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The effects of pharmaceutical consumption on health and economic development

Peters, Jonathan Richard, Ph.D.

City University of New York, 1992

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THE EFFECTS OF PHARMACEUTICAL CONSUMPTION ON HEALTH AND ECONOMIC DEVELOPMENT

by

JONATHAN PETERS

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy,

The City University of New York

1992

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ABSTRACT

THE EFFECTS OF PHARMACEUTICAL CONSUMPTION

ON HEALTH AND ECONOMIC DEVELOPMENT

by

Jonathan Peters

Adviser: Distinguished Professor Michael Grossman

This paper estimates the effects of pharmaceutical consumption, measured at the country level of aggregation, on health. We study the effect of a number of other inputs into health such as the number of physicians and auxiliary health workers per capita, nutrition, the population served by rural water supply, the economically active population that works in agriculture and a measure of income. We use a number of different measures of health status: infant mortality, life expectancy at various ages and child mortality. Using a double log model of health production, we find that our model explains the majority of the variation that is observed in our health variables. We also find that pharmaceutical consumption exhibits consistent and significant effects on the majority of our measures of health status.

We also studied the observable differences in the effects of gross pharmaceutical consumption on life expectancy for males and female in the OECD. We observe that

increased consumption had significant positive effects earlier in the life cycle for females, and these effects were more pronounced than was observable in males. These results indicate that the kinds of pharmaceuticals consumed may be very important. It also may indicate that the observable effects we see in both infant mortality and life expectancy at birth may be related to women's health.

We also observe no systematic relationship between pharmaceutical consumption and child mortality. We therefore conclude that the most significant effects of pharmaceuticals seem to be linked to consumption by women.

We have explored a relationship that has been ignored in previous health production functions. Given that our results clearly show that pharmaceutical consumption has a positive effect on a number of measures of health status, we question the omission of it from future health production functions studies. We have also shown that pharmaceutical consumption improves a number of measures of health. Therefore there is some indication that less developed countries are not consuming adequate amounts of pharmaceuticals.

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My colleagues have provided me with a great deal of encouragement and support during graduate school. Robin Carey, Samuel Schwarz, and Phil Sigler of The College of Staten Island continuously were there to help me during difficult times, and encouraged me to pursue my doctorate. Robin Carey also gave me my first opportunity to teach. This helped reinforce the correctness of my decision to pursue my doctorate.

I would also like to thank all the members of my family that provided both economic and moral support during this period. My parents, in particular, were extremely supportive of my work and were confident enough in my ability to encourage my journey on a very risky path. They also instilled in me the love of knowledge and the intense curiosity that made this work possible. I hope this work in some way compensates them for all of the questions I asked while I was growing up. Hopefully my father will agree with the results of my research in the following area, however, I would not bet on it.

Finally I would like to thank my wife Nancy, whose constant inspiration and encouragement made this work a reality. She has been extremely patient during the lost weekends and late nights, and never complained of the sacrifices needed to complete this work. She also is a testament to faith, as she married me during this very long process. I am very lucky to have a person of her intellect and compassion share my life.

For Nancy

For Joan and Allen, My Parents

Faith and devotion have their rewards

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I. INTRODUCTION

Since ancient times the use of magical potions by shamans and medicine men has been a part of the human experience. The desire to use potions and herbal tonics to provide for better health and or increased well being is a very ancient tradition. That tradition remains with us today. We still seek the medicine men to cure our ills, and they still provide us with magical potions to treat our ills. This paper seeks to explore the effects of potions in our modern world; pharmaceuticals.[1] For the most part, the actual potions have changed, but the rituals and ingrained human needs remain the same.

The effects of chronic poor health have many ramifications in developing countries. Poor health affects the quality of life, life span, labor productivity and economic growth. We are interested in the use of imported goods in health care. We have focused on pharmaceuticals for our first inquiry. We are interested to see if differentials in the consumption of pharmaceuticals have any measurable effects on mortality, life span and economic development.

The number of diseases that are treatable by drug therapy has risen dramatically in the past sixty years. Smallpox, malaria, yellow fever, cholera, plague, typhoid-

[1] How large a departure pharmaceuticals are from the original magic potions is a subject for debate. However it is noted by The World Health Organization (WHO) that 30 percent of the medicaments on the WHO essential drug list are derived from medicinal plants. See United Nations Industrial Development Organization (UNIDO) Global Study of the Pharmaceutical Industry, Unpublished UNIDO document, ID/WG.331/6, 1980, p 93.

paratyphoid fever, rabies, typhus, polio, tetanus, diphtheria, measles, and mumps are all examples of diseases that have been or can be effectively controlled or eradicated by drug or inoculation therapy.[2] However, these types of therapy and control are not universally the case. As pointed out by The United Nations Industrial Development Organization (UNIDO) "millions of people continue to suffer from symptoms which can be alleviated, die from diseases which can be treated and develop diseases which can be prevented entirely".[3] In 1980 more than 800 million people, of a world population of 4800 million, lived in abject poverty.[4] This fact creates a very difficult situation for many developing countries, namely, where to spend their limited national budget, and how much of that to spend on health. Pharmaceuticals are not an insignificant budget item for most developing countries. As stated by UNIDO, "In general, developed countries spend 5-8 per cent of GNP on health care, out of which the expenditure on pharmaceuticals accounts for 10-20 per cent. In contrast, the expenditure on health care in many developing countries is below 2 per cent of the GNP which up to 50 per cent represents expenditure on pharmaceuticals."[5]

We feel that our study of pharmaceuticals is overdue. To quote from The World Health Organization (WHO), "A vital question that has not received an answer is whether

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[2] UNIDO (1980) p 12.

[3] UNIDO (1980) p 8.

[4] UNIDO (1980) p 9.

[5] UNIDO (1980) p 9.

the proliferation of drugs is on the balance helpful or harmful, or even justified in terms of opportunity costs for poor families or poor countries. The question is almost irrelevant for the vast majority of the people living in developing countries, particularly in the rural areas; for them access to the 20 or 30 drugs essential to their health needs can make the difference between life and death, or at least between a life plagued by disease and a life that is socially and economically productive."[6] This study answers part of the question posed by The World Health Organization.

A secondary question is do poor countries have a productive labor surplus, or is there indeed a shortage of available, productive labor for domestic production. This question is very important in the evaluation of the health as an input into economic development. If countries do not have a shortage of available, productive labor, then the value of improving health may be zero in terms of economic development. The sign of health with respect to output may be ambiguous. As Malenbaum points out, increases in health may lead to larger population, greater poverty and as a subsequent result, a deterioration of health in the future.[7] Malenbaum also calls attention to the possibility that investment in health may improve labor productivity.

The basic needs approach to economic development promotes the idea that a country must satisfy the health, education, and nutritional needs of the population to spur

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[6] The Rational Use of Drugs: Report of the Conference of Experts, Nairobi, 25-29 November 1987. Geneva, World Health Organization (WHO) p 203.

[7] Malenbaum (1970) p 32.

economic growth.[8] If one follows the basic needs approach, then one is compelled to place higher social value on the development of the health care system. If we can alter the pattern of disease for a significant period of time, then the level of economic development should improve.

We hope that the empirical results from our analysis may help the developed world formulate aid policy for the less developed countries. Since a large percentage of pharmaceuticals are imported, this may introduce a foreign exchange constraint or a foreign aid constraint to investments in health for developing countries. If pharmaceuticals are valuable in increasing economic growth, then direct aid in pharmaceuticals for developing countries may be warranted.

The production of pharmaceuticals in developing countries has received a limited amount of research. The World Health Organization (WHO) has become a leader in the drive to increase domestic production, and also to promote the rational use of drugs. WHO introduced its blueprint for this in 1977, when it produced its essential drug list. This is a list of drugs which focuses on drugs that have proven curative power, are low cost, are without severe side effects, and are needed for basic health care. The WHO also established in 1981 The Action Program on Essential Drugs. The policy set forth in the Essential Drugs Program is that domestic production of basic pharmaceuticals should be encouraged and that replacement of foreign supplies by domestic producers is a designed

[8] For a good introduction to the basic needs approach, see Sheehan and Hopkins (1979).

aim of The World Health Organization. Nevertheless, we feel that the domestic production of all pharmaceuticals in developing countries may introduce some of the problems associated with import substitution, including low quality, improper production, ineffective drugs and high cost of domestic substitutes. These are interesting issues. However, they are not very persuasive arguments, even though they are used quite extensively by the multinational pharmaceutical manufacturers.

The majority of drugs on The WHO essential drug list are very low technology or old process drugs. They are drugs such as penicillin, ampicillin, etc. that are long out of patent and have proven their effectiveness in long clinical use.

We have no doubt that the supply of imported pharmaceuticals to developing countries includes a significant amount of drugs that are not necessary to produce higher levels of health in these societies.[9] This is in contrast to goods that are produced locally, which tend to include more basic drugs and herbal remedies. These drugs, coupled with high tech drugs produced without license in developing countries, are probably more effective in producing health than the imported drugs that may improve comfort for patients, or may help a small segment of the wealthy class in these countries. This is not always the case. Greenhalgh in her study reports domestic firms promoting most of the unsafe drugs.[10]

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[9] See Muller (1982) for examples of improper promotion of unsafe products. Muller cites the example of steroids being promoted for the 'treatment of malnutrition and fatigue or to stimulate appetite'.

[10] Greenhalgh (1987), p 316.

Domestic production may lead to more availability of drugs, but do these new allocations increase the health stock of the country, or do they draw tight another constraint, such as nutrition, health workers, or a safe water supply?

Clearly there is a need to expand the supply of pharmaceuticals in certain areas if we are to limit the number of cases of diseases. For an example of this, let's look at malaria. The World Health Organization said "strategies required to reduce suffering from disease include improvement in availability of health facilities for early diagnosis and prompt treatment of malaria with easy access to effective chemotherapy".[11] However important pharmaceuticals and health care services are to disease control, vector control measures are also important to reduce transmission. Malaria transmission can also be effectively controlled using pesticides for mosquito control. Clearly, pharmaceuticals are merely a portion of rational disease control and health promotion. They are goods that enter the mix of inputs that produce health. We should also consider the value and cost of alternative inputs that might yield the same results in terms of health. Proper sanitation, proper water supply, health education and nutrition should all be examined for potential benefits to health.

Another problem for developing countries is the limited research programs for tropical diseases. Major multinational pharmaceutical companies seem to be not as

[11] World Health Organization (1990) World Health Statistics Annual, p 14.

interested in developing drugs with limited sales potential.[12] Given that developing countries tend to have lower incomes, this lowers the effective demand for drugs that may be applicable to tropical and regional diseases. The majority of pharmaceutical research dollars are invested in drugs for the treatment of the problems of the developed world. Western health problems such as heart disease, stress (ulcers), mental health problems, and cancer receive a greater share of the research and development budget due to the greater market possibilities for drugs addressing these issues.[13]

Pharmaceuticals have an important advantage over many inputs into health. They are for the most part extremely portable, and used correctly, can be quite effective in reducing suffering, morbidity and mortality. We therefore feel that the question of pharmaceutical inputs into the production of health is an understudied question.

The ease of transport and dosage, while being a useful advantage for foreign aid donors, can also lead to problems such as self medication, incorrect prescribing and multiple drug prescribing.[14] Hardon (1987) presents some interesting results regarding

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[12] See also Personal Perspectives: Drug Development and Tropical Disease: Time for a New Impetus by Dr. C. D. Ginger in WHO Drug Information Volume 4 Number 3 1990.

[13] It is not our intent to imply that the major pharmaceutical companies do not produce drugs that are very important to developing countries. For example, Pfizer Pharmaceuticals has two new drugs with exciting potential for use in developing countries: Zithromax, a once a day, five day therapy antibiotic and Diflucan, a once a day antifungal agent.

[14] See reports on self medication and multiple drug prescribing in WHO The Rational Use of Drugs (1987) and Hardon (1987). Hardon (1987) gives a very interesting case study of this problem. In a rural village in the Philippines, a child developed what is classified as simple diarrhoea. A private doctor prescribed 5 drugs: a drug to prevent vomiting, an antidiarrheal, an antibiotic, a multivitamin, and an analgesic. The total cost of this package is 120 Philippine Pesos; this is equivalent to one week's salary.

self medication. In her study of children in a Filipino village, 38 per cent of children with illness are treated with self medication, whereas only 20 per cent received help from health professionals. Forty-two per cent receive no medicines. Hardon also makes the compelling point that the number of multiple drug treatments is much higher for doctor prescriptions than they are for self medication. The vast majority (64 per cent) of the doctor prescriptions involved 3 medicines, in sharp contrast to self medication of which 78 per cent used only one medicine.[15] Many strains of antibiotic resistant bacteria are developing in the world due to overutilization or improper use of pharmaceutical products. This may lead to decreases in the effectiveness of certain pharmaceutical products in the future.[16]

Other problems such as misprescibing and self medication may rob some of the positive effects of pharmaceuticals. The misdiagnosis and improper treatment of conditions by physicians or other health care workers may yield the patient anything from a negligible benefit down to iatrogenic diseases. This is not due to the pharmaceuticals per se, but due to their usage.[17] Problems also exist in the prescribing of drugs. Hardon (1987) mentions some of the problems of village health workers who dose drugs without

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The recommended treatment for simple diarrhoea is oral rehydration therapy according to WHO.

