimated annual cost associated with lead exposure in Peru is estimated at S/. 0.80–1.20 billion per year, with a mean of S/. 1 billion per year[4]. Table 6 shows that children bear the greatest burden of the cost of health impacts of lead exposure with morbidity in children—mostly associated with IQ loss—accounting for S/. 650 million, or 65 percent of the mean cost. The cost of mild mental retardation alone represents an estimated 34 percent of the mean cost. Cardiovascular mortality and elevated blood pressure morbidity in adults constitute 1 percent of the mean cost.

Recommendations for Mitigating Health Impacts of Air Pollution

Particulate matter and lead pollution

Particulate air pollution is an important cause of adverse health impacts in adults and children, particularly in large urban centers in Peru. In this context, there is an

Table 4. Health Effects of Lead

Health Effect	*Blood lead threshold concentration[a] (µg/dl)*		*Observations on dose-response effects*
	Children	*Adults*	
Loss of Intelligence Quotient (IQ)[b]	5	ND	A linear relationship exists between blood lead level and IQ loss for blood lead levels between 5 and 20 µg/dl. Within this range, 1.3 IQ points are lost per 5 µg/dl increase of blood lead level. For blood lead levels above 20 µg/dl, this rate increases to 3.5 IQ points lost per 5 µg/dl increase of blood lead level.
Increased systolic blood pressure[c]	ND	5	A linear relationship is assumed between blood lead level and systolic blood pressure for blood lead levels between 5 and 20 µg/dl. Within this range, systolic blood pressure increases by 1.25mmHg in males, and by 0.8mmHg in females, per 5 µg/dl increase in blood lead level. For blood lead levels above 20 µg/dl, systolic blood pressure increases by 3.75mmHg in males, and by 2.4mmHg in females, per 5 µg/dl increase in blood lead level.
Gastrointestinal effects	60	ND	Gastrointestinal effects occur in 20 percent of children at blood lead levels greater than 60 µg/dl (Schwartz et al., 1990; section 4.1).
Anemia	70	80	Anemia occurs in 20 percent of people at blood lead levels greater than 70 µg/dl (Schwartz et al., 1990; section 4.1).

Source: Fewtrell et al., (2003).
Note: a. Thresholds for gastrointestinal effects and anemia are levels "at risk," as defined by ATSDR (1999). b. The disease burden is always estimated for one particular year and the effects of previous exposures are not accounted for in the year of assessment. As a result, only children aged 0–1 year old were considered in the calculations, since effects of lead on previous cohorts were considered in previous years. c. Adults aged 20–79 years only.

urgent need to develop a broad strategy to reduce exposure to elevated concentrations of air pollutants, specifically PM2.5, and to enhance monitoring and enforcement activities to mitigate the health impacts of exposure to air pollution. To this end, recommendations for policy changes, investments, and technical assistance are provided below.

Table 5. Health Effects of Lead Exposure in Peru
(Annual Estimates)

	Low	*High*
IQ Loss in Children	**Number of IQ Point Losses**	
IQ (1)—loss of 0.65 points per child	42,000	30,000
IQ (2)—loss of 1.95 points per child	45,000	43,000
IQ (3)—loss of 3.25 points per child	32,000	41,000
IQ (4)—loss of 3.50 points per child	40,000	120,000
Total number of IQ point losses	159,000	234,000
Other Health Effects	**Number of Cases**	
Mild Mental Retardation (MMR) in children	1,750	2,670
Gastrointestinal effects in children	1,400	23,000
Anemia in children	800	18,000
Anemia in adults	0	0
Cardiovascular mortality in adults	0	40

Source: Larsen and Strukova (2005).

Table 6. Annual Costs of Health Impacts from Lead Exposure

Health outcome	*Cost (SS/. million)*	*Percentage of mean cost*
IQ loss in children	530–775	65
Mild Mental Retardation	270–415	34
Cardiovascular mortality in adults	0–10	0.7
Elevated blood pressure morbidity in adults	0–5	0.3
Total Annual Cost	800–1,205	100.0

Source: Larsen and Strukova (2005).

POLICY RECOMMENDATIONS

- Establishment of national ambient standards for PM10 and PM2.5 from mobile, stationary, and diffuse sources in priority urban areas. This could be complemented with strengthening of technology-specific emission standards for PM and its precursors.
- Design and implementation of ambient standards for particulate matter pollution may be considered as a matter of urgency.
- Development of regulations that empower the national government, when needed, to enforce ambient standards for particulate matter in municipalities through the use of sanctions and penalties.
- Design and implementation of a tax policy that imposes higher taxes on fuels that are precursors of particulate matter emissions.
- Enactment of laws and regulations that make it mandatory for regional and local governments to establish land use zoning plans and sustainable transport

policies in order to minimize fuel consumption and travel time between housing developments and business centers.
- Design and implementation of regulations for reducing the sulfur content of diesel in urban areas where ambient concentrations exceed ambient standards. In the short term, this may require the importation of low-sulfur diesel.
- Establishment of regulations to upgrade urban bus fleets and other forms of transit in major cities; create incentives to scrap older vehicles; and prohibit importation of used diesel-fueled cars.
- Public disclosure of information on industries that emit the largest amounts of particulate matter and lead to promote accountability in environmental management and behavioral change to reduce pollution.

