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Quantification of Health Impact of Air Pollution in a Developing Country

Salpie S. Djoundourian[1], Iman A. Nuwayhid[2] and Farid B. Chaaban[3]

[1]*School of Business, Lebanese American University,*
P.O. Box 36, Byblos, Lebanon
E-mail: sdjndran@lau.edu.lb
[2]*Faculty of Health Sciences, American University of Beirut,*
Beirut, Lebanon E-mail: nuwayhid@aub.edu.lb
[3]*Faculty of Engineering and Architecture, American University of Beirut,*
Beirut, Lebanon E-mail: fbchaaban@aub.edu.lb

Abstract

In spite of the recognition of air pollution as a priority environmental problem in developing countries, policy actions are blocked on the basis of limited financial resources. This study represents a rare multidisciplinary attempt to quantify the impact of air pollution on health in Lebanon, a country at a crossroad between less developed and the developing world. The work presented here is part of a regional study on 13 Mediterranean countries, sponsored by the MedPolicies Initiative of the Mediterranean Environmental Technical Assistance Program (METAP III). The objective of the METAP III Initiative is the promotion of sustainable economic growth through the integration of environmental concerns in economic decision making. The multidisciplinary study proceeded along several parallel lines. First, the magnitude of air pollution in Beirut was estimated using actual measurements and modeling. Second, the scientific literature pertaining to the relationship between air pollutants and health was reviewed to identify dose-response relationships. Third, using a combination of primary and secondary data, mortality and morbidity were estimated. The findings indicate that for every 10 $\mu g/m^3$ increase in the concentration of particulates in Beirut, there is an excess of 80 premature deaths, 3000 hospital admissions, and 2800 emergency room visits. This translates into more than US $ 10 million spent annually for statistical lives lost, cost of medical care, and days of restricted activity. With an estimated average concentration of 200 $\mu g/m^3$ of particulates in Beirut, the social and economic impacts become truly significant. Since automobiles represent the major source of urban air pollution in Lebanon, the policy recommendations include modernizing the car fleet which is predominantly old, imposing strict technical check-ups on vehicles, and adopting an aggressive transport management program as measures that will help reduce air pollution and consequently help reduce its adverse health effects.

Keywords: mortality, morbidity, social cost, health effects, particulates, Lebanon.

Introduction

Pollution imposes a wide range of direct and indirect adverse effects on economic activity. Numerous studies confirm the existence of a close association between health, as measured by mortality and morbidity rates, and air pollution ([1], [2]). Health problems associated with exposure to pollutants often necessitate expenditures on health care, absence from work, and, in extreme cases, cause permanent disability or death. Approximately four percent of the death rate in the United States can be attributed to air pollution [3]. Pollutants can also have damaging effects on materials and vegetation through influencing deterioration rates of materials and agricultural productivity of land. Finally, pollutants impose aesthetic damages ranging from reduced atmospheric visibility to reduced property values. Improvements in environmental quality mean reducing the magnitude of these adverse effects. However, in spite of the growing concern over environmental quality, the scarcity of resources competing for different social programs, particularly in developing countries, is a major hindrance for action. The possible welfare implications of reduced environmental amenities need to be weighted against the cost of prevention or intervention.

While the developing world suffers from the same or similar adverse effects as that of the developed world, the literature pertaining to estimation of such effects is limited to the latter for variety of reasons. This study investigates the impact of air pollution on health in Beirut, Lebanon and estimates, through a multidisciplinary effort, the physical and economic costs from pollution triggered illnesses. It represents one of the rare attempts at such quantification (see [4],[5]).

The following section presents the materials and methods used in the study. Section 3 presents the findings of the study in four subsections: Section 3a presents the estimated levels of air pollutants in the city, Section 3b presents a brief review of the literature on the impact of air pollution on mortality and morbidity. Section 3c presents the estimated excess mortality and morbidity due to air pollution and Section 3d presents the estimated cost of air pollution. Section 4 discusses the findings and Section 5 concludes the study with recommendation for policy makers.