[15] Hardon (1987), p 282.

[16] See Greenhalgh for an interesting example: "A study in Bombay in 1978 found strains of Escherichia Coli with multiple resistance to sulphonamide, streptomycin, ampicillin, chloramphenicol, tetracycline and kanamycin in 28% of healthy subjects." This problem will mean that countries will have to continue to buy more high technology drugs or produce them without license to combat these resistant strains.

[17] See WHO (1985) The Rational Use of Drugs p 198-199.

proper diagnosis.[18] Self medication has been reported as a cheaper method of dealing with illness. Greenhalgh in her study of the Indian self medication found that the average price of a private prescription drug was 24.50 Rupees. The average cost of self medication was 10.30 rupees. The average laborer earns 3 rupees per day, and a teacher 300 rupees per month.[19] It is quite clear from these statements that the cost of medications will tend to be a significant barrier to their use. Also, the use of self medication clearly appears to have some cost advantage.

Patient compliance is a major problem in the promotion of the rational use of drugs.[20] The Greenhalgh study shows that patient compliance, for the use of the correct amount of drugs, is quite low. In her study of anti-infectives in the Philippines, she found approximately 3/4 of all drug uses outside the hospital are not used for the recommended clinical course.[21] Compliance appears not to be strongly linked to educational levels as a priori assumption would suggest.[22] These effects should limit both the explanatory power of education and pharmaceuticals on health.

Another interesting relationship which may dilute the effects of pharmaceuticals is

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[18] Hardon (1987), p 279.

[19] Greenhalgh (1987), p 308.

[20] See Haynes, R.B., Taylor, D.W. and Sackett, D.L. (1979) and Sackett, D.L. and Haynes, R.B. (1976) quoted in WHO (1985) The Rational Use of Drugs p 197, 202.

[21] Greenhalgh (1987), p 310.

[22] See Sackett and Haynes (1976) quoted in WHO The Rational Use of Drugs (1985) p 202.

the societal assumption that doctors must prescribe something when they treat a patient. This is clearly not always true. However, for a physician not to dose more than is clinically needed, she must swim against this societal pressure. The prescription for a drug has the ritual position of treatment. So both patient and doctor look toward the drug as a validation for the services provided. This may undermine the effects of pharmaceuticals that are observable at the macroeconomic level.[23]

Financing of drug imports continues to present problems for countries that import the majority of their domestic consumption. The need for hard currency for purchases from foreign producers may discourage the government from investing in pharmaceuticals. The other problem is the recovery of the foreign investment. Pharmaceutical expenditures are viewed, for the most part, as a consumption expenditure that will not return hard currency to the government for exchange purposes. Pharmaceutical and health care equipment purchases from abroad both face strong competition for foreign exchange from other economic agents. New manufacturing capital equipment, scientific equipment, and food imports can all compete successfully against health care goods. Is this rational? Do the benefits of investments in pharmaceuticals far outweigh the short term economic costs? We will attempt to give some indication of the potential relative value of pharmaceutical and other inputs into the production of domestic health.

All of the above problems make research in pharmaceuticals both interesting and

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[23] See WHO The Rational Use of Drugs (1985), p 201.

frustrating at the same time. We hope to clarify and expound on some of the basic relationships between this input and health outcomes.

We will estimate in this paper the effects of pharmaceutical consumption, measured at the country level of aggregation, on health. We study the effect of a number of other inputs into health such as number of physicians per capita, number of auxiliary health workers, nutrition, percentage of the population served by a safe rural water supply, percentage of the economically active population that works in agriculture and a measure of income (GNP or GDP per capita). We use a number of different measures of health status: infant mortality, life expectancy at various ages and child mortality. Using a double log model of health production, we find that our model explains the majority of the variation that is observed in our health variables. We also find that pharmaceutical consumption exhibits consistent and significant effects on the majority of our measures of health status.

II. EVIDENCE FROM THE LITERATURE

Since there has been very limited cross national research study of the effects of pharmaceutical consumption on health, we will explore some interrelated areas for indications as to the correct methodology for use in our research. Our research bridges the fields of health economics and economic development.

Many studies have been performed on the effects of the use of different types of health services and goods in the developed world. The developing world, most likely due to lack of useable data, has had very few national or cross-national studies of health. The effects of health on labor productivity is also of interest in our research, as the value of that outcome is the next logical step in the appraisal of investments in health as a tool for economic development. The final areas of interest are the use and utilization of pharmaceuticals at the microeconomic level in developing and developed counties, and trade and production problems in the pharmaceutical market.

Foundation papers by Becker (1965) and Grossman (1972) have studied the theory of consumer behavior, household production, and health production in the developed world. Grossman's analysis looks at health as a choice variable, from which consumers derive utility directly, and which also is an input into the determination of income and wealth. If we follow that logic then investments in health should provide us with a return in terms of utility. Our research is based upon the effects of national investment in health and the health outcomes on average that are the result of our choice variables.

Auster, Leveson and Sarachek (1969) studied the effects of medical and other inputs on a health production function in The United States. They found statistically significant results for the composite effect of medical inputs into their health production function. They experienced mixed results in establishing statistical significance for individual inputs into medical care: namely drug expenditures per capita, physicians per capita,

paramedical personnel per capita (roughly analogous to our auxiliary health personnel), hospital capital and two additional factors intended to measure the quality of the physician inputs; medical school in state, and percentage of practicing physicians in group practice. For their health measure, Auster et al. use age adjusted death rates. They argue quite persuasively that "measures of mortality possess a number of properties which make them suitable for health research. They are objectively measured, reasonably accurate, readily available, and universally understood."[24] They, however, point out that average life expectancy is in theory a better measure of health, as it takes in variation in both average age at death as well as differences in patterns of age specific death rates. This is an important point, as one pattern of age specific death rates may be preferred by an individual over another, even though both result in the same average age at death.[25]

Sheehan and Hopkins (1979) estimated health production functions for a cross-section of less developed and developing countries in the year 1970. They utilized a double log model of infant mortality and life expectancy at birth. Their independent variables were doctors per 100,000 people, calorie consumption, protein consumption, access to safe water, and GNP per capita. They tested the model with and without the variable access to safe water. Their model had a maximum of 87 observations. As such, they found statistical significance for only number of doctors per 100,000 people. They also modeled 1970 infant mortality and life expectancy using lagged values (1960) for doctors per

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[24] Auster, Leveson and Sarachek (1969), p 142.

[25] For an interesting argument about alternatives to age specific death rates as a measure of health, see Auster et al. (1969) p 143.

100,000, calorie consumption and GNP per capita. In the lagged model they found that doctors per capita and GNP per capita were significant for both life expectancy and infant mortality. While we feel that Sheehan and Hopkins have used the correct model for this phenomenon, they have controlled for little of the regional variation in the model.

Wheeler (1980) presents a simultaneous model of economic growth. He studies the growth rate of gross domestic product as a function of labor, capital and the quality of labor (health, education and nutritional status). He obtained parameter estimates from three-stage least squares on data from The World Bank for 54 countries in Africa, Asia, and South America. Wheeler also includes, in the second stage of his model, a series of dummy variables for major sub regions to control some of the unexplained variance.[26]

Wheeler finds that health and nutrition changes have higher response elasticities than changes in the capital stock for countries that had low values for education, nutrition, GDP per capita, and life expectancy. For his middle values group, education starts to exert some influence on productivity. Wheeler argues that his results indicate that for poor nations "the general conclusion is that almost any welfare investments seem equivalent or superior to general capital accumulation at the margin."[27]

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[26] Wheeler uses 12 regions: the Caribbean, Central America, the Andean Countries, the rest of South America, North Africa, The Sahel, West Africa, East Africa, West Asia, South Asia, Southeast Asia and East Asia.

[27] Wheeler (1980), p 449.

Middle range countries seem to have less health effects; however, nutrition changes still seem important. We find Wheeler's results quite interesting. The data from which we estimate our models could be further refined to be applicable to a model such as Wheeler's. Therefore the results presented by Wheeler indicate the basic relationship we expect between health and economic development.

An excellent overview of health production functions and macroeconomic studies of health is available in Carrin's Economic evaluation of health care in developing countries (1984). The model he presents, a basic needs model of economic development, is the same basic model that we are exploring here. Carrin used a log-linear model for his health production function. He used a cross section of 51 developing countries to explore the effects of physicians per thousand population, nurses per thousand population, calorie consumption per day, safe water supply, and literacy rate on health. His measures of health were life expectancy at birth, crude death rates and child death rates.

Carrin also separately explores the effects of Gross National Product per capita on the independent variables, and also the effects of literacy rate, child death rate, and contraception on the crude birth rate. The effects of literacy on contraception use is also explored. Given that Carrin used cross sectional analysis, he is able to avoid our problem of corrections for variation over time.

Knowing his data sources, we feel that the inclusion of regional dichotomous

variables and or GNP would have caused the health variables in his model to lose significance. This is due to the high level of multicollinearity in the data. It is not important to include GNP per capita per say, but some regional or country factors must be included in a data set that represents a wide range of economic development. He does fail to specify his model correctly, as he leaves out any correction for regional difference in endemic disease, number of hospital beds, or GNP per capita from his model. Leaving out GNP per capita without any correction for national or regional variation, we feel will introduce a significant amount of bias.

While Carrin's model is the correct kind of model, we feel that it suffers from too few observations and also has too few variables. This data set is also censored, so that only countries of lower levels of development are included. We feel that this censorship limits the applicability of the model.

Given these comments, we still find his results interesting. He finds that literacy rates and physicians per thousand population are very significant in increasing life span. In his crude death rates model, his only significant coefficients are literacy rates, physicians per thousand population and calorie supply per capita. In his child death rate model, his only significant coefficients are literacy rate and physicians per thousand population. Carrin reports significant coefficients on population per physician, and the literacy rate for life expectancy at birth. His coefficients of .0484 on the ln of physicians per thousand population, and of .0991 on the ln of adult literacy rate are reasonably consistent with

our results.[28]

Empirical estimation of production functions, in developing areas, has been explored by Malenbaum (1970). His work studies the production of agricultural output based upon labor, capital (fertilizer), and measure of health such as the cases of malaria or dysentery and population per physician, along with conventional labor quality variables such as literacy. His study was a cross sectional study of agricultural output, using aggregate data at the country level. He was also able to collect data on autonomous states in Thailand, Mexico and India.

Malenbaum found statistically significant results for infant mortality used as an explanatory variable for agricultural output in twenty-two developing countries. We feel that there may be reverse causation in this model, as increases in agricultural output may cause improvements in health. Whether or not you agree with Malenbaum's model, we do tend to agree with his result that there appears to be an interrelationship between health and agricultural output. Taken at face value, this gives some credence to the proposition that infant mortality is an indication of labor productivity. He also found significant results for population physician ratio, with increases in population physician ratio lowering output.

Malenbaum also found that 4/5 of the total explained variation in agricultural output

[28] See model 3 of database 3 for a comparison.

was explained by his two health inputs. His model explained 62% of the total variation in output. His other independent variables were literacy rate (insignificant and 2% of explained variation), fertilizer inputs and agricultural labor. For his independent states studies, in Mexico, he found statistically significant results for infant mortality and literacy rate for average production per worker in agriculture in 1940. In Thailand, he found significant results for percentage of population in agriculture, land irrigation, and literacy rate for output measured in tons of rice produced per capita. In India, he found significant results for average number of drinking wells constructed per year for total value of agricultural output.

David Blau's (1986) work centers on the level of infant mortality, fertility and child size based upon household variables, such as family income, wages, education, place of residence. His work uses a household survey in Nicaragua during 1977-78 as the basis for his data.

The dissertation by Dor (1986) examines the role of non - price issues in the demand for health in the Ivory Coast. He uses data collected in The Living Standards Measurement Study from The World Bank as the basis for his work. His work estimates the demand for health logit and probit models for probability of getting traditional, nursing or doctor care. Variables included education, age, travel time, sex, family size, and other consumption goods. He also examines the role of the above variables on pharmaceutical expenditures. Dor points out that the governmental policy of free medical

care in the Ivory Coast is not a reality as non price rationing occurs in a large amount of the market.