Technical Assistance

- Development of a detailed inventory of emissions and improved understanding of pollutant transport by developing transportation and dispersion models for emissions.
- Continued monitoring of morbidity and mortality associated with particulate matter emissions.
- Incorporation of a pollution fee within the price of lead-containing products.
- Establishment of air quality monitoring networks to monitor PM2.5, PM10, and ozone in priority urban areas.
- Establishment of inspections programs aimed at testing vehicle exhaust emissions.

Investments

- Retrofit refineries in order to reduce sulfur content of diesel.

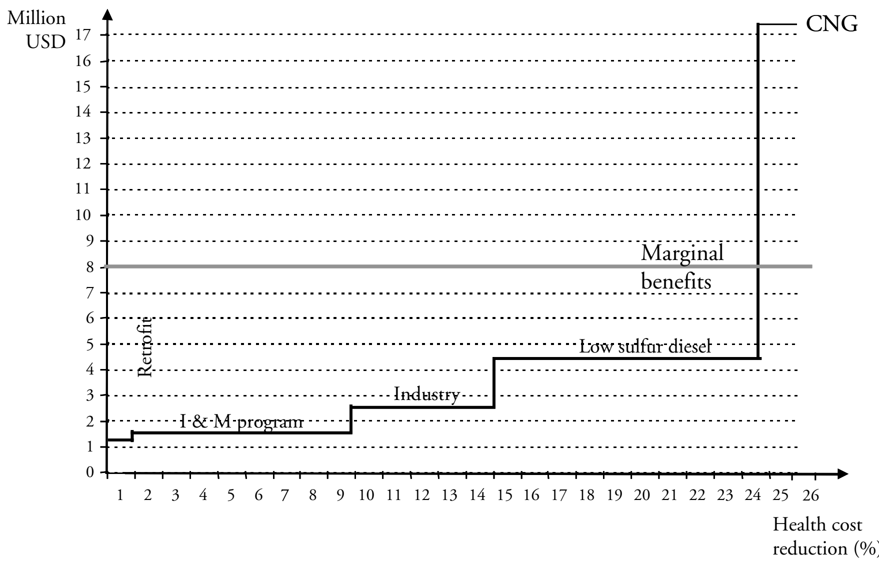
Alternative interventions to control particulate matter pollution are ranked based on the estimation of costs and benefits associated with the prevention or reduction of disease and mortality through the implementation of such interventions (Figure 8). These interventions include retrofitting of particle control technology on existing heavy duty diesel vehicles, a vehicle inspection and maintenance program to control vehicle exhaust emissions, control of stationary sources in industry, introduction of low-sulfur diesel, and substitution of diesel with compressed natural gas. It is important to note that there are, in addition, other benefits and co-benefits associated with the implementation of these interventions, which are not captured by the analysis.

Exposure to lead pollution

Policy Recommendations

- Establishment of national ambient standards for lead concentrations.

Figure 8. Marginal Costs and Benefits of Actions to Reduce PM Emissions



Source: ECON (2005).

- Establishment of a pollution control program that may include development of regulations with provisions for fines and closure of polluting facilities in cases of noncompliance.
- Inclusion of requirements in housing policies to prohibit the use of lead-based materials in housing construction.
- Incorporation of a pollution fee within the price of lead-containing products.

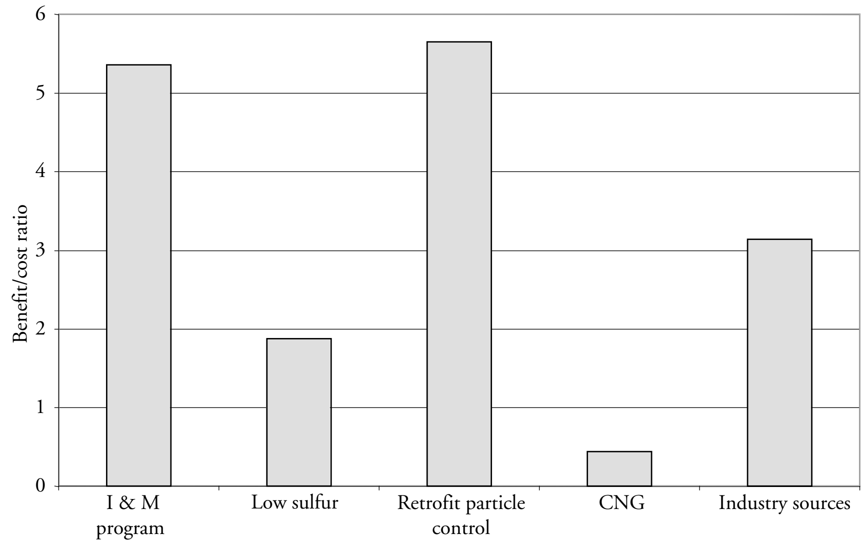
INSTITUTIONAL RECOMMENDATIONS

- Consideration of a restructuring of the Institute for Environmental Health so that it can assume responsibility for monitoring of air quality and enforce related national regulations.