Materials and Methods

The absence of data on air pollution and on morbidity and mortality in Lebanon preclude the ability to investigate trends. Instead, this study estimates the annual cost associated with the health impact of a unit increase in one of the pollutants in the city of Beirut. Beirut is chosen because it is the most populated city in the country with the largest number of vehicles, the main source of outdoor air pollution, and the potential to provide better estimates on pollution and health outcomes.

The multidisciplinary study proceeded along several parallel lines. The following activities were performed:

First, the magnitude of air pollution in Beirut was estimated using actual measurements and modeling. The concentration of particulate matter (PM10) was measured in Bliss Street, a medium-traffic one-way street. The choice was constrained by the location of air pollution monitoring station. Measurements were done over 24 hour intervals in different periods of the year. Ozone levels were measured using simple badges in different areas of the city. Line and area source modeling was also conducted to estimate the level of other air effluents such as carbon monoxide and lead. Available data on car fleet size, traffic density, average vehicle speed, and wind speed were used in the models [4].

Second, the scientific literature pertaining to the relationship between air pollutants and health was reviewed to identify dose-response relationships. The review was limited to the more recent literature and articles that presented an estimate of excess morbidity and mortality with the increase of fixed units of air effluents.

Third, it was decided to use particulate matter as a benchmark for air pollution. The association between exposure to particulate matter and mortality and hospital admissions was consistently shown in research studies and more strikingly than other air effluents. Hence, the excess number of deaths, hospital admissions, especially for cardiovascular and respiratory diseases, and emergency room cases were estimated for every increase of 10 μg/m^3 in the concentration of particulates. Data on mortality was estimated using several national and Beirut household studies. Overall hospital admissions, hospital admissions for cardiovascular and respiratory diseases, and emergency visits in Greater Beirut Area (GBA) were also estimated using Ministry of Public Health (MOPH) data, contacts with major hospitals, and previous studies.

Fourth, the economic cost associated with excess morbidity and mortality was estimated. In this study, cost included direct costs for hospitalization and emergency care treatment, cost of absenteeism from work, and cost of premature death from diseases that are provoked or caused by air pollution.

A serious attempt was made to present ranges rather than absolute numbers whenever applicable and to err, where possible, on the more conservative side.

Findings

Magnitude of Air Pollution in Beirut

The concentration of all air pollutants, whether measured or estimated, was found to exceed by far the National Ambient Air Quality Standards (NAAQS) and the World Health Organization (WHO) limits (Table I). In Bliss Street, the annual average reading of PM10 stood at 100 μg/m^3. With an average traffic volume twice that of Bliss Street, the average concentration of particulates in the city was estimated at 200 μg/m^3. While this represents a conservative estimate for some experts, it is 150 μg/m^3 higher than the NAAQS. Similarly, the ozone concentration was estimated to fall in the range 250 to 600 μg/m^3 with a direct correlation with traffic congestion. The concentrations of carbon monoxide and lead in Beirut were also much higher than the NAAQS and WHO limits.

Table 1: Average concentration of selected air pollutants in Beirut compared to other standards.

Pollutant	Beirut	NAAQS limits[1]	WHO limits[2]
Carbon Monoxide (mg/m^3) (8 hours)	16	10	10
Particulates (μg/m^3) (annual)	200[3]	60	40-60
Lead (μg/m^3)	3-5	1.5 (3 months)	0.5 (1 year)
Ozone (μg/m^3) (1 hour)	350-500	240	150-200

[1]National Ambient Air Quality Standards
[2]World Health Organization
[3]The concentration was 100 μg/m^3 in Bliss street

Impact of Air Pollution on Mortality and Morbidity: Literature Review

The American Thoracic Society (ATS) defines adverse respiratory health effects as "medically significant physiological or pathological changes generally evidenced by one or more of the following: 1) interference with the normal activity of the affected person or persons, 2) episodic respiratory illness, 3) incapacitating illness, 4) permanent respiratory injury, and/or 5) progressive respiratory dysfunction". ([6, p. 666]).