A large portion of the literature on the use and consumption of pharmaceuticals has focused on the questions of multinational corporations and financing of pharmaceutical imports. A number of works focus on the issue of multinational corporations and their effects on pharmaceutical production and consumption in the developed and developing world. Books by Heller (1977) and Muller (1982) and papers by Bleidt (1986) and Micklitz (1988) focus on the unethical promotion of non-essential pharmaceuticals, exports of dangerous drugs and the extraordinary profits of multinational pharmaceutical companies in developing countries. While the arguments have some merit, especially regarding the issue of non-essential drug promotion, we feel that they focus on the shortcomings of multinational corporations too much and underemphasize the positive role that pharmaceuticals play in the developing world. Reports from The World Health Organization indicate that there is excessive promotion of ineffective tonics and multivitamins in many countries, and that these products drink up tight foreign exchange moneys and domestic consumer income.[29]

However, clearly the most important issue is gross supply and consumption issues. For example, it has been reported that 80% of the population in India does not have

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[29] See WHO The Rational Use of Drugs (1985), p 195.

access to the drugs listed on The WHO essential drug list.[30] Individuals cannot have problems with incorrect medication if it is completely unavailable. A more effective way of dealing with this problem, if it is deemed important, may be to enforce national rational drug lists that limit the number of drugs available.[31]

III. THE MODELS

For our models, we will use macroeconomic data. This implies that we are making certain assumptions about the aggregation of health and demographic variables. To use an aggregated value for a health measure, such as average life expectancy at birth, implies that we have a social utility function. We then must specify the value that we place on improvements in our health measure. To assume that we have a totally egalitarian-humanitarian ethic, we place equal value on an improvement in health status for any individual in our society. This implies that an increase in life span of 10 years for a wealthy individual is worth as much as a 1 year increase in life span for 10 poor people. Both of these improvements have the same social value in an egalitarian social welfare function.[32] Whether or not one agrees with this valuation system, it does measure increases in utility. Since this is the only way we can use the available macroeconomic data, we are placed in a world with this assumption. One should be cautious in

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[30] Lall (1981), p 203.

[31] See WHO The Rational Use of Drugs (1985) p 205.

[32] See Willams (1981) for an expansion of our discussion about the proper measure of health status and the problems of aggregation.

interpreting our results to imply that they are maximizing utility, given the underlying social welfare function.

The underlying health model for an individual is as follows:

$H = f(E, M, Z)$

where

E = a vector of health endowments

M = a vector of health inputs

Z = a vector of other goods that affect health.

Individual health is a function of health inputs such as medical care, pharmaceuticals or nutrition, other goods such as smoking, leisure time and exercise and also health endowment. Therefore an individual can alter her health status to some degree by altering M or Z. If an individual's health level drops to a certain point, H_{min}, the individual dies. For infant mortality, we may be also altering the health endowment for an infant if we alter the health status of the mother.[33] This has been shown to be an important determinant of infant mortality.

For infant mortality, this results in a variable that for an individual is dichotomous in nature. Either one dies in the first year of life, given that you were live born, or not. For life expectancy at birth, these variables alter the expected life span of an individual.

[33] A good example of this is infants with low birth weights. If we improve nutritional status of the mother, we may also be improving the initial health endowment for the infant.

We are at this point in time unable to observe the outcomes for a given individual. We therefore are forced to use aggregate observations for countries. The resulting country model is as follows:

We will assume that the consumption of pharmaceutical products and other health care inputs are not just consumption expenditures, but are also investments in human capital. We will start with the assumption that this investment has positive utility so that it is worthwhile for the consumer.[34] This assumption will cause consumers to purchase or use health care goods, given that they have sufficient resources to purchase health care, when necessary.[35] Other goods also enter the production of health. Literacy, GNP per capita, protein consumption per capita, percentage of the economically active population involved in agriculture and percentage of the population served by safe water all should have important effects on health.

Our a priori analysis suggests that pharmaceuticals should have a significant impact on health and labor productivity. We expect that the decline in disease should increase production in developing nations.

We are concerned that nutrition may also play a role in the effectiveness of the consumption of pharmaceuticals. If the society faces widespread poor nutrition, then we

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[34] An alternative assumption could be that health care increases earning power for an individual.

[35] The obvious caveat to this assumption is that it may not bind when health care expenditures are subsidized or provided by the government. This releases consumers from their own budget constraints.

expect that an increase in pharmaceuticals will not significantly alter the labor productivity. Essentially, we are positing a minimum level of sustenance that consumption of pharmaceuticals cannot overcome. To study this, we will attempt to control for differences in protein consumption.

We feel that it is important that we consider, also, the productivity of people in the society, not just the persistence of their biological functions, as a measure of success in terms of health and economic development. The question of the measurement of the productivity, we expect to be a formidable task. We wish to explore the ability of the population to provide productive labor. This will be explored in our future work. However, as our mortality and life span measures are in some ways proxies for morbidity, we do capture the ability of our population to provide labor.[36]

We are considering models that are log-linear in formulation. Four interesting models come to mind using aggregate data; 1) A health production function using pharmaceutical and other variables 2) A labor productivity function using pharmaceutical and other inputs. 3) A pharmaceutical consumption function that is dependent on the terms of trade and the balance of payments 4) A development model that emphasizes the structural transformation of production.

For now we will focus on the health production function, as the structural

[36] For an example of this interrelationship see UNICEF (1990) for a description of the problems caused by guinea worm disease.

transformation model and the labor productivity models are dependent on the health production function. Our model for the health production function follows models such as the ones used by Auster, Leveson and Sarachek (1969), Sheehan and Hopkins (1979) and Carrin (1984) with the addition of pharmaceutical consumption.

$$\text{Health} = A\ \text{AGRI}^{B1}\ \text{AUXCP}^{B2}\ \text{BEDS}^{B3}\ \text{GNP}^{B4}\ \text{LIT}^{B5}\ \text{PHARM}^{B6}\ \text{PHYCP}^{B7}\ \text{PRO}^{B8}\ e^{u+di\ldots dn}$$

Where

Health = Infant Mortality Rate (INF) or Life Expectancy at Birth (LIFE) or Life Expectancy at Age 15 for Females (FEM15) or Child Death Rate (CHILD)

AGRI = Percentage of the Economically Active Population Involved in Agriculture

AUXCP = Auxiliary Health Personnel Per Capita

BEDS = Hospital Beds Per Capita

GNP = Gross National Product Per Capita

LIT = Literacy Rate

PHARM = Pharmaceutical Consumption Per Capita

PHYCP = Physicians Per Capita

PRO = Nutrition: Total Daily Protein Consumption Per Capita Per Day

u = error term

di = control variable for time periods (DUMyy) and countries (Di) other than the base

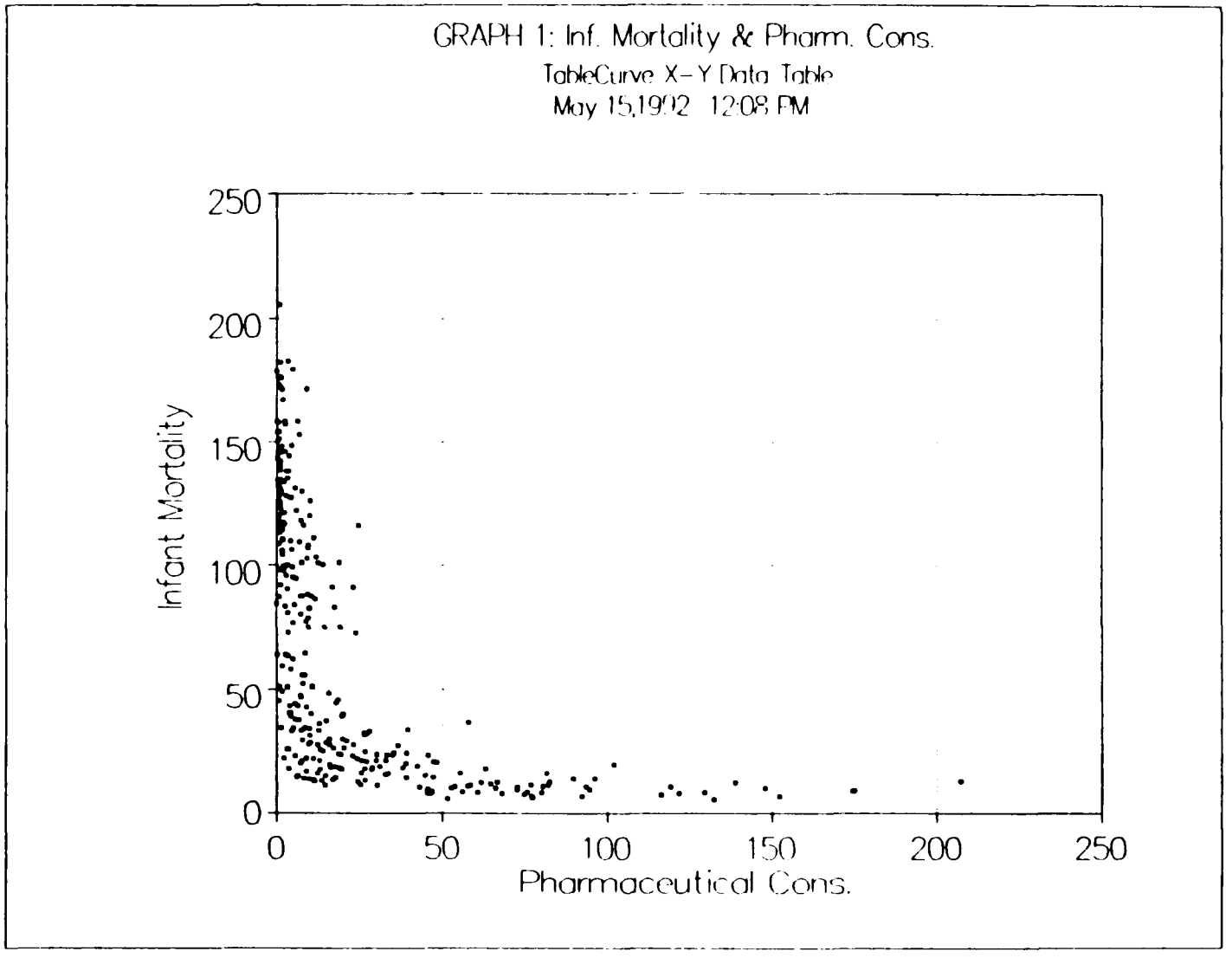
This model linearizes in double natural logs to:

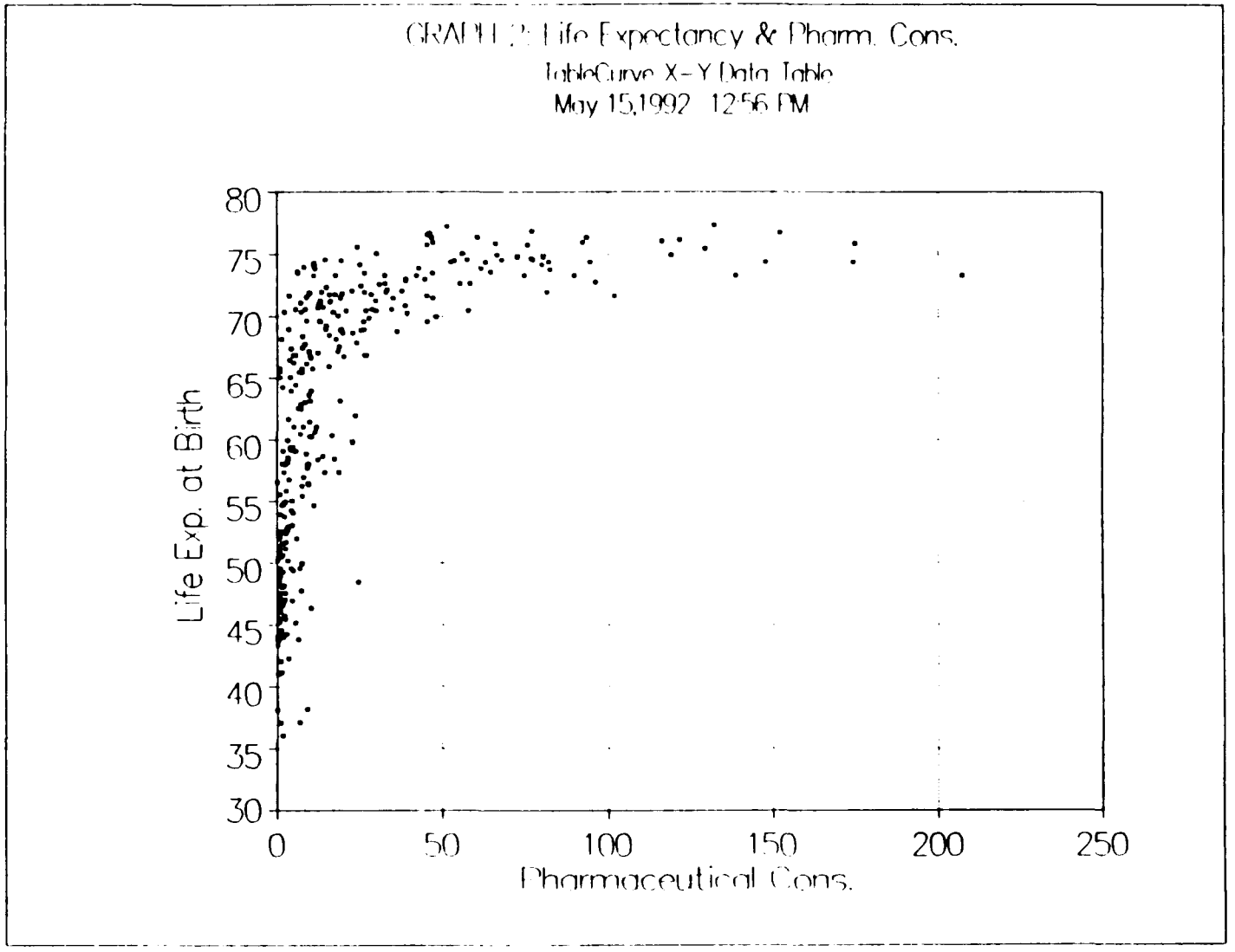
$$\ln(\text{health}) = \ln A + b1\ln PHYCP + b2\ln BEDS + b3\ln AUXCP + b4\ln LIT + b5\ln PRO + b6\ln AGRI + b7\ln PHARM + d1.....dn + u.$$

This is the model we will estimate. As is well known in log linear models, the regression coefficients will be the elasticities of health with respect to the independent variables.

Based upon preliminary analysis of our data, it appears that the correct model is double log linear in nature. As can be clearly seen by graph 1, the relationship seems quite appropriate for the relationship between pharmaceutical consumption per capita and infant mortality rates. In graph 2, we can clearly see that it is also the correct specification for our model of life expectancy at birth.

There is some question as to whether our model has captured all of the relevant production factors for health. The obvious assumption is that we have omitted some of the independent variables in our model. Variables for variation in the quality of health care inputs and health workers in particular are not included in our model. This most likely introduces bias into our coefficient estimates. If we have omitted important explanatory variables then our coefficients are biased. A possible solution to this is to include a proxy variable for our unobserved variables. The most obvious proxy for our unobservable variables is GNP per capita. Using this proxy however introduces other


GRAPH 1: Inf. Mortality & Pharm. Cons.
TableCurve X-Y Data Table
May 15,1902 12:08 PM
250
200
150
100
50
0
Infant Mortality
0
50
100
150
200
250
Pharmaceutical Cons.


GRAPH 2: Life Expectancy & Pharm. Cons.
TableCurve X-Y Data Table
May 15,1992 12:56 PM
Life Exp. at Birth
80
75
70
65
60
55
50
45
40
35
30
0
50
100
150
200
250
Pharmaceutical Cons.

problems.

Income also is a major factor, along with the prices of goods in determining the demand for health inputs. Therefore, if we include GNP per capita in our model, our parameter estimates are a mixture of both demand and production coefficients. Because of these problems, we have reservations about both estimation techniques, as neither approach is perfect.[37] The above problems lead us to present both types of models, with the caveat that models with GNP per capita are not purely production functions.

In theory, our health production function should be estimated by two stage least squares, with inputs treated as endogenous. We lack a sufficient number of truly exogenous variables to estimate our production function by this method. We therefore estimated our models using ordinary least squares (OLS). An argument in favor of this method of estimation is that if income and input prices vary a lot relative to the disturbance terms in the production and demand functions, then OLS introduces very little bias. This assumption does not seem completely inconsistent with the data and a priori analysis.

Our methodology will not be able to separate out where consumption takes place. We suspect a strong urban, higher income bias in pharmaceutical consumption. This is consistent with most of the literature. It has been reported that the majority of the

[37] We wish to thank Michael Grossman for his commentary and help in defining this point.

medicinal shortages occur in the rural areas of developing countries.[38]

IV. THE VARIABLES AND DATA SOURCES

We will have to use aggregate data for our first research of this area. We have found it difficult to get disaggregate data, especially for the developing countries. In the future, we hope to rectify this problem with a further direct country study. This first group of studies will give us a base line as to the effect of pharmaceutical consumption in the world at an aggregate level.

We could use our data for a time series of an individual country to develop coefficients for the independent variables. This will limit the amount of our data for a given country. We would be able to develop a set of coefficients for a given country that might be useful for the formulation of policy regarding that specific country. We also expect the results to be country specific in applicability. This methodology is limited as the time series data for developing countries is not long; approximately 24 years at best, and so we would have a very limited number of observations. The reporting of certain variables also would not allow us to calculate yearly figures for most countries, since data such as calorie and protein consumption per capita is reported as three year averages. This is acceptable for 5 year intervals, as the data is distinct for each interval, whereas, yearly observations would require extensive interpolation. All of these

[38] There is quite a bit of literature on this problem. See WHO (1988) and also Fabricant and Hirschhorn in WHO (1985) p 193-194.

problems, we feel, would make the results suspect at best, and prompted us to discard this methodology for the present. It may prove useful in the future.

The alternative is to use the data as a cross sectional series and develop one set of coefficients for all countries in the survey. The benefit of this is the applicability to countries that share some of the same parameters as the countries under consideration. This follows the methods of Sheehan and Hopkins (1975) and Carrin (1984). However, we would like to control for some of the country or regional variation in our model. This is our preferred methodology for the present.

Our research used 3 different methods of collecting data for our study. There is a good deal of overlap in most of the methodology. However, we feel it is necessary to outline our methods and highlight the similarities and differences in each method.

DATABASE 1

The first method produced the most limited data base, 24 countries. It is cross sectional in nature, for the year 1980. All data comes from the Organization for Economic Co-operation and Development (OECD) publication, Measuring Health Care 1960-1983. The countries included are what you think of as developed countries; a list of OECD countries is provided in table 1. As this group is quite homogeneous in terms of development, it provides us with an opportunity to examine pharmaceutical

Table 1
OECD Country List By Name

Country Name	DATA-BASE 1	Country Code	Region Code	Region Name
Australia	YES	183	20	AUST NZ
Austria	YES	173	18	W EUROPE
Belgium	YES	174	18	W EUROPE
Canada	YES	143	14	N AMERICA
Denmark	YES	154	16	N EUROPE
Finland	YES	156	16	N EUROPE
France	YES	175	18	W EUROPE
Germany	YES	176	18	W EUROPE
Greece	YES	166	17	S EUROPE
Iceland	YES	157	16	N EUROPE
Ireland	YES	158	16	N EUROPE
Italy	YES	167	17	S EUROPE
Japan	YES	59	6	E ASIA
Luxembourg	YES	178	18	W EUROPE
Netherlands		180	18	W EUROPE
New Zealand	YES	184	20	AUST NZ
Norway	YES	160	16	N EUROPE
Portugal	YES	169	17	S EUROPE
Spain	YES	171	17	S EUROPE
Sweden	YES	161	16	N EUROPE
Switzerland	YES	181	18	W EUROPE
Turkey		95	9	W S ASIA
United Kingdom	YES	162	16	N EUROPE
United States of America	YES	146	14	N AMERICA

consumption with a limited number of control variables.

The developed world should be able to avoid some of the constraints of the developing world, namely the foreign exchange constraint, the nutrition constraint and the pervasiveness of endemic disease.

The variables in this database are as follows:

Nutrition: One measure of nutrition levels is obtained by using the amount of butter consumed annually per person, measured in kilograms per head per year. Wolfe and Gabay (1987) use butter consumption as a measure of lifestyle (richness of diet). Their results however found a positive relationship between butter consumptions and health status. Their explanation of this was that butter consumption may be an indicator of nutritional status or income in their model.

Pharmaceutical Consumption: Per capita expenditures on pharmaceuticals is calculated from the reports of total expenditures in domestic currency, converted to United States dollars. This value is divided by the population to get per capita consumption.

Physicians Per Capita: reported as total number of physicians and population.

Auxiliary Health Personnel Per Capita: Reported as number of auxiliary health personnel and population.

GDP Per Capita, Infant Mortality Rates, Life Expectancy at Birth, and Mortality Rates are all reported directly.

This database has the important advantage that it is drawn from reports by the OECD. OECD countries are probably the most advanced in the collection and correction of data for international comparisons. This data is probably the most consistent and accurate international health data. We therefore feel that this database will allow us to explore some of the more detailed and sublime interrelationships between our health inputs and our measures of health status.

DATABASE 2

Database 2 presents data collected for the year 1984. A large portion of the data was provided by the International Data Base, produced by The U.S. Department of the Commerce, Bureau of the Census, Center for International Research. This provided us with the majority of our data for the control variables and measures of health status.[39] This was augmented by data from the sources listed for database 3.

The pharmaceutical trade data comes from The OECD publication Trade by Commodities, Schedule C. Domestic pharmaceutical production data is from The United Nations Industrial Statistics Yearbook, Volume 1.

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[39] For an interesting overview of the kinds of data available in the International Database, see Children's Well-being: An International Comparison by Hobbs and Lippman (1990).

The overall mixed results from the first 2 databases prompted us to attempt to expand the data, and to control for more of the regional variation in our samples. We felt that small cross sections of data could not adequately estimate the coefficients on a population that was so diverse. The results for all of our databases are discussed in the next section, however, we would like to emphasize the experimental nature of the collection of the first 2 data bases. We therefore feel that any empirical results, for counties outside the OECD should only be drawn from the third database.

DATABASE 3

Database 3 is a cross sectional and time series data base for 94 countries across the world. This represents aproximately 50 per cent of the countries in the world. Table 2 provides a list of the countries included in database 3. It covers the years 1960 to 1985, reporting on data at 5 year intervals. We felt that to attempt closer divisions would not be possible given the quality of the reporting for some of our data. This database represents a reasonable compromise in terms of time intervals and variation.
The sources for database 3 are as follows:

Dependent Variables:

Infant Mortality Rates: This is our basic measure of health. This is the number of deaths in the first year of life per 1000 live births. This measure of health should be strongly

Table 2
Country List By Name

Country Name	DATA-BASE 3	Country Code	Region Code	Region Name
Afghanistan	YES	74	8	MID S ASIA
Albania	YES	163	17	S EUROPE
Algeria	YES	27	3	NTH AFR
American Samoa		194	23	POLYNESIA
Andorra		164	17	S EUROPE
Angola		18	2	MID AFR
Anguilla		201	10	CARIBBEAN
Antigua and Barbuda		99	10	CARIBBEAN
Argentina	YES	129	12	TEMP S AMER
Aruba		206	10	CARIBBEAN
Australia	YES	183	20	AUST NZ
Austria	YES	173	18	W EUROPE
Bahamas, The		100	10	CARIBBEAN
Bahrain		83	9	W S ASIA
Bangladesh	YES	75	8	MID S ASIA
Barbados		101	10	CARIBBEAN
Belgium	YES	174	18	W EUROPE
Belize		121	11	MID AMER
Benin		39	5	WEST AFR
Bermuda		142	14	N AMER
Bhutan		76	8	MID S ASIA
Bolivia	YES	132	13	TROP S AMER
Botswana		34	4	STH AFR
Brazil	YES	133	13	TROP S AMER
British Virgin Islands		102	10	CARIBBEAN
Brunei		64	7	E S ASIA
Bulgaria		147	15	E EUROPE
Burkina		55	5	WEST AFR
Burma		65	7	E S ASIA
Burundi	YES	1	1	EAST AFR
Cambodia		66	7	E S ASIA
Cameroon	YES	19	2	MID AFR
Canada	YES	143	14	N AMER
Cape Verde		40	5	WEST AFR
Cayman Islands		103	10	CARIBBEAN
Central African Republic	YES	20	2	MID AFR
Chad	YES	21	2	MID AFR
Chile	YES	130	12	TEMP S AMER
China, Mainland		56	6	EAST ASIA
China, Taiwan		57	6	EAST ASIA
Colombia	YES	134	13	TROP S AMER
Comoros		2	1	EAST AFR
Congo		22	2	MID AFR
Cook Islands		195	23	POLYNESIA
Costa Rica	YES	122	11	MID AMER
Cuba		104	10	CARIBBEAN
Cyprus	YES	84	9	W S ASIA
Czechoslovakia	YES	148	15	E EUROPE
Denmark	YES	154	16	N EUROPE