TECHNICAL ASSISTANCE

- Continued monitoring of lead levels in blood through epidemiological studies to develop more comprehensive data on morbidity and mortality attributable to lead poisoning.
- Inclusion of early testing of children for lead poisoning in childhood development programs.

Figure 9. Benefit-Cost Ratios for Various Control Options



Source: ECON (2005).

- Inclusion of requirements in housing policies to prohibit the use of lead-based materials in housing construction.
- Development of a detailed inventory of lead pollution hotspots.
- Establishment of a deposit refund system for disposal of used products containing high concentrations of lead, such as batteries.

Water, Sanitation, and Hygiene

Inadequate drinking water quantity and quality, and poor sanitation and hygiene conditions are associated with various illnesses in adults and children, such as hepatitis, cholera, intestinal worms, and diarrhea.[5] Although diarrheal illness is generally not as serious as some other waterborne illnesses, it is more common and affects a larger number of people. According to WHO, an estimated 90 percent of diarrheal illness cases globally are attributable to poor water quality and quantity, and poor sanitation and hygiene.

Data obtained from the Ministry of Health in Peru indicates that 4.6 percent of child mortality cases were due to intestinal diseases in the year 2000. The 2002 Global Burden of Disease Study, which takes into account possible substantial under-reporting of mortality,[6] indicates that 9–13 percent of child mortality cases in Peru could be from diarrheal illness. More recent estimates from a study of the cost of environmental health problems in Peru show that diarrheal illness is estimated to cause approximately 8.4 million and 11.8 million cases per year of morbidity, in children and adults, respectively (Larsen and Strukova 2005). Children, however, are most affected by death from diarrheal illness. Between 845 and 2,390 premature deaths in children under five are attributed to diarrheal illness. Death and illness from diarrhea account for the loss of 42,550 to 104,750 DALYs per year, of which more than 60 percent is attributable to diarrheal child mortality. The health impacts of inadequate water, sanitation, and hygiene—in terms of the number of cases of adverse health outcomes and the number of DALYs lost—are summarized in Table 7.

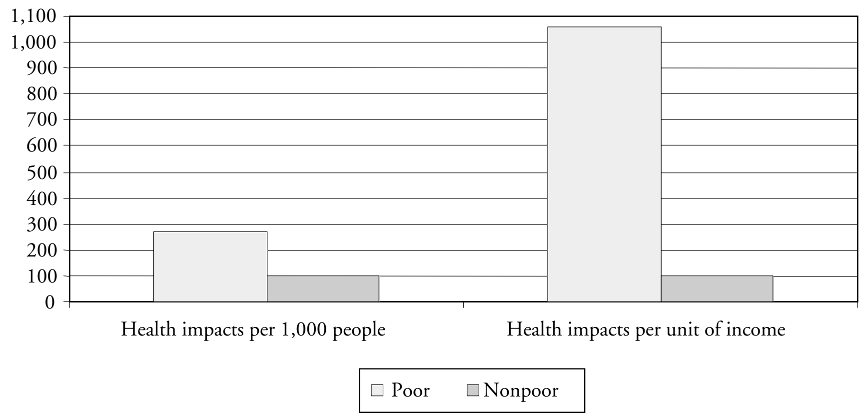
The health impacts of inadequate water, sanitation, and hygiene vary according to age and income levels, with children and the poor bearing the highest burdens. Based on a national poverty incidence rate of 55 percent in 2002—and a national child mortality rate of 34 per 1,000 live births in 2003—it is estimated that the child mortality rate among the poor is around 42 per 1,000 live births, compared to 17 among the nonpoor. Similarly, based on an average diarrheal prevalence rate of 15 percent in 2000 (Demographic and Health Survey, Peru 2000), the prevalence rate among the poor is estimated at 18 percent, and at 12 percent among the nonpoor (Larsen and Strukova, 2005). The health impacts or disease burden per 1,000 people are nearly three times higher in the poor population than on the nonpoor population[7]. The difference in health impacts relative to income is even larger. Per unit of income, the health impacts

Table 7. Estimated Annual Health Impacts of Inadequate Water, Sanitation and Hygiene
(Diarrheal Illness)

Health Outcomes	*Estimated annual cases*		*Estimated DALYs*		*% of total DALYs*
	Low	*High*	*Low*	*High*	
Cases of Diarrheal Illness					
Children (under 5 years of age)—increased mortality	845	2,390	27,760	81,285	68–78
Children (under 5 years of age)—increased morbidity	8,360,000	8,360,000	2,790	3,715	4–7
Population over 5 years of age—increased morbidity	9,900,000	13,680,000	11,000	19,750	19–26
Cases of Diarrheal Hospitalization					
Children (under the age of 5 years)	6,300	6,300			
Population over 5 years of age	5,900	5,900			
Total			**42,550**	**104,750**	

Source: Larsen and Strukova (2005).

Figure 10. Health Impacts of Inadequate Water, Sanitation, and Hygiene per 1,000 People and Per Unit of Income
(Diarrheal Illness)



Source: Larsen and Strukova (2005).