The scientific literature pertaining to the relationship between air pollutants and health was reviewed to identify dose-response relationships. Our review of the literature limited itself to the more severe outcomes: mortality, hospital admissions, admissions for respiratory and cardiovascular diseases, and emergency room visits. Tables II and III summarize the main effects of the different air pollutants on mortality and morbidity as reported by the referenced epidemiological studies. The differences reported among these studies reflect differences in methodologies, measurements of air pollutants, measurements of health outcomes, and quality of data collected or analyzed.

Table 2: Impact of selected air pollutants on mortality.

Air pollutant	Change in mortality	Reference
Particulates (PM_{10})		
High (147 ug/m^3) vs. low (47 ug/m^3)	Increase of 8%	[7]
Increase of 100 ug/m^3	Increase of 26% (8-47%)	[8]
Increase of 10 ug/m^3	Increase of 0.96% (0.31-1.49%)	[9]
Region 1 (29.6 ug/m^3) vs. Region 2 (11 ug/m^3)	Increase of 11%	[10]
Increase of 1ug/m^3 (fine)	Increase of 8 deaths per year per 100,000 persons	[11]
Particulates (Total Suspended Particles)		
Increase of 100 ug/m^3 (meta-analysis)	Increase of 6% (5-7%)	[12]
Increase of 100 ug/m^3	Increase of 5.8% (3.3-8.3%)	[13]
Increase of 34.5 ug/m^3	Increase of 1.04% (-0.03-2.1%)	[14]
Ozone [1ppb = 2 ug/m^3]		
Increase of 100 ppb	Increase of 2.4%	[13]
Increase of 20.2 ppb	Increase of 1.95% (0.71-3.17%)	[14]
Sulfur dioxide [1ppb = 2.66 ug/m^3]		
Increase of 12.9 ppb	Increase of 1.08% (0.14-2.02%)	[14]

In adopting these findings to the situation in Beirut, several assumptions were implicitly employed. Chief among the assumptions is the no-threshold semi-linear dose-response relationship governing the relationship between air pollution and health outcome. It was also assumed that the Lebanese population does not differ from the populations studied in different regions in the world; i.e., no difference in susceptibility or exposure to other interfering factors. Finally it is assumed that the health care practice in Lebanon is similar to that of other populations. Table IV presents the lower, average, and upper limits for the concentration-response associations. These associations are used throughout the paper to represent the best, average, and worst case scenarios.

Excess Mortality and Morbidity due to Air Pollution

Mortality: The estimated crude mortality rate in Lebanon stands at 8.2 deaths per thousand individuals per year. This is extracted from different household surveys conducted in Beirut or nationally ([28], [29], [30]). Assuming that the Lebanese population totals about 3.5 million individuals of whom 1 million are living in Greater Beirut, then the estimated number of deaths per year is 28,700 persons in all of Lebanon and 8,200 persons in Beirut.

Assuming that an increase of 10 μg/m^3 in particulates is associated with an average increase of 1% in mortality rate, then the excess annual deaths due to 10 μg/m^3 increase in particulates in Beirut is estimated at approximately 80 individuals (Table IV). The extreme case scenarios present a lower and upper limit of 25 and 440 deaths, respectively.

Table 3: Impact of selected air pollutants on morbidity.