Table 2 (Continued)
Country List By Name

Country Name	DATA-BASE 3	Country Code	Region Code	Region Name
Djibouti		3	1	EAST AFR
Dominica		105	10	CARIBBEAN
Dominican Republic	YES	106	10	CARIBBEAN
Ecuador	YES	135	13	TROP S AMER
Egypt	YES	28	3	NTH AFR
El Slavador	YES	123	11	MID AMER
Equatorial Guinea		23	2	MID AFR
Ethiopia	YES	4	1	EAST AFR
Faroe Islands		155	16	N EUROPE
Fed. States of Micronesia		207	22	MICRONESIA
Fiji	YES	196	23	POLYNESIA
Finland	YES	156	16	N EUROPE
France	YES	175	18	W EUROPE
French Guiana		136	13	TROP S AMER
French Polynesia		197	23	POLYNESIA
Gabon	YES	24	2	MID AFR
Gambia		41	5	WEST AFR
Gaza Strip		85	9	W S ASIA
German Dem. Rep. (EAST)		149	15	E EUROPE
Germany, F.D.R. (WEST)	YES	176	18	W EUROPE
Ghana	YES	42	5	WEST AFR
Gibraltar		165	17	S EUROPE
Greece	YES	166	17	S EUROPE
Greenland		144	14	N AMER
Grenada		107	10	CARIBBEAN
Guadeloupe		108	10	CARIBBEAN
Guam		191	22	MICRONESIA
Guatemala	YES	124	11	MID AMER
Guernsey		205	16	N EUROPE
Guinea		43	5	WEST AFR
Guinea – Bissau	YES	44	5	WEST AFR
Guyana		137	13	TROP S AMER
Haiti		109	10	CARIBBEAN
Honduras	YES	125	11	MID AMER
Hong Kong	YES	58	6	EAST ASIA
Hungary	YES	150	15	E EUROPE
Iceland	YES	157	16	N EUROPE
India	YES	77	8	MID S ASIA
Indonesia	YES	67	7	E S ASIA
Iran	YES	78	8	MID S ASIA
Iraq	YES	86	9	W S ASIA
Ireland	YES	158	16	N EUROPE
Isle of Man		159	16	N EUROPE
Israel	YES	87	9	W S ASIA
Italy	YES	167	17	S EUROPE
Ivory Coast	YES	45	5	WEST AFR
Jamaica	YES	110	10	CARIBBEAN
Japan	YES	59	6	EAST ASIA
Jersey		153	16	N EUROPE

Table 2 (Continued)
Country List By Name

Country Name	DATA-BASE 3	Country Code	Region Code	Region Name
Jordan		88	9	W S ASIA
Kenya	YES	5	1	EAST AFR
Kiribati		189	22	MICRONESIA
Korea, P. D. R. (NORTH)		60	6	EAST ASIA
Korea, Rep. of (SOUTH)	YES	61	6	EAST ASIA
Kuwait	YES	89	9	W S ASIA
Laos		68	7	E S ASIA
Lebanon		90	9	W S ASIA
Lesotho		35	4	STH AFR
Liberia	YES	46	5	WEST AFR
Libya	YES	29	3	NTH AFR
Liechtenstein		177	18	W EUROPE
Luxembourg		178	18	W EUROPE
Macau		62	6	EAST ASIA
Madagascar		6	1	EAST AFR
Malawi	YES	7	1	EAST AFR
Malaysia	YES	69	7	E S ASIA
Maldives		79	8	MID S ASIA
Mali		47	5	WEST AFR
Malta		168	17	S EUROPE
Marshall Islands		208	22	MICRONESIA
Martinique		111	10	CARIBBEAN
Mauritania		48	5	WEST AFR
Mauritius		8	1	EAST AFR
Mayotte		204	1	E AFR
Mexico		126	11	MID AMER
Monaco		179	18	W EUROPE
Mongolia		63	6	EAST ASIA
Monserrat		112	10	CARIBBEAN
Morocco	YES	30	3	NTH AFR
Mozambique		9	1	EAST AFR
Namibia		36	4	STH AFR
Nauru		192	22	MICRONESIA
Nepal		80	8	MID S ASIA
Netherlands	YES	180	18	W EUROPE
Netherlands Antilles		113	10	CARIBBEAN
New Caledonia		185	21	MELANESIA
New Zealand	YES	184	20	AUST NZ
Nicaragua	YES	127	11	MID AMER
Niger		49	5	WEST AFR
Nigeria	YES	50	5	WEST AFR
North Mariana Islands		202	22	MICRONESIA
Norway	YES	160	16	N EUROPE
Oman		91	9	W S ASIA
Pakistan	YES	81	8	MID S ASIA
Panama	YES	128	11	MID AMER
Papua New Guinea	YES	187	21	MELANESIA
Paraguay		138	13	TROP S AMER
Peru	YES	139	13	TROP S AMER

Table 2 (Continued)
Country List By Name

Country Name	DATA-BASE 3	Country Code	Region Code	Region Name
Philippines	YES	70	7	E S ASIA
Poland	YES	151	15	E EUROPE
Portugal	YES	169	17	S EUROPE
Puerto Rico		114	10	CARIBBEAN
Qatar		92	9	W S ASIA
Reunion		10	1	EAST AFR
Romania		152	15	E EUROPE
Rwanda		11	1	EAST AFR
Saint Helena		51	5	WEST AFR
Saint Lucia		116	10	CARIBBEAN
Saint Pierre and Miquelon		145	14	N AMER
San Marino		170	17	S EUROPE
San Tome and Principe		25	2	MID AFR
Saudi Arabia	YES	93	9	W S ASIA
Senegal		52	5	WEST AFR
Seychelles		12	1	EAST AFR
Sierra Leone	YES	53	5	WEST AFR
Singapore		71	7	E S ASIA
Solomon Islands		188	21	MELANESIA
Somalia	YES	13	1	EAST AFR
South Africa		37	4	STH AFR
Soviet Union		182	19	USSR
Spain	YES	171	17	S EUROPE
Sri Lanka	YES	82	8	MID S ASIA
St. Christopher and Nevis		115	10	CARIBBEAN
St. Vincent and the Gren.		117	10	CARIBBEAN
Sudan	YES	31	3	NTH AFR
Suriname		140	13	TROP S AMER
Swaziland		38	4	STH AFR
Sweden	YES	161	16	N EUROPE
Switzerland	YES	181	18	W EUROPE
Syria	YES	94	9	W S ASIA
Tanzania	YES	15	1	EAST AFR
Thailand	YES	72	7	E S ASIA
Togo	YES	54	5	WEST AFR
Tonga	YES	199	23	POLYNESIA
Trinidad and Tobago	YES	118	10	CARIBBEAN
Trust Terr. Pacific Isl.		193	22	MICRONESIA
Tunisia	YES	32	3	NTH AFR
Turk And Caicos		119	10	CARIBBEAN
Turkey	YES	95	9	W S ASIA
Tuvalu		190	23	POLYNESIA
Uganda	YES	16	1	EAST AFR
United Arab Emirates		96	9	W S ASIA
United Kingdom	YES	162	16	N EUROPE
United States	YES	146	14	N AMER
Uruguay	YES	131	12	TEMP S AMER
Vanuatu		186	21	MELANESIA
Venezuela	YES	141	13	TROP S AMER

Table 2 (Continued)
Country List By Name

Country Name	DATA-BASE 3	Country Code	Region Code	Region Name
Vietnam		73	7	E S ASIA
Virgin Islands		120	10	CARIBBEAN
Wallis and Futuna		200	23	POLYNESIA
West Bank		203	9	W S ASIA
Western Sahara		33	3	NTH AFR
Western Samoa		198	23	POLYNESIA
Yemen (Aden)		97	9	W S ASIA
Yemen (Sanaa)	YES	98	9	W S ASIA
Yugoslavia	YES	172	17	S EUROPE
Zaire	YES	26	2	MID AFR
Zambia	YES	17	1	EAST AFR
Zimbabwe		14	1	EAST AFR

Source: United States Department of Commerce, Bureau of the Census, Center for International Research, International Database. 1990.

related to nutritional status for mothers, along with a consequence of effective infant health care and proper child rearing practices. Rip, et al. (1987) point out that infant mortality rates appear to have two clear components. The first is neonatal deaths (deaths in the first month of life) which are mostly caused by factors related to pregnancy and birth weight. The second is post neonatal deaths (1-11 months) which is linked to malnutrition and infectious disease. Rip et al., in a survey in Cape Town, South Africa, found the post neonatal component was a major contributor (60%) to the infant mortality rates in poor sections of Cape Town. In more affluent communities, neonatal mortality was the main component in infant mortality rates.[40] Infant mortality is also valuable as a measure of health due to it's consistent reporting by a broad cross section of countries. It also has the positive attribute that it is a very objective measure. The reporting of death we feel is more consistent and accurate than other health measures. We also feel that the infant mortality rate has the highest probability of being accurately reported of all of our measures. The sources for infant mortality rates are: The WHO Health Statistics Annual, The World Bank's World Development Report, and The International Database.

Life Expectancy at Birth: This is the length of life, on average, that a newborn is expected to live, if the prevailing patterns of mortality, at the time of birth, remain constant in the future. This variable gives us some indication of the probability of reaching adulthood, and one's expectations for life span. This may be biased by a large

[40] See Rip et al. 1987 p 889.

amount of infant mortality, which will tend to depress life expectancy at birth. Infant mortality does not in itself alter the rest of the expectation of life series after the first year, except for the effects of poor health in the first year increasing morbidity or mortality in later years. As Auster et al. point out, life expectancy may be one of the better measures of health.

Life Expectancy at Age 15 for Females: The argument for the use of this variable is that this is near the age of entrance, for many, into the work force. Therefore, health measures for the population at this point are very important. The use of female life expectancy at age fifteen, also removes from the sample some of the causes of death in males such as industrial accidents, murder, and agricultural accidents. The female rate should reflect more the types of disease that are treatable by health care workers. So, therefore, the kinds of bias that are introduced into the life expectancy for females may actually improve the data, in that we may be removing the untreatable and/or violent deaths in our population. What life expectancy for females will include is deaths due to child bearing. This should be an indicator of the availability of modern medical care. Low levels of development and a lack of birth control may cause women to have closer birth spacing, which also tends to lower women's life span.

Child Death Rates: This measure shows deaths of children between the ages of one and five years. The argument for using this measure of health is that it may help study the effects of health inputs on a mortality measure that is at a point where the probability of

death is not based as much on the mother's nutritional status as are infant mortality rates. For children to avoid serious illness, they must be provided clean water, proper sanitation and adequate food for weaning. During this critical period of physiological development, the risks are high. Therefore, this offers us a measure of the current health status of the actual children. Both infants and young children tend to transmit information about health conditions in quickly observable ways. Data comes from the World Bank's World Development Report.

Of our dependent variables, we expect that infant mortality and life expectancy at age 15 for females should be most closely linked to pharmaceutical consumption. The clear path of the pharmaceutical effect is though the health status of women. The causation should run from women's health to lower infant mortality. Women's health effects birth wight and the amount of calories that a child receives during nursing. This should be translated into improved infant health that is observable very soon after the health status changes. We therefore expect that these two dependent variables should show the most significant effects.

Independent Variables:

Auxiliary Health Personnel: Auxiliary health personnel are usually the most important care givers in developing countries, as they are present most of the time. This is in marked contrast to physicians, who may appear on a weekly, biweekly, or sporadic basis

in rural health centers.[41] It is our feeling that in terms of developing countries and basic health care services, auxiliary health care personnel should be very important to the overall health of the society.

It is quite clear, from the model programs described by Carrin (1984), that the rural health worker is a much more important input into health than physicians or hospital services. In our study, this variable includes graduate, practical assistant and auxiliary nurses. Also included are first aid workers, health workers, midwives and traditional birth attendants. Basically, we feel that this is a more comprehensive view of the availability of health care outside of the major urban centers. The majority of our data comes from The World Bank's World Development Report, and The World Health Organization Health Statistics Annual. We have augmented this with data from The United Nations Economic Commission For Africa's Africa Economic Indicators, The United Nations Industrial Development Organization's Africa In Figures, The Organization for Economic Co-operation and Development's Social Policy Studies Number 7: Health Care Systems in Transition, The World Resource Institute's World Resources 1988-1989 and The World Bank's World Tables. Reporting takes place in various formats such as total number of auxiliary personnel or population per auxiliary health worker. All data is converted into auxiliary health workers per capita.