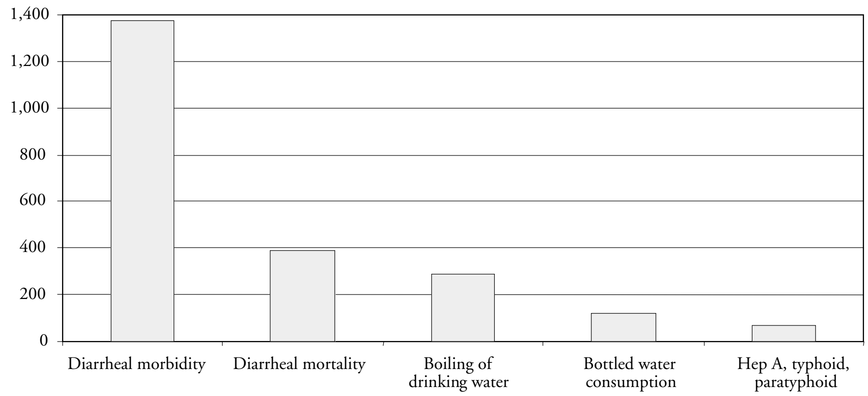
are more than 10 times higher on the poor population than on the nonpoor population (Figure 10). This is explained by the fact that the income of the nonpoor is nearly four times higher than that of the poor. Furthermore, the poor have limited access to improved water supply and safe sanitation, and live in less hygienic conditions.

The estimated annual cost associated with inadequate water supply, sanitation, and hygiene in Peru lies between S/. 1.79 and S/. 2.73 billion per year, with a mean value of S/. 2.26 billion /year (Figure 11). This cost estimate includes the costs of mortality, based on the human capital approach: morbidity, including medical treatment, medicines, and value of lost time; and averting expenditures. "Averting behavior" results in costs that are incurred if individuals perceive a risk of illness from consumption of a municipal or other source of water, and consequently purchase bottled water for drinking purposes, boil their water, or install water purification filters. Of the total cost associated with inadequate water supply, sanitation, and hygiene, health impacts—morbidity and mortality –account for 82 percent (S/. 1.9 billion), and averting expenditures account for the remaining 18 percent (S/. 0.4 billion). The cost of DALYs attributable to consumption of unsafe water is estimated at 1–1.9 percent of GDP, similar to countries such as Bolivia, Ecuador, Guatemala, and Nicaragua.

Cost of Diarrheal Illness

The cost of diarrheal illness is distributed between mortality and morbidity (Table 8). About 25–35 percent of health costs are associated with the value of time lost to illness (including caregiving), and 65–75 percent are from cost of treatment and medicines.

Figure 11. Estimated Annual Cost of Inadequate Water Supply, Sanitation and Hygiene
(S/. million)



Source: Larsen and Strukova (2005).

Table 8. Estimated Annual Cost of Diarrheal Illness
(Mortality and Morbidity)

	Estimated Annual Cost (S/. billion soles)	
	Low	***High***
Mortality		
Children under age 5	0.21	0.58
Morbidity		
Children under age 5	0.59	0.65
Population under age 5	0.67	0.88
Total Annual Cost of Diarrheal Illness	1.46	2.11

Estimated Annual Cost of Diarrheal Morbidity by Category

	Estimated Annual Cost (S/. billion soles)	
	Low	***High***
Cost of medical treatments (doctors, hospitals, clinics)	0.53	0.55
Cost of medicines	0.31	0.33
Cost of time lost to illness	0.30	0.47
Total Annual Cost of Diarrheal Morbidity by category	1.14	1.35

Source: Larsen and Strukova (2005).

Cost of Hepatitis A and Typhoid/Paratyphoid

In 2000, 39,336 cases of typhoid/paratyphoid and 16,838 cases of hepatitis A were recorded in Peru according to data from the Ministry of Health. The cost of these illnesses is estimated at S/. 70 million (Table 9). About 55 percent of this estimate is from hospitalization and 40 percent from time losses for the ill individuals and their care givers during illness. More than 40 percent of the cost of time losses is associated with ill individuals and almost 60 percent with caregiving.

Estimated averting expenditures are presented in Table 10, based on total bottled water consumption of about 120 million liters per year (*Ministerio de la Producción—Oficina de Estadística Industrial*) and boiling of drinking water in nearly 70 percent of households (USAID Hand Washing Survey 2004).

Recommendations to prevent disease and death due to inadequate water supply, sanitation and hygiene

One of the interventions to prevent waterborne diseases, fostered by the government of Peru since the early 1990s, has aimed to increase access to drinking water and sanitation. Peru's current program to increase water and sanitation coverage will help reduce the incidence of waterborne diseases and benefit the poorest population groups in the country. Nonetheless, experience and the literature show that increasing water and sanitation coverage provides only a partial response to the problem of waterborne disease, and is able to achieve up to a only 30 percent reduction in diarrheal disease (Fewtrell et al. 2004). Behavioral change that pro-

Table 9. Estimated Annual Cost of Hepatitis A and Typhoid/Paratyphoid (Morbidity)

	Estimated Annual Cost (S$S/. million)
Cost of hospitalization	50
Cost of medication	2
Cost of time losses	18
Total Annual Cost	**70**

Source: Larsen and Strukova (2005).