Air pollutant	Change in health outcome	Reference
Particulates (PM_{10})		
Increase of 100 ug/m^3	Increase of 17% (2-33%) in admissions (pneumonia)	[15]
	Increase of 57% (20-106%) in admissions (COPD*)	
Increase of 50 ug/m^3	Increase of 6% (0-13%) in hospital admissions (region 1)	[16]
	Increase of 10% (3-17%) in hospital admissions (region 2)	
Increase of 12 ug/m^3	Increase of 2.5% in overall admissions	[17]
Increase of 10ug/m^3	Increase of 1.2% (0.4-1.9%) in admissions (pneumonia)	[18]
	Increase of 2.0% (0.4-3.2%) in admissions (COPD*)	
Increase of 10ug/m^3	Increase of 3.7% (1.2-6.4%) in emergency cases (asthma)	[19]
Increase of ≥ 150 ug/m^3 vs. < 150 ug/m^3	Admissions of children tripled	[20]
	Admissions of adults increase by 44%	
Increase of ≥ 50 ug/m^3 vs. < 50 ug/m^3	Admissions of children doubled	[20]
	Admissions of adults increase by 46%	
High (33 ug/m^3) vs. low (10 ug/m^3)	Report of cough and bronchitis doubled	[21]
Particulates (Black smoke)		
Increase of 50 ug/m^3	Increase of 3% in admissions among >14 years (asthma)	[22]
	Increase of 4.6% in admissions among <14 years (asthma)	
Increase of 25 ug/m^3	Increase of 6% in emergency cases in the winter (asthma)	[23]
Particulates (Total suspended particles)		
Increase from 10 to 70 ug/m^3	Increase of 27% (8-47%) in cases of croup	[24]
Ozone [1ppb = 2 ug/m^3		
Increase of 50 ppb	Increase of 4.5% in admissions (respiratory)	[25]
Increase of 50 ppb	Increase of 15% (0-36%) in admissions (pneumonia)	[15]
Increase of 36 ppb	Increase of 21% (8-34%) in daily emergency visits	[26]
Increase of 30 ppb	Increase of 2.8-5% in admissions in 3 seasons (respiratory)	[27]
Increase of 50 ug/m^3	Increase of 6-10% in hospital admissions	[16]
Increase of 50 ug/m^3	Increase of 3.5% in admissions (asthma)	[22]
Increase of 5 ppb	Increase of 2.6% (1.3-4%) in admissions (pneumonia)	[18]
	Increase of 2.8% (0.7-4.9%) in admissions (COPD*)	
Nitrogen dioxide [1 ppb =1.91 ug/m^3		
Increase of 50 ug/m^3	Increase of 28% in cases of croup	[22]
Increase from 10 to 60 ug/m^3	Increase of 3.8% (0.8-6.8%) in admissions (asthma)	[24]
Sulfur dioxide [1ppb = 2.66 ug/m^3]		
Increase of 50 ug/m^3	Increase of 6-10% in hospital admissions	[16]
Increase of 50 ug/m^3	Increase of 7.5% in children admissions (asthma)	[22]
Increase of 25 ug/m^3	Increase of 6-9% in emergency cases (COPD*)	[23]

* COPD- Chronic Obstructive Pulmonary Disease

Table 4: Estimated increase in selected health indices for every 10 ug/m^3 increase in particulates*

Health index (outcome)	Estimated increase	Lower-upper limits
Mortality	1%	0.3-5.5%
Admissions to hospitals	2%	1.2-4.4%
Admissions to hospitals for cardiovascular and respiratory diseases	2%	0.6-10.6%
Emergency room visits	2%	1.2-6.4%

* Based on Tables II and III.

Morbidity: The MOPH estimates a total of 455,000 hospital admissions in Lebanon per year in the private and public sectors. Breakdown by age, sex, or diagnosis is not available since hospitals in Lebanon are not required to report detailed discharge summaries. It is estimated that about one third of these cases, 150,000 cases, are admitted to hospitals located in Beirut.

The proportion of patients admitted to hospitals for respiratory and cardiovascular diseases is estimated based on a sample of 28,485 admissions to two major hospitals in Beirut. The proportion of respiratory (ICD-9: 490-496, 480-486, 464-466) and cardiovascular admissions (ICD-9: 410-417) in Beirut is estimated at approximately 15% (n = 4,293) of total hospital admissions. The ratio of respiratory to cardiovascular diseases is 1:2. Applying this proportion to the total number of admissions to all hospitals in Beirut, the number of admissions for the diseases most affected by air pollutants is estimated at 20,000.