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[41] See Carrin (1984) for a more detailed look at the time allocations and responsibilities of both physicians and rural health care workers in two model programs: The Etimesgut project in Turkey and The Jamkhed project in India. You clearly see the important role health workers should play in the provision of basic health care (p 20-28).

Hospital Beds per Capita: This measure of the availability of inpatient hospital services hopes to capture some of the capital inputs into the production of health. We may in part think of this as a measure of the total capital in the health care system. There will be considerable variation in what is counted in the total number of hospital beds in a given country. Some countries count clinic beds and outpatient facilities in hospital beds. Availability of this data is more limited than the data on auxiliary health personnel and on physicians. Data comes from The U.S. Census Bureau's International Data Base, The World Health Organization's Health Statistical Annual, The United Nations Economic Commission for Africa's African Economic Indicators, The World Bank's World Development Reports, World Bank Atlas and The World Resources Institute's World Resources 1988-89.

Physician Services: The use of medical doctors may have some effect on health in our study. The issue of whether medical doctors' procedures produce health improvements in a society is not being discussed here. Our initial postulate is that the effect of physicians overall should be to increase the level of health in a given region. We suspect, and there is considerable anecdotal evidence to support our view, that physician distribution is not uniform. Urban areas and wealthier rural areas will tend to have more physicians per capita. Rural and impoverished areas will tend to have sporadic physician presence and limited involvement of physicians in basic health care decisions. The chronic shortage of rural physicians in the United States is a simple example.[42] UNIDO

[42] See WHO Health Manpower Requirements for a more detailed look at the uneven distribution of doctors in the United States and other developed countries.

outlined some of the distributional problems; " in many developing countries, health services are concentrated in urban areas, based in city hospitals which may utilize 80 per cent of national health care expenditures, but only cater for the needs of 20-30 percent of the population."[43]

The reporting of data on physicians per capita is reasonably consistent. It is important to note that who is defined as a physician can be somewhat ambiguous. An example is Mainland China, where doctors of traditional Chinese healing arts are counted as physicians. Also included in some countries are medical assistants that lack the full formal training of physicians, but who provide similar services, including operations. However, due to licensing requirements and registration requirements for physicians, who is a physician in any given country is usually better spelled out than other health professions. The vast majority of our data comes from The World Bank's World Development Report, various years, which reports population per physician. Some of the data was collected from The World Health Organization's Health Statistics Annual and The United States Census Bureau's International Data Base which reports total number of physicians.

In the above three measures of the health care inputs into health production, we used in some cases data that was 2 years prior to or after our observation date for our main

[43] UNIDO (1980) p 14. See also WHO (1985) Health manpower requirements for the achievement of health for all by the year 2000 through primary health care; "in some countries of Africa, for example, 50-75% of physicians are in the capital city where less than 10% of the population live." p 23.

variables, if closer data was unavailable. We also filled gaps in the data if we had valid reporting of data prior to our needed observation and after our observation. Data was then interpolated for the observation. As a rule the values of these demographic variables change at a slow rate. For example, the number of physicians needed to significantly change physicians per capita is large for most countries. The result of this is that we feel quite strongly that interpolation does not present a serious risk for error in these variables.

Nutrition: This variable may be daily per capita calorie supply or daily per capita protein supply. This is a control variable for the effects of nutrition on health. The magnitude of the malnutrition problem is immense. To quote UNIDO, " nearly 450 million people have less food than is necessary for basic survival".[44] Nutrition should play an important part in the production of health. We collected data on both calorie consumption per capita per day and protein consumption in grams per capita per day. We have decided to concentrate on protein consumption as protein malnutrition can be measured in routine blood work by levels of albumen. This suggests the possibility that we may be able to get an objective measure of nutritional status for use in a future field study. That possibility makes protein consumption more interesting for our present analysis. The correlation between protein and calories consumed per day is extremely high, about .92. It therefore seems inappropriate for us to include both measures in our study. The interaction between pharmaceuticals and malnutrition is included in the

[44] UNIDO (1985) p 9.

analysis of new drugs when they are proposed for inclusion on essential drug lists produced by WHO.[45] This data was collected from The United Nations Food and Agricultural Organization (FAO) Statistical Yearbook.

Education: This is both a measure of the quality of the work force and also a measure of the ability of the population to have information transmitted to them. A more literate population may allow the transfer of basic health knowledge in a very cost effective manner.[46] Examples of this may be public health bulletins in the local newspapers, or pamphlets distributed by health care workers or government agencies. Also incorporated in this measure is the ability of consumers to learn more effective ways of combining inputs into the production of health and to avoid dangerous behaviors and environments that might lower the level of personal health. A useful survey and critique of the literature regarding health and schooling is provided in Grossman and Joyce (1987). To follow the arguments of Grossman and Joyce, education may interact through three basic paths with health: "The first argues that there is a causal relationship that runs from increases in schooling to increases in health. The second holds that the direction of causality runs from better health to more schooling. The third argues that no causal relationship is implied by correlation. Instead, differences in one or more "third variables" such as physical and mental ability and parental characteristics, affect both

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[45] See UNIDO (1985) p vii and 19.

[46] See WHO Health Principles of Housing (1985) p. 7 on health promotion from the proper education in the use of available health facilities.

health and schooling in the same direction."[47] We agree with Grossman and Joyce that the causality appears to run from schooling to higher levels of health. That argument is supported by results that show that increases in education expenditures would yield greater returns to health than increases in expenditures on medical care, reported by Auster, Levinson, and Sarachek (1969). We believe that the value of schooling as a control variable is well supported by previous analysis.

Income: We would like to use Gross National Product per capita for part of our study. This is due to our desire to study two different effects. The first is the impact of differences in pharmaceutical consumption on health, given a specific level of income. You may think of this as the pure choice issue of the allocation of national resources towards additional consumption of pharmaceuticals over other goods holding income constant. The second type of model will not hold income constant, in order to measure the total effect of pharmaceutical consumption; a gross effect if you will, caused by additional pharmaceuticals ignoring income. The GNP per capita figures used were collected from The World Bank's World Tables: 1991 and 1976. The conversion into domestic currency uses The World Bank Atlas method. Please note that we have made no correction for distribution of income in our study. It is hypothesized that there is not an equitable distribution of income in many countries. This may impact health through nutrition, health care access, and lifestyle issues. GNP per capita is used as our measure of income due to its consistent reporting and its availability. Questions as to the

[47] Grossman and Joyce (1989) p. 141.

applicability of G.N.P. per capita as a measure of income are of course valid. However, we feel that it is a reasonable proxy for consumers' ability to command goods and services. It would be helpful if we could combine the G.N.P. per capita figures with a measure of income distribution such as a GINI coefficient. However, reporting of GINI coefficients is not common or consistent at present.[48] We therefore feel that GNP per capita is the best proxy for our current study.

Percentage of the Economically Active Population that is Involved in Agriculture: This is a measure of economic development that is in line with current thinking on the subject. The basic premise is that more developed countries have less of their population involved in the agricultural sector and more involved in the industrial sector. We feel that this is a reasonable measure of development and it is consistently reported. We expect that less developed countries will tend to have higher infant mortalities and lower life expectancies due to lower levels of technology than in developed countries. So this variable functions in two ways, as a measure of development; as an inverse measure of industrialization, and as a measure of the rural population.[49] Both should raise infant mortality and decrease life span. This negative effect of ruralness on health is caused by a number of factors including: the lack of health care facilities and/or rural practitioners and/or

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[48] GINI coefficients are reported by Hoover (1989) for a number of countries. He reports data collected from a number of researchers around the year 1970. As Hoover points out, many researchers use GINI coefficients from different time periods in cross sectional analysis, under the assumption that income distribution is rather stable in the short run.

[49] Adelman (1963) used percentage of nonagricultural employment of the labor force (the compliment of our percentage of economically active involved in agriculture) as her measure of both industrialization (economic development) and urbanization (the compliment of ruralism) p 317.

supplies and high own time inputs into the production of health in rural areas. There of course is a high probability that industrialization will bring with it many new health problems such as industrial diseases and accidents. Concentrating our work force in urban areas also should increase the incidence of communicable diseases such as cholera.

Rural Water Supply: Given that many of the major parasitic and infectious disease are helped in transmission by a low level of sanitation, we felt that it would be valuable to try to control for these vectors in our analysis. Water borne diarrhoeal disease may cause 1/3 of the deaths of children before the age of 5 in some developing countries.[50] A good overview of the effects of safe water supply is given in The World Health Organization's Health Principles of Housing (1989). An important point regarding health and water supply is that education regarding correct personal hygiene practices must be linked with the use of additional clean water in order to reduce the incidence of disease.

We were able to collect data on both total percentage of the population served with safe water, and also the percentage of the rural population served by safe water. Both of these measures should give us a measure of the level of sanitation in many countries.

We were able to collect 198 valid observations of data. This represents approximately 50% of our sample. Unfortunately, the availability of this data is not random, and more developed countries are more frequent reporters of data than less developed countries.

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[50] See WHO (1989).

This problem will definitely lead to some bias in our results. Nevertheless, we hope it will give us some general insight into the effect of sanitation on health. However, we are careful in drawing any firm conclusions from this censored subsample. The data were collected from The World Resource Institute's World Resources 1988-89, The World Bank's World Tables and World Development Report.

Pharmaceutical Consumption Per Capita: The posited relationship between pharmaceuticals and infant mortality rates has 3 main components. For infant mortality, 1) there may be effects of pediatric use of antibiotics that may prevent or cure infectious disease, therefore decreasing both neonatal and post neonatal mortality 2) increases in pharmaceuticals may have a positive impact on health of mothers, therefore causing less neonatal mortality, 3) increases in pharmaceutical consumption in other family and community members decrease the probability of contracting a disease.

For life expectancy and child mortality, the own consumption effects and the transmission effect are present. Most likely the most important effect for both of these groups will be the curative power of the pharmaceuticals directly.

Pharmaceutical consumption is the new area of consideration that we are exploring in this study. This variable presents some problems in terms of estimation. We would like to have obtained a disaggregate measure of all of the variables in our study but, for the developing areas, that appears to be unavailable at the present time. In using

aggregate data, finding domestic consumption presents many problems. Pharmaceuticals that are consumed in a hospital setting may be grouped into hospital expenditures[51] and data on domestic consumption is suspect or non existent. Our proposed method of solving this problem is to estimate domestic consumption using some of the available trade data.[52] This methodology is consistent with the methodology used by The United Nations Food and Agricultural Organization for the estimation of per capita protein and calorie consumption.

Pharmaceutical consumption per capita is calculated by the following relationship for countries that do not have per capita consumption reported.

PHDC = (IMPH - EXPH) + DPPH - SP

Where

PHDC = Domestic Consumption of Pharmaceutical

IMPH = Imports of Pharmaceutical

EXPH = Exports of Pharmaceutical

DPPH = Domestic Production of Pharmaceutical

SP = Spoilage and loss

PHARM = PHDC / population

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[51] OECD Social Policy Studies No. 4, p 77.

[52] This methodology was developed independently by the author, but subsequent research has shown that the methods are the same as the methods of Lall (1978) writing for UNIDO in The Growth of the Pharmaceutical Industry in Developing Countries: Problems and Prospects: Table 7. Lall reported gross consumption at the national level. He did not apply his results further or calculate per capita consumption.

For a substantial number of countries in the developed and developing world, IMPH and EXPH are available. The sources for this data are from The Organization for Economic Co-operation and Development (OECD) Foreign Trade by Commodities: Schedule C and The United Nations: World Trade Annual: International Trade Statistics. The reporting of pharmaceutical imports and exports by The United Nations and the OECD is under the Standard International Trade Classification (SITC) number 541: medicinal and pharmaceutical products.[53] The use of OECD data may not represent a serious compromise in our analysis, as seven of The OECD countries: The United States, Japan, The Federal Republic of Germany, France, The United Kingdom, Italy, and Switzerland produced more than 90% of world pharmaceutical output in 1980.[54]

The bulk of the data for imports and exports comes from The United Nations World Trade Annual. Data is listed in United States dollars from 1970 on. Prior to this date, Imports and Exports are reported in domestic currency units. The trade conversion factors explained below are used to convert data from these years into United States dollars. Prior to the mid 1960's, reporting by most countries, especially developing countries, is very spotty. Therefore, our database starts in the mid 1960's with 1965 being our first year for many countries. We collected data on 5 year intervals from 1960 up until 1985 for reporting countries. OECD data was used for countries that did not report in the Trade Statistics Annual, but had viable data reported in the OECD. This

[53] For a detailed description of the products that are in SITC 541 see The United Nations Standard International Trade Classification. Revised 1961.