Table 10. Estimated Total Annual Household Cost of Averting Expenditures

	Total Annual Cost (S/. million soles)	
	Low	*High*
Cost of bottled water consumption	75	165
Cost of household boiling drinking water	190	380
Total annual cost	**265**	**545**

Source: Larsen and Strukova (2005).

motes handwashing has been identified as a cost-effective means of reducing diarrheal disease, particularly in children, as compared with more costly water and sanitation infrastructure programs. Handwashing with soap alone could reduce cases of diarrhea by 35 percent (Esrey et al. 1991; Hutley et al. 1997). Examples that demonstrate the effectiveness of safe water programs include pilot cases developed by the Center for Disease Control in the Peruvian Amazon, which report a mean reduction in diarrheal illness of about 45 percent. Furthermore, the Government, in collaboration with the private sector, has designed and begun implementation of a hand washing program.

POLICY RECOMMENDATIONS

- Design of a national handwashing program, incorporating lessons learned from the implementation of programs such as the PRONASAP program implemented in the slums of Lima.
- Establishment of very stringent standards for drinking water quality parameters, including for coliforms and other pathogenic organisms.
- Public disclosure of environment-related health parameters such as water quality, including pathogenic quality; rates of morbidity and mortality associated with waterborne diseases in specific cities; and best and worst water quality indicators achieved during the month, on monthly water bills of consumers that live in those cities.
- Establishment of regulations that prohibit using bacteria-contaminated wasterwater for irrigation of vegetables such as lettuce, cabbage, broccoli, and tomatoes.
- Public disclosure of water quality, including pathogenic parameters, in tourist areas, especially resorts and lakes and other bodies used for recreational activities.
- Establishment of penalties for utility operators and administrators where water utilities do not comply with water quality standards.

INSTITUTIONAL RECOMMENDATIONS

- Consideration of restructuring the Institute for Environmental Health so that it can assume responsibility for monitoring pathogenic quality of water and enforce related national regulations.

TECHNICAL ASSISTANCE

- Continued monitoring of water quality, including pathogenic organisms.
- Continued monitoring of morbidity and mortality associated with waterborne diseases.

INVESTMENTS

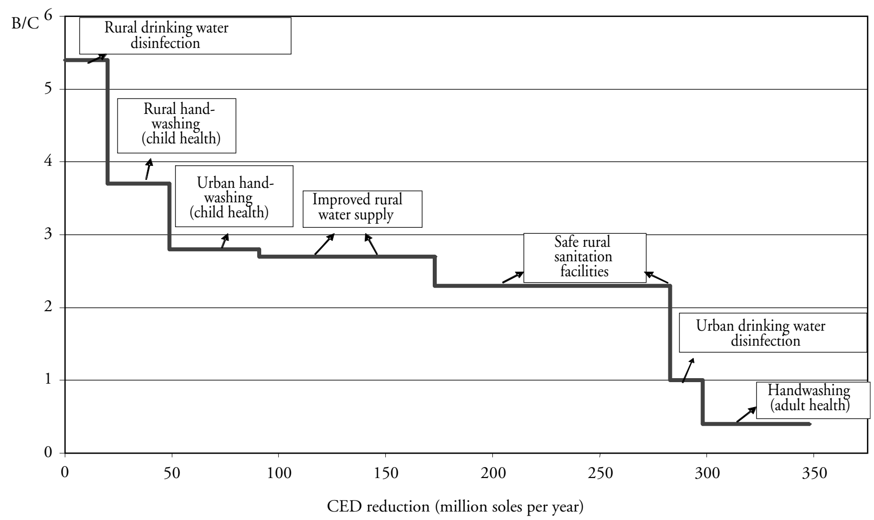
An analysis of the benefits and costs of alternative interventions to address waterborne diseases shows that the most effective intervention in Peru would be the design and implementation of a safe water program that promotes hygienic behavior through handwashing and improvements in water quality at the point of use (Figure 12) (Larsen and Strukova 2005). Furthermore, drinking water disinfection (i.e., household boiling of drinking water) in rural areas has the highest ratio of benefits to costs, followed by handwashing by mothers or caretakers of young children in rural areas. This is followed by handwashing in urban areas and provision of improved water supply and safe sanitation facilities in rural areas. Drinking water disinfection at point-of-use is also estimated to provide higher benefits than costs. In contrast, benefits of handwashing among adults, unless caring for young children, are estimated to be significantly lower than the cost. In total, these measures could reduce the cost of health effects by S/. 350 million per year. In light of the foregoing, the following investments are recommended:

- Continued investments in rural drinking water disinfection. To this end, the government should consider subsidizing the production of chlorine or the use of disinfecting tablets for use in waters meant for public use.
- Continued investments in handwashing and safe water programs. The benefit-cost analysis illustrated in Figure 13 shows that the benefits of handwashing are more significant in children than in adults (Larsen and Strukova 2005). Consequently, it is recommended that the existing handwashing program in Peru be restructured and oriented toward children. Furthermore, the scope of the program may be broadened to a safe water program that includes handwashing and point-of-use treatment.
- Continued investments in rural water supply and sanitation and urban drinking water disinfection.