The total number of emergency room visits per day is extracted from a study where all active emergency services in Beirut were visited in 1992 [31]. Emergency room logbooks were manually reviewed and/or hospital directors and emergency room supervisors were interviewed to estimate the average number of emergency visits. The number of emergency room visits was estimated at 140,000 to 150,000 cases per year. No breakdown by age, sex, or diagnosis is available.

Excess morbidity refers to the increase in total hospital admissions, admissions for cardiovascular and respiratory conditions, and emergency room visits due to increased contamination in the air. An average increase of 2% in all three indices for an increase of 10 μg/m^3 in particulates was extracted from the literature (Table IV). This translates into an annual increase in total hospital admissions of 3,000 patients (lower-upper limits: 1800-6600), with 400 being admissions for respiratory and cardiovascular ailments (lower-upper limits: 120-2120). In addition, the annual increase in emergency room visits is estimated at 2,800 cases (lower-upper limits: 1680-8960).

Economic Cost of Air Pollution in Beirut

Health impacts could be expressed in monetary (dollar value) terms for statistical lives lost to premature death, hospital admissions, chronic disease cases, emergency room admissions, and days of restricted activity due to hospitalization for various diseases.

Estimated Mortality Costs

Human life value is based on the concept of the “Value of a Statistical Life” (VOSL). VOSL is usually used to value the monetary benefits of reducing mortality risks. It is dependent to a large extent on the income and wage levels in a given country. Studies that used VOSL have been mostly conducted in the United States where the lowest possible value of life was estimated at $600,000 per person [32].

Adjusting for the income differentials between Lebanon and the United States (per capita GNP in 1996 are $2,660 and $26,980, respectively) as reported by the World Development Report 1997 [33], the result would be a very conservative Lebanese VOSL of $59,155 per person. This value is assumed as an estimate of the average mortality cost for all individuals regardless of income, age, sex, education, and/or occupation. It is, however, worth noting that a VOSL of $59,000 is higher than the amount a judge would usually offer to families as a compensation for victims of accidents in Lebanon ($20,000 - $50,000). Consequently, with a VOSL of $59,000, the cost of 80 excess deaths due to air pollution in Beirut is estimated at $ 4.7 million.

Estimated Direct Morbidity Costs

In principle, the direct costs for morbid conditions include expenditures for prevention, detection, treatment, rehabilitation, research, and capital investment in medical facilities. In this study, only hospitalized patients and those presenting to emergency care are considered.

Cost of Hospitalization

To obtain an estimate of overall hospitalization cost, approximately 49,000 hospital admission claims, administered by the largest third party administrator in Lebanon, were reviewed. The average daily cost of hospitalization for all diseases is estimated at US $495.29 (SD 3.81) while the average duration of hospitalization is estimated at 3.32 days (SD 0.0376). Hence, the average cost of hospitalization is estimated at approximately $1,644 per admission. The average duration of hospitalization for respiratory and cardiovascular admissions ranged between 4.5 and 10 days at an average daily cost of $ 198 to $ 461. Hence, the total cost of hospital stay ranged from $892 to $2680.

Based on this, the total cost of hospitalization was estimated at $4 million (lower, upper limits: $2.7 - 7.4 million) for all admissions excluding cardiac and respiratory admissions. The latter cases cost approximately $1 million (lower, upper limits: $280,000 - $5 million).

Cost of Emergency Room Visits

The average cost of an emergency room visit is estimated at US $76.04 based on a sample of 33,600 visits for the period January 1, 1996 to July 31, 1998. The total cost of 2800 (range 1680-8960) emergency room visits associated with air pollution is hence estimated at $213,000 (lower, upper limits: $128,000 - $681,000).

Value of Restricted Activity Days

The average duration of hospitalization, used in this study, represents a conservative estimate of the average restricted activity days (RADs) associated with a medical condition. This estimate excludes days of disability, bed rest at home, and other imputed costs such as opportunities foregone.