[54] UNIDO Industry and Development (1991) p 172.

methodology was checked when sources were provided by both methods for a given observation. We feel that the variation overall between the methods is not a major contributor to error.

Using these sources we are able to calculate the net trade position in pharmaceuticals. The unavailable portion of domestic consumption is spoilage and domestic production. We are unable to find data on spoilage and loss for pharmaceuticals at this time. A considerable amount of anecdotal information exists that suggests that this may not be an insignificant problem.[55] We will continue to look for a viable measure of spoilage and loss (SP) for use in future studies.

An acceptable measure of domestic production is available in The United Nations Industrial Statistics Yearbook Volume 1. The International Standard Industrial Classifications of All Economic Activities (ISIC) code for drugs and medicines is 3522.[56] The measure of domestic production presents a problem in that it is quoted in domestic currency units. To convert this data, we will use conversion factors reported by The International Bank for Reconstruction and Development / World Bank in World Tables 1991, 1976. As a rule, this is an average of three years of annual average exchange rate reported in The International Monetary Fund's International Financial Statistics with

[55] See UNIDO (1980) for a description of some of the problems tropical countries face in terms of degradation during transportation and storage p 24.

[56] A description of exactly the products included in ISIC code 3522 is available from The United Nations Index to the International Standard Industrial Classification of All Economic Activities (1971).

corrections for differences in the price level between the country and The United States.[57] Certain exceptions to the use of World Bank conversion factors were made. For certain countries the conversion factors were not reported, and for others they were clearly not accurate. In these instances, end of period exchange rates from The United Nations Statistical Yearbook were used as the measure of exchange for our monetary units. The problems of conversion factors were most pronounced in countries that exhibited high inflation, and/or monetary devaluation. Particularly problematic examples are Israel and Peru. Also problematic were countries that do not have convertible currencies; command economies such as Czechoslovakia, Hungary, The Soviet Union and Albania. Conversion factors for these countries were again obtained from The United Nations Statistical Yearbook.

The requirements of 5 variables, namely: exchange rates, imports of pharmaceuticals, exports of pharmaceuticals, domestic production, and population presented problems for data collection for inclusion in our per capita pharmaceutical data. This limited the number of cases. Certain exceptions were allowed. If data were available from other sources, such as below, then a case was included in the sample. Also, if reports of no domestic production were available from reliable sources, then a country was included if trade figures were complete. A country was also included if it had positive imports reported and an amount of zero reported as exports. This convention allows us to include a number of countries that have small economies, and limited reporting of production.

[57] For further discussion of the conversion factors, please see The World Bank's World Tables 1991 p viii in sources and methods.

This does leave open a window of potential error; however, we feel that this is limited in nature, and the value of having these countries in our survey should outweigh the risk of including them. Typical examples are Gabon, Zaire, Syria, Chad and Ethiopia. We feel that the levels of domestic production by countries included is limited, and most have very minimal domestic industry.

Our data was expanded by reporting of OECD countries data in The OECD publication Social Policy Studies Number 7: Health Care Systems in Transition. The data in this work are reported as total expenditures on pharmaceutical products from 1960 to 1987. The data were also augmented by reporting by The United Nations Industrial Development Organization of per capita pharmaceutical consumption for a number of countries in International Organizations' Role in the Development of Pharmaceutical Industries in the Arab World.

Obviously, what we will be measuring is apparent consumption of pharmaceutical products. The true availability of drugs is affected by illegal import or exports of products. This may be a cause for concern, as smuggling may affect the availability of products. This would be counted in our unavoidable loss function SP.[58] We also may be under reporting, to some degree, consumption in countries that import a significant amount of bulk drugs or raw materials that are processed or packaged for the domestic market. This problem may be partially offset by the lower cost of domestically produced

[58] For evidence of this problem, see Van der Geest (1987) p 297.

products. We are quite aware of the limitations of this data collection technique, and therefore we will not attempt to draw too many strong conclusions from the data. We do feel that this work should give some indication as to directions for future study.

We will not separate the categories of pharmaceuticals into prescription and non prescription markets, as this is not a correct model for most developing countries. It is also not possible for us at the present time, as our data counts both prescription drugs and over the counter items in pharmaceuticals. While the duality of the market is apparent in the developed world, the majority of developing countries either do not have a prescription requirement, or they do not enforce such laws. As a consequence, the division between prescription and non prescription drugs is blurry at best.[59] Greenhalgh and Wolfers report extensive dispensing of prescription drugs without a prescription in India and Sri Lanka. Wolfers reports that tetracycline is available over the counter in most pharmacies in Colombo, Sri Lanka, which is a direct violation of state laws.

Also not corrected for are differentials in the pricing of goods across nations and time. This is not attempted as proper price indexes for pharmaceuticals do not appear to be available. There is some evidence that the pricing of pharmaceutical products is not uniform across nations.[60] This possibly would affect our results. However, it is impossible to explain the massive differences in per capita consumption that we observe

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[59] See UNIDO (1980) and Hardon (1987).

[60] See WHO (1988) p 15. Also see the report by Rublee and Schneider in Health Affairs Fall (1991) 187-198.

in our data (a maximum of U.S. $204.00 to a minimum of U.S. $0.12 per year), as being caused by price differentials. Clearly, there is a difference in the actual physical amount of pharmaceuticals being purchased across nations. The changes in price over time should be significantly offset by quality increases in the pharmaceutical market over time. No correction has been made for quality issues in our study.

Dichotomous Variables: In these models we have included two types of dichotomous variables to compensate for variation caused by a number of extraneous effects.

Time Variables: We have included variables to compensate for differences in time periods. Periods were constructed around 1960, 1965, 1970, 1975, 1980 and 1985. The standard for all of our time variables was 1980. This was chosen for the simple fact that 1980 had the largest number of observations. Eighty-seven out of 306 observations were for this time period. The expected coefficients for our time variables are as follows: 1960 to 1975 all should be positive for negative measures such as infant mortality. We tend to observe higher infant mortalities in the early periods 1960, 1965 as opposed to later periods. This should be due to increased levels of health caused by improvements in the quality of health care facilities in many countries. It may also include some technological improvements in both surgical and medical techniques, improvements in the potency of pharmaceuticals, increases in the types of diseases that are preventable by vaccination, increases in vaccination coverage and improved health information over this time period. Smallpox was effectively eliminated during our study period. The technological advances

that allowed the program to succeed included the bifurcated needle and the jet injector coupled with freeze dried vaccine.[61]

Country Dichotomous Variables: These variables were included to control for effects of the different cultural and environmental factors in the diverse countries. Obviously, there may be some spillover effects of vector controls and vaccination programs outside of the political boundary. There is some discussion over where economists, sociologists or epidemiologists should define the "whole community".[62] The reference for our country dichotomous variables is the United States. The United States is also advantageous due to the consistency of reporting of data. The codes for classification of the countries comes from the United States Department of the Census International Data Base.

V. RESULTS

We will present our result for the three different samples in chronological order. We present first our infant mortality and life expectancy models for the 1980 data from the OECD. Our second group of models use the same sample from the OECD, however they track the changes that are observed between male and female life expectancy at various ages.

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[61] See Hopkins (1988) for an overview of the technological advances that helped eradicate smallpox in 1976.

[62] This name taken from Williams (1981), p 276.

The third group of models is related to our 1984 sample drawn from United Nations data collected on 44 countries across the world. We again present infant mortality and life expectancy models.

The fourth group of models is produced from our third cross national database, which includes data from 1960-1985. We again present models of infant mortality and life expectancy at birth. The fifth group of models explores the relationship in our third database between life expectancy at age 15 for females and our explanatory variables. The sixth group examines child mortality, again using our third database.

We present in table 3 an outline of the data definitions and some measures of the variation in our variables. Please note that all means and variances relate to the original data: not the natural log transform.

DATABASE 1

Dependent Variable: LN OF INFANT MORTALITY

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	6.13810	1.53453	27.370	0.0001
Error	18	1.00918	0.05607		

TABLE 1: VARIABLES: CROSS NATIONAL DATABASE 3

VARIABLE NAME	VARIABLE DESCRIPTION	ORIGINAL DATA Mean	Stan.Dev.
LNAGRI	Natural log of the percentage of the population that is works in agriculture	36.92	26.22
LNAUXCP	Natural log of the number of auxiliary health personnel per capita	0.0031	0.0034
LNBEDS	Natural log of the number of hospital beds per capita	0.0055	0.0043
LNCHILD	Natural log of the number of deaths per 1000 children between the ages of 1 and 5	9.51	11.97
LNFEM15	Natural log of the life expectancy of females at the age of 15 years	62.13	1.54
LNGNP	Natural log of Gross National Product per capita	2840	3776
LNINF	Natural log of the number of infant deaths per 1000 live births (age 0 to age 1)	63.84	52.28
LNLIFE	Natural log of the life expt. at the time of birth, if current patterns of deaths continue in the future	62.53	10.99
LNLIT	Natural log of the literacy rate	71.38	29.68
LNPHARM	Natural log of the expenditures per capita on pharmaceutical products	23.21	33.09
LNPHYCP	Natural log of the number of physicians per capita	0.001	0.0008
LNPRO	Natural log of the protein consumptions per capita	75.64	21.74
LNRURWAT	Natural log of the percentage of the rural population that is served by a safe water supply	46.08	34.64
LNFEMXX	Natural log of the life expectancy for females in the OECD at a given age XX, example fem00	76.88	3.40
LNMALXX	Natural log of the life expectancy for males in the OECD at a given age XX, example mal80	6.25	0.474
DUMXX	Dichotomous variables for different time periods 19XX. Base period is 1980.		

C Total 22 7.14729

Root MSE 0.23678 R-square 0.8588

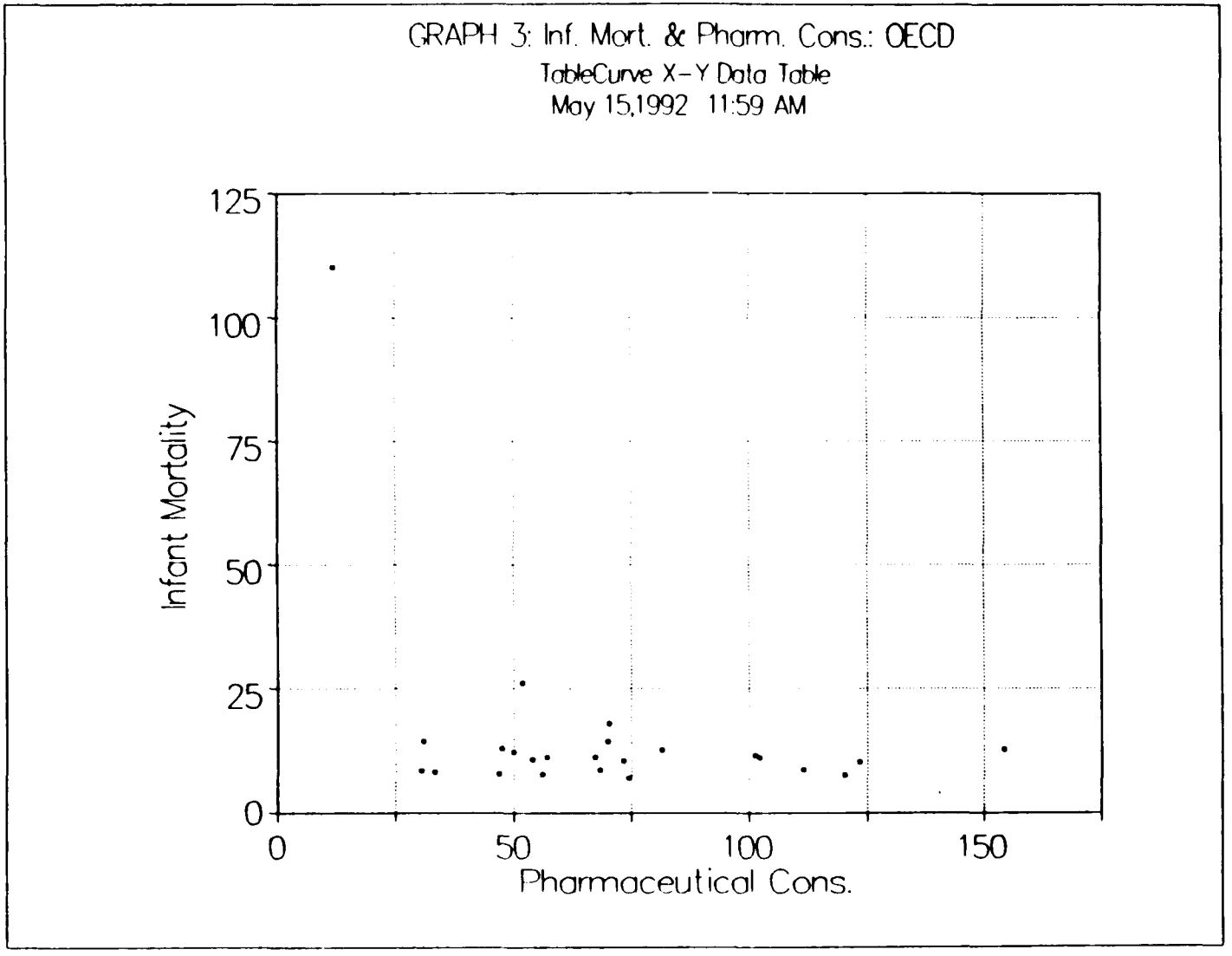
Dep Mean 2.49374 Adj R-sq 0.8274

C.V. 9.49506

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	-0.348536	0.09630316	-3.619	0.0020
LNBEDS	-0.572723	0.17276439	-3.315	0.0039
LNPHARM	-0.138671	0.11733333	-1.182	0.2526
LNPHYCP	-0.612089	0.18315812	-3.342	0.0036
INTERCEP	-5.436055	1.53483006	-3.542	0.0023

This first model of infant mortality rates, as a function of our independent variables, presents some interesting findings. Please note the correct sign on all of the explanatory variables, and also the significance at 1% level for per capita auxiliary health personnel, physicians and hospital beds. Pharmaceutical consumption per capita is insignificant in this model. The relationship between pharmaceutical consumption per capita and infant mortality in our OECD data is plotted in graph 3. The overall relationship between pharmaceutical consumption is not readily apparent in this limited sample of the developed world. Also please note that the values for infant mortality are extremely low in relation to the world average. The single exception is Portugal, which exhibited an


GRAPH 3: Inf. Mort. & Pharm. Cons.: OECD
TableCurve X-Y Data Table
May 15,1992 11:59 AM
125
100
75
50
25
0
Infant Mortality
0
50
100
150
Pharmaceutical Cons.

infant mortality rate of 26 per 1000 live births.[63] Given the extremely small size of this database, we must be cautious in drawing conclusions regarding the interrelationship between our variables.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	5	6.27358	1.25472	24.413	0.0001
Error	17	0.87371	0.05139		
C Total	22	7.14729			

Root MSE	0.22670	R-square	0.8778
Dep Mean	2.49374	Adj R-sq	0.8418
C.V.	9.09090		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	-0.266372	0.10517914	-2.533	0.0215
LNBEDS	-0.477149	0.17557296	-2.718	0.0146
LNGDP	-0.348523	0.21466258	-1.624	0.1229

[63] The extreme observation of infant mortality is Turkey, which unfortunately does not report data consistently, and was not included in the regression model.

LNPHARM	-0.082087	0.11762089	-0.698	0.4947
LNPHYCP	-0.522503	0.18383804	-2.842	0.0113
INTERCEP	-1.080618	3.05872492	-0.353	0.7282

The inclusion of GDP per capita in our model lowers the significance of our pharmaceutical coefficient. It is important to remember that the effect of including an income variable is to change the interpretation of our coefficients to be a mixture of demand and supply effects. GDP per capita is not significant in our model, and this model has little more explanatory power than our first model of infant mortality rates.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	6	6.39488	1.06581	22.664	0.0001
Error	16	0.75241	0.04703		
C Total	22	7.14729			

Root MSE	0.21685	R-square	0.8947
Dep Mean	2.49374	Adj R-sq	0.8553
C.V.	8.69594		

Parameter Estimates

	Parameter	Standard	T for H0:

Variable	Estimate	Error	Parameter=0	Prob > |T|
LNAUXCP	-0.219534	0.10475109	-2.096	0.0524
LNBEDS	-0.665218	0.20473967	-3.249	0.0050
LNBUTTER	0.101171	0.06299480	1.606	0.1278
LNGDP	-0.480312	0.22112584	-2.172	0.0452
LNPHARM	0.015396	0.12783955	0.120	0.9056
LNPHYCP	-0.459420	0.18018435	-2.550	0.0214
INTERCEP	-0.689114	2.93597277	-0.235	0.8174

For our third model, using the OECD database, we added our butter consumption variable to study any effects that this nutrition variable had on our results. Butter consumption had no significant effect on infant mortality rates. We observe that the inclusion of butter supply in our model lowers the overall significance of the model and does not contribute to the explanation of variation in infant mortality rates. We have discovered that this variable is not a good proxy for nutrition status. This is opposite to the results obtained by Wolfe and Gabay (1987), who found butter consumption to have a negative effect on infant mortality rates, and so argued that it may be a measure of income or nutrition. We feel, overall, that consumption of butter is most likely too linked to cultural and societal norms to be an adequate measure of nutritional status.

Dependent Variable: LNFEM0

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	0.04516	0.01129	22.824	0.0001
Error	18	0.00890	0.00049		
C Total	22	0.05407			

Root MSE	0.02224	R-square	0.8353
Dep Mean	4.33981	Adj R-sq	0.7987
C.V.	0.51251		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.036524	0.00904615	4.038	0.0008
LNBEDS	0.012180	0.01622846	0.751	0.4626
LNPHARM	0.024203	0.01102160	2.196	0.0414
LNPHYCP	0.077572	0.01720479	4.509	0.0003
INTERCEP	4.989226	0.14417284	34.606	0.0001

For our 4th. OECD model, we examined life expectancy at birth for females. You clearly see that the explanatory variables, for the most part, exhibit the correct signs. Physicians per capita, and auxiliary health personnel show the correct sign and are significant at the 1% level. Pharmaceutical consumption is significant at the 5% level and its coefficient exhibits the correct sign. This is an important result as this subsample

consists of countries that overall have a very high level of health status and pharmaceutical consumption. Therefore we expect that there may be a considerable amount of overutilization of drugs in these societies. This overutilization should tend to lower the explanatory power of pharmaceuticals on health, however this is not what we observe in this model.

Dependent Variable: LNFEM0

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	5	0.04517	0.00903	17.255	0.0001
Error	17	0.00890	0.00052		
C Total	22	0.05407			

Root MSE	0.02288	R-square	0.8354
Dep Mean	4.33981	Adj R-sq	0.7870
C.V.	0.52724		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.036992	0.01061569	3.485	0.0028
LNBEDS	0.012724	0.01772051	0.718	0.4825
LNGDP	-0.001982	0.02166581	-0.091	0.9282

LNPHARM	0.024524	0.01187143	2.066	0.0544
LNPHYCP	0.078082	0.01855470	4.208	0.0006
INTERCEP	5.013996	0.30871595	16.241	0.0001

In model 5 we have added Gross Domestic Product per capita to our model. The effect is decreased significance on the coefficient of physicians per capita and auxiliary health personnel per capita. The significance of pharmaceuticals basically remains unchanged. GDP per capita is insignificant at the 10% level. All of the coefficients, with the exception of GDP per capita remain with the correct sign, and the numerical values of the coefficients are not altered in a significant way. The model also has an almost nonexistent improvement in R^2, and in the overall F statistic for the model. This again undermines the position that GDP per capita is contributing to the explanatory power of our model, and that our other dependant variables are not the primary determinants of life expectancy at birth.

Based upon a concern about the relative weights placed upon observation from countries with radically different populations, we re-estimated the models using population in thousands as weights. We were concerned that a country such as the United States, with a population of 227,757 thousand people was given the same weight in our model as Iceland with 228 thousand people. By weighting we then give more importance to the larger countries with more deaths.

This then gives every death or individual the same relative value in our model. A country that is small and has poor health status is given less weight than a large country with good health status. We feel that this weighting should give us a more accurate estimate of the relative effects of our health inputs.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	231333.6048	57833.40119	35.891	0.0001
Error	18	29004.41522	1611.35640		
C Total	22	260338.01998			

Root MSE	40.14170	R-square	0.8886
Dep Mean	2.55194	Adj R-sq	0.8638
C.V.	1572.98663		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	-0.426151	0.10991978	-3.877	0.0011
LNBEDS	-0.547495	0.18935660	-2.891	0.0097
LNPHARM	-0.314750	0.15931384	-1.976	0.0637
LNPHYCP	-0.199307	0.18373552	-1.085	0.2923

INTERCEP	-2.344599	2.23681845	-1.048	0.3084

Weighting the model by population increases the explanatory power of our model, with improvements in both R^2 and the F statistic. This model, the simplest weighted model; health inputs only, is very consistent with our a priori expectations. By leaving out GDP per capita, we see that the signs on all our coefficients confirm our a priori predictions. The significance level is high, and overall the model exhibits good explanatory power. The insignificance of physicians per capita is not extremly distressing, as the high level of multicollinearity in the data may cause this result.

We feel there is good indication that our model is explaining the primary components of infant mortality rates. This also therefore emphasizes the fact that pharmaceutical consumption does have a measurable impact on infant mortality rates. We must remain cautious in our use of this model, as it does not hold many of the underlying societal variables constant. The homogeneity of the developed world helps to diffuse some of this problem, as we have a sample with closer levels of development than a sample from all countries.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F

Model	5	231407.63	46281.53	27.196	0.0001
Error	17	28930.39	1701.79		
C Total	22	260338.02			

Root MSE	41.25273	R-square	0.8889
Dep Mean	2.55194	Adj R-sq	0.8562
C.V.	1616.52321		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	-0.451838	0.16712096	-2.704	0.0151
LNBEDS	-0.536953	0.20105540	-2.671	0.0161
LNGDP	0.061439	0.29459204	0.209	0.8373
LNPHARM	-0.335314	0.19112155	-1.754	0.0974
LNPHYCP	-0.216197	0.20545464	-1.052	0.3074
INTERCEP	-3.006275	3.91788678	-0.767	0.4534

Weighting the model obviously increases the F statistic and also the R^2. Weighting the model increases the significance of the parameter estimates, however the model of infant mortality rates with GDP per capita remains with only a very marginal improvement in R^2, and lower F statistics than the model without GDP per capita. For the most part, coefficients remain with consistent signs and very high significance. The one insignificant coefficient is GDP per capita. This may be due to the limited

explanatory power of GDP on health, given that we have included our other health variables. It may also be caused by the overall high levels of GDP per capita in the OECD. This reduces the explanatory power of GDP, as we have probably reached the level of nutrition and health quality that is most important in reducing infant mortality and life expectancy in most of our OECD countries.

Dependent Variable: LNFEM0

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	1862.47032	465.61758	29.150	0.0001
Error	18	287.51203	15.97289		
C Total	22	2149.98235			

Root MSE	3.99661	R-square	0.8663
Dep Mean	4.33639	Adj R-sq	0.8366
C.V.	92.16450		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.036466	0.01094389	3.332	0.0037
LNBEDS	0.037567	0.01885282	1.993	0.0617
LNPHARM	0.032519	0.01586169	2.050	0.0552

LNPHYCP	0.029738	0.01829317	1.626	0.1214
INTERCEP	4.767240	0.22270332	21.406	0.0001

The health coefficients of the weighted model of life expectancy at birth exhibit all of the correct signs, and with the exception of physicians per capita, are significant at the 10% level. Again as in our infant mortality models, we find that the overall significance of the model is improved, and we have a corresponding increase in R^2.

Dependent Variable: LNFEM0

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	5	1880.12768	376.02554	23.688	0.0001
Error	17	269.85467	15.87380		
C Total	22	2149.98235			

Root MSE	3.98419	R-square	0.8745
Dep Mean	4.33639	Adj R-sq	0.8376
C.V.	91.87819		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.049011	0.01614056	3.037	0.0075

LNBEDS	0.032418	0.01941796	1.669	0.1133
LNGDP	-0.030008	0.02845174	-1.055	0.3063
LNPHARM	0.042563	0.01845854	2.306	0.0340
LNPHYCP	0.037987	0.01984284	1.914	0.0726
INTERCEP	5.090411	0.37839002	13.453	0.0001

In this model, we have again weighted the observations by population, and have added GDP per capita. The overall effect is very interesting. The coefficients, with the exception of GDP per capita and hospital beds per capita, all exhibit the correct sign and are all significant at the 10% level. The insignificance of GDP per capita makes perfect sense when we again remember the basis for the sample. All of the countries in this sample are in the developed world, therefore, the vast majority (basically all the countries except Greece, Portugal and Turkey) have high enough levels of GDP per capita to