Indoor Air Pollution

According to the Peru Demographic and Health Survey 2000, around 87 percent of rural households and 11 percent of urban households in Peru burn traditional fuels, including wood, charcoal, coal products, and dung for domestic purposes. Indoor smoke from burning solid fuels causes an estimated 1.6 million deaths annually and accounts for 2.7 percent of the global burden of disease (WHO, 2002). Indoor air pollution (IAP) is linked to several diseases, including acute respiratory infections (ARIs), chronic obstructive pulmonary disease (COPD), and cancers of the respiratory system. Young children under the age of five years and adult females are most affected by the adverse health impacts of exposure to IAP because they spend more time at home and in the cooking environment. Furthermore, poor rural families that typically cannot afford to pay for cleaner fuels or are not connected to the grid supply are more likely to be affected by the adverse health impacts of IAP.

Figure 12. Interventions to Control Health Impacts of Inadequate Water Supply, Sanitation, and Hygiene



Note: B/C = benefit-cost ratio. CED = cost of environmental damage (i.e., cost of health effects).

In Peru, IAP accounts for 21–39 percent of morbidity and mortality cases caused by ARIs and for 23–41 percent of morbidity and mortality cases caused by COPD (Table 11). Furthermore, it is estimated that ARI causes 911–1,291 premature deaths and 2.1–3.1 million cases of morbidity in children under the age of five. An estimated 42,000–62,000 DALYs are lost each year due to IAP. About 75–79 percent of the lost DALYs are attributable to mortality and about 21–25 percent to morbidity.

Cost of Health Impacts of Indoor Air Pollution

The mean annual cost of health impacts from indoor air pollution associated with the use of traditional fuels (mainly fuel wood) is estimated at S/. 0.78 billion per year.[8] About 20 percent of this cost is associated with COPD and 80 percent with ARI. Combined, COPD and ARI mortality represents about 51 percent of the total cost, and morbidity about 49 percent (Figure 13).

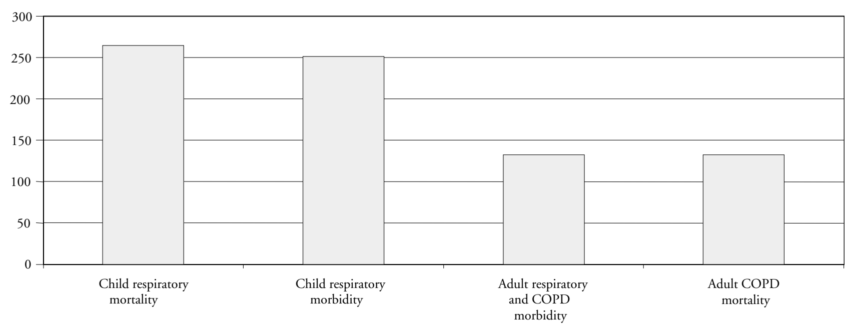
The poor suffer the worst health effects of IAP. Based on the estimated health effects from solid fuel use in urban and rural areas, 80–85 percent of the total health effects are borne by the poor population (Larsen and Strukova, 2006). However, differences in impact of solid fuel use for poor and nonpoor households using these fuels are not readily estimated as they depend on factors such as wood stove characteristics, ventilation, stove condition, pollution generating capacity of the stove, and general health conditions of those exposed to IAP.

Table 11. Estimated Annual Health Impacts of Indoor Air Pollution

Health outcomes	*Estimated annual cases*		*Estimated DALYs*		*% of total DALYs*
	Low	*High*	*Low*	*High*	
Acute Respiratory Illness (ARI)					
Children (under 5 years of age)—increased mortality	911	1,291	30,968	43,883	71–73
Children (under 5 years of age)—increased morbidity	2,121,400	3,102,200	3,500	5,119	8
Females (30 years and older)—increased morbidity	546,200	825,600	3,823	5,779	9
Chronic Obstructive Pulmonary Disease (COPD)					
Adult females—increased mortality	334	605	2,008	3,631	5–6
Adult females—increased morbidity	924	1665	2,079	3,745	5–6
Total	**2,669,769**	**3,931,361**	**42,379**	**62,157**	

Source: Larsen and Strukova (2005).

Figure 13. Annual Costs of Indoor Air Pollution
(S/. million/year)



Source: Larsen and Strukova (2005).

Recommendations to mitigate health impacts of indoor air pollution

The adverse health impacts of indoor air pollution disproportionately affect the poorer segments of Peru's population. Cross-sectoral interventions—that promote the mitigation of health impacts in addition to reduction of IAP—are helpful in the short term in order to reduce the cost of environmental degradation associated with indoor air pollution. Based on the experience from countries at similar levels of development, the associated benefits derived from such a program are typically realized reasonably quickly. Such a program should include the following elements:

Table 12. Estimated Annual Cost of Indoor Air Pollution

	Estimated Annual Cost (S$S/. million soles)	
	Low	*High*
Acute Respiratory Illness (ARI):		
Children (under the age of 5 years)—increased mortality	220	311
Children (under the age of 5 years)—increased morbidity	200	302
Adult females—increased morbidity	84	130
Chronic obstructive pulmonary disease (COPD):		
Adult females—increased mortality	22	244
Adult females—increased morbidity	19	33
Total	**545**	**1014**

Source: Larsen and Strukova (2005).

POLICY RECOMMENDATIONS

- Promote a gas pricing policy that makes compressed natural gas (CNG) and liquefied petroleum gas (LPG) available and affordable options for the poor to use as substitutes for fuelwood.
- Provide housing subsidy programs for rural, low-income housing may include requirements for building codes and housing design to allow for improved ventilation, including design of chimneys.
- Implement subsidies targeted to poor families and people most affected by adverse health impacts of exposure to IAP, so they can afford technical mitigation options such as improved stoves.

TECHNICAL ASSISTANCE

- Complement technical interventions with promotion of awareness and dissemination of information on the links between IAP and poor health in order to promote long-term changes in behavior that help to mitigate exposure to IAP.
- Establish of a technical unit to certify improved stoves that are marketed in the country, for both fuel efficiency and reduced pollution. The Ministries of Energy, Health, and Housing could be active in this unit.

INVESTMENTS

- A benefit-cost analysis of alternative technical interventions to control indoor air pollution in rural households in Peru shows that the use of improved stoves is the most efficient option, followed by substitution of a cleaner fuel, Liquefied Petroleum Gas (LPG) for fuelwood (Table 13). Similarly, for community kitchens, switching to LPG from either improved stoves or unimproved stoves yields higher benefits than costs. The different interventions are ranked in

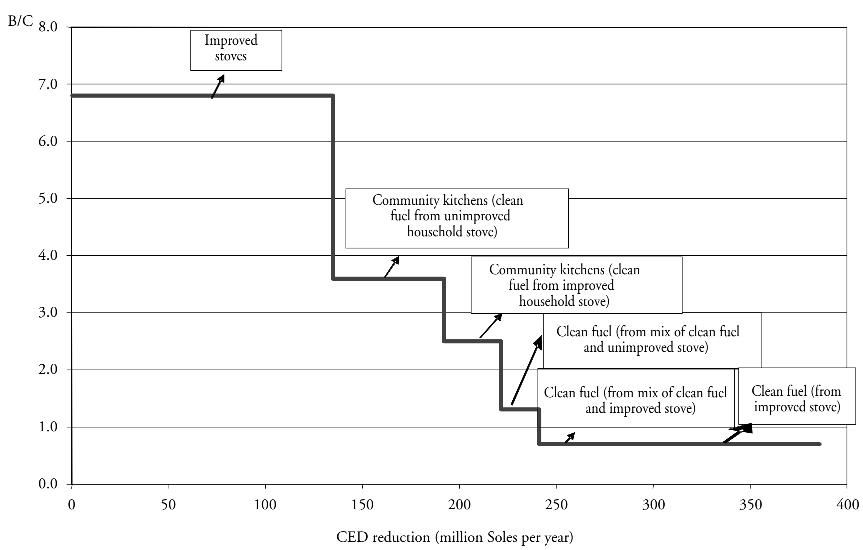
Table 13. Benefit-Cost Ratios of Interventions to Control Indoor Air Pollution in Rural Households and in Rural Community Kitchens

Intervention	*Benefit-cost ratio*
Rural households	
Unimproved to improved stove	6.8
Improved stove to LPG	0.7
Unimproved stove/LPG to LPG only	1.3
Improved stove/LPG to LPG only	0.7
Community kitchens	
Unimproved stove to LPG	3.6
Improved stove to LPG	2.5

Source: Larsen and Strukova (2005).
Note: Benefits include health and time savings benefits.

terms of their contributions toward reducing environmental damages and the ratio of benefits to costs (Figure 14). Household switching from unimproved to improved stove has the highest ratio of benefits to costs. This is followed by switching to community kitchens with LPG from unimproved or improved stoves in individual households, and household switching to LPG alone from a mix of unimproved stove and LPG.

Figure 14. Interventions to Control Indoor Air Pollution



Source: Larsen and Strukova (2005).
Note: B/C = Benefit-Cost ratio. CED = cost of environmental damage (i.e., cost of health effects). A change from unimproved stoves to LPG is not included in the graph. This would avoid double counting of reductions in health effects from indoor air pollution because switching from unimproved stoves is already reflected in the change to improved stoves.

III. Conclusions and Recommendations

Environmental problems associated with the highest costs of environmental degradation in Peru are waterborne diseases and ambient and indoor air pollution. Children under the age of five are the most vulnerable to the health consequences of environmental degradation. It is estimated that every year, there are over 8 million cases of diarrheal morbidity in children under the age of five. Almost 4,000 people die prematurely each year from illnesses associated with poor outdoor air quality. Also, about 1,000 children under the age of five die each year from respiratory illnesses caused by poor indoor air quality. In addition, while lead exposure in early childhood lowers the average IQ by 1 to 2 points, on an annual basis about 2,200 children suffer enough IQ loss to cause mild mental retardation. Due to these environmental risk factors, Peru annually loses an estimated 210,000 disability-adjusted life years, a massive loss for an economy whose human capital is limited. These environmental problems cost approximately S/. 5.85 billion or 2.8 percent of Peru's GDP. The poor and less powerful stakeholders in Peru bear a disproportionately high amount of this cost. In order to combat these problems, a number of cost-effective interventions are identified below which could be adopted in the short-, medium-, and long-term to reduce the cost of environmental degradation.

In Peru, the allocation of financial and human resources for addressing air pollution might be increased. Furthermore, there is an urgent need to update regulations, issue standards, and create economic instruments that minimize the concentration of fine particulate matter in the air. In order to achieve this, some of the most promising options, in order of decreasing benefit to cost ratio, include: (1) retrofitting of particle control technology; (2) an inspection and maintenance program; (3) reduction of emissions from industrial sources; (4) introduction of low-sulfur-content diesel fuel; and (5) promotion of compressed natural gas.

A hygiene program that includes a handwashing component has the greatest potential health benefits. With a 20 percent program effectiveness—i.e., if 20 percent of the targeted population practices handwashing and a household drinking water disinfection program—the estimated total avoided cases of diarrheal illness and diarrheal child mortality are 16 to 18 percent of baseline cases, respectively. Hygiene improvement and disinfection of drinking water at point-of-use have a substantial potential to reduce diarrheal illness and mortality. The challenge, however, is to develop and deliver programs that induce sustained behavioral response on a large scale, while maintaining program costs at an affordable level. Thus, it is recommended to design and implement a safe water program that includes components on handwashing and point-of-use disinfection of drinking water. Furthermore, the handwashing program should be restructured and oriented toward children in order to realize maximum health benefits.

With respect to indoor air pollution, there are no reliable time series data. Nonetheless, indoor air pollution and the health problems associated with it continue to pose challenges. With respect to indoor air pollution, possible options include the use of cleaner fuels, technical mitigation options such as improved cooking stoves, and policies that promote improved housing design.

INSTITUTIONAL ASPECTS

The results of the study of the costs of environmental degradation in Peru point to the need for Peru to address environmental health problems in a concerted manner through the establishment of institutions that focus on such problems, and the development of regulations to control the adverse health impacts of environmental degradation. In this context, it is recommended that:

- CONAM's responsibilities be broadened so it can set priorities jointly with the Ministry of Economy and Finance
- Capacity building commence in CONAM and the Ministry of Health for the design and implementation of policies to address environmental health problems
- As environmental health problems and their solutions are cross-sectoral by nature, inter-institutional coordination be strengthened between CONAM and the following institutions:
  - Ministry of Health and Ministry of Housing and Sanitation, on safe water programs
  - Ministry of Energy, Ministry of Housing and Sanitation, and Ministry of Health, on indoor air pollution control
  - Ministry of Economy and Finance and Ministry of Energy, on gas pricing

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Endnotes

1. The cost of mortality for adults is based on the value of statistical life (VSL) as a high bound and Human Capital Approach (HCA) as a low bound, and on HCA for children. The cost of morbidity includes the cost of illness (medication, treatment, value of lost time, etc.) and disability-adjusted life years (DALYs) from morbidity, valued at GDP per capita, to reflect the cost of reduced well-being associated with illness.

2. The health effects of air pollution can be converted to disability-adjusted life years (DALYs) to facilitate a comparison to health effects from other environmental risk factors.

3. The scenarios indicate the assumptions used by Larsen and Strukova (2005) in relation to mortality and morbidity levels among the poor and nonpoor. The base-case assumes that mortality and morbidity levels are identical among the poor and nonpoor. Mid- and High-case scenarios assume that mortality and morbidity levels progressively increase among the poor in comparison to the nonpoor.

4. The cost of health impacts of lead exposure provided in Table 6 are only for the urban population in cities with more than 100,000 inhabitants. Estimates are based on adjustments made to BLL measurements reported by Espinoza et al., (2003). Because there is great uncertainty about current blood lead levels in the urban population as a whole and the rural population, it is necessary to undertake new studies that examine BLL in children and adults in order to provide a more accurate estimate of health effects and their costs.

5. Hygiene refers to personal hygiene (such as handwashing), domestic hygiene, and food hygiene.

6. For diarrheal morbidity, however, it is very difficult, or practically impossible, to identify all cases of diarrhea. The main reason is that a substantial share of cases are not treated or do not require treatment at health facilities, and are therefore never recorded. A second reason is that cases treated by private doctors or clinics are often not reported to public health authorities. Household surveys therefore provide the most reliable indicator of total cases of diarrheal illness. Most household surveys, however, contain only information on diarrheal illness in children. Moreover, the surveys only reflect diarrheal prevalence at the time of the survey. As there is often high variation in diarrheal prevalence across seasons of the year, extrapolation to an annual average will result in either an over- or underestimate of total annual cases. Correcting this bias is often difficult without knowledge of seasonal variations.

7. This is a larger difference than the difference in child mortality and diarrheal prevalence. The main reasons for this are that the share of children in the poor population is much higher than in the nonpoor population, that diarrheal mortality is largely among children, and the diarrheal incidence rate is much higher in children than in adults.

8. The cost of mortality for adults is based on the value of statistical life (VSL) as a high bound and Human Capital Approach (HCA) as a low bound, and on HCA for children. The cost of morbidity includes the cost of illness (medication, treatment, value of lost time, etc.) and DALYs from morbidity, valued at GDP per capita, to reflect the cost of reduced wellbeing associated with illness.