The total number of hospitalization days was estimated at 14,000 (range 8,000 - 38,000 days) for all hospital admissions. With no available breakdown by age, sex and profession, the study assumes that the value of a RAD is equivalent to the daily wage of the average income earner estimated at approximately US $34.00 assuming 22 working days per month. The total value of RADs associated with air pollution is consequently estimated at $480,000 (range $275,000 - $1,300,000).

Total Cost of Air Pollution

Table V summarizes the number of deaths and morbid conditions associated with an increase of $10\mu g/m^3$ concentration of particulates and their estimated cost. The total cost of an increase of 10μg/m3 in particulates is estimated at US $11 million (range $5 - 40 million). Of these, pure medical cost is approximately $5.4 million.

Table V: Estimated number and cost of excess mortality and morbidity associated with an increase of 10μg/m^3 in particulates.

Health Index	Excess Cases (Lower-Upper Limits)	Cost Per Case ($)	Total Cost ($) (Lower-Upper Limits)
Mortality	80 (25-440)	59000	4,700,000 (1,500,000-26,000,000)
Admissions to hospitals			
Total	2,600 (1,680-4,480)	495	4,275,000 (2,760,000-7,400,000)
Respiratory diseases	147 (44-778)	1,901	279,000 (84,000-1,480,000)
Cardiovascular diseases	253 (76-1,342)	2,673	676,000 (203,000-3,590,000)
Emergency Room visits	2,800 (1,680-8,960)	76	213,000 (128,000-681,000)
Restricted days of activity	14,160 (8,076-38,279)	34	480,000 (275,000-1,300,000)
Total	-	-	10,600,000 (4,900,000-40,400,000)

Discussion

Our study confirms what is already known that the level of air pollution in the city of Beirut is way above the international standards. What this study adds is an attempt to put a dollar value on this fact. We estimated an excess of 80 deaths, 3000 hospital admissions, 2800 emergency room visits, and 14000 restricted days of activity. If the average increase of health indices for every 10 μg/m^3 increase in the concentration of particulates is applied, then we estimate that more than 10 million US dollars are spent annually for the health impact of air pollution in Beirut. The lower and upper limits of our estimate ranged between 5 and 40 million US dollars. In other words, if the level of particulates is reduced by around 100-120 μg/m3 to reach the international standard, then the estimated annual savings will exceed US $100 million.

At this point, a valid question to ask is: *how accurate is this estimate?* The study was based on several assumptions that could be challenged; chief among them is the base value of the particulate level used to build the exercise upon. Using the sampling results from one location is an obvious limitation. This was unavoidable since continuous air monitoring from multiple stations in Beirut is lacking. However, the data obtained from this location took into consideration various climatic and traffic conditions (day and night, dry and rainy days, weekdays and week ends,…). Currently efforts are being made to establish a national monitoring network to measure air quality in various regions of the country. Such data, when available, will provide a better picture of the air quality in Lebanon and could be linked with concurrent admissions to hospitals to estimate the contribution of air pollution to hospital admissions.

The assumption of linearity of association between the concentration of particulates and health outcomes could also be challenged when the level of particulates is very low, i.e., below a certain threshold. However, in a country where the concentration of particulates is significantly above the threshold, the assumption should be more robust. Nevertheless, the expected increase in mortality and morbidity for every unit of increase in particulates could have been overestimated. To accommodate for this, we presented a best and worst case scenarios. Even the best case scenario was associated with a minimum cost of $5 million annually. In addition, we assumed that the relationship between pollution concentration and health outcomes documented in the literature applies to Beirut. This is a major shortcoming in the absence of data on other contributory factors such as smoking, eating, and exercising habits of the Lebanese, as well as, the preventive measures taken to avoid exposure to pollutants. The use of data from developed countries in developing countries has been challenged due to the differences in health care system, economic development, level of air pollution, and the presence of other health problems [34]. We elected to err on the conservative side by using the lower estimate of change in morbidity and mortality due to air pollution. Studies from cities in Latin America where air quality is much worse than North America have shown much higher estimates in all age groups [35].

On the other hand, we could have underestimated the overall cost by limiting medical expenses to emergency care and hospitalization. Bates argues that when increased mortality to air pollution is reported, it means that other health indices such as hospital admissions, emergency visits, and physician visits have also increased [36]. Outpatient treatment, rehabilitation, cost of medications, and cases that did not present to emergency care or hospitals have not been considered.

Limiting restricted days of activity to days of hospitalization could have also underestimated expenses. One could argue, however, that by assuming all cases to be economically active, regardless of age and gender, we could have overestimated cost. This would be true if one's productivity is measured by one's wage rate. However, if the patient is unemployed, such as a housewife, there is still an economic loss associated with hospitalization. The value of the services of a housewife can be approximated to the wage of a domestic help. If a child is hospitalized, then school days are lost and time is taken off by an adult to keep company of the child. The same is true for an elderly.

Another point worth discussing is the value of a human life. One of the more controversial techniques in estimating mortality costs involves equating the value of human life to current monetary value of future productivity lost due to premature mortality. The estimated cost to the society is the product of the number of deaths and the discounted value of an individual's lifetime productivity, with age and sex taken into account. Such an approach is criticized on the grounds that it fails to value people who choose not to join the labor market or retired people and does not account for the value of non-market leisure activities including personal feelings. We adopted the concept of the "Value of a Statistical Life" (VOSL) which is a less controversial approach to valuing human life. VOSL is usually used to value the monetary benefits of reducing mortality risks. When assessing the benefits of risk reduction using VOSL, what matters is the risk bearing individual's own willingness to pay for a reduction in the probability of death. For public choices, what matters is the society's overall willingness to pay for the risk reduction. Hence, VOSL estimates are usually much higher than an individual's lifetime earnings. In this study, we valued a human life at a VOSL of less than $60,000. In as much as it is difficult to put a dollar value to human life, we believe that our estimate is a conservative one.

In conclusion, all things considered and in the absence of actual detailed data, our estimates can be thought of as "best" rough estimates available.

Conclusion and Policy Recommendations

Lebanon has survived an enduring 15 years of civil war that destroyed its physical infrastructure, killed more than a 100,000 souls, and displaced hundreds of thousands. For the last decade, the country has been actively involved in reconstruction effort, not without political opposition and criticism of priorities. Decision making and priority setting is exceptionally difficult in a country with multitude social and economical problems, limited resources, and above all limited data and information. Our study is an attempt in the right direction. The capital Beirut is overpopulated with people and vehicles. The city is plagued with a high level of air pollution. This might be costing us more than 100 million US dollars a year. In a country with limited financial resources, action should not be delayed. Taking proper measures will save lives and reduce overall medical and economic bill. In case of Beirut where transportation is the primary source of air pollution, the best recommendation would be to modernize the car fleet, impose strict technical check-ups on vehicles and adopt an aggressive transport management program. The age distribution of the vehicle fleet in Lebanon is skewed to the right indicating that a large number of old and improperly maintained cars are in circulation [4]. An old fleet of cars coupled with improper maintenance leads to low fuel combustion efficiencies and consequently higher emissions from the exhaust. Modernizing the fleet of cars would imply replacing the old inefficient cars with new and efficient ones. A properly administered inspection and maintenance (IM) program to upgrade the technical status of the fleet would gradually reduce the magnitude of pollution in the city. An IM program is already adopted and is being gradually implemented to avoid social conflict that may arise from sudden banning of high number of vehicles from driving. Currently only six major items (including CO and PM10 emissions) are considered decisive for the vehicle to pass the test. These inspected items will gradually increase in coming years. A mass transport scheme could also lead to an increase in the average speed inside the city which would lead to an increase in fuel efficiency and reduction in emissions [37]. Obviously these measures are costly and impose a burden on the society in the short run; however, they might prove to be money saving in the long run.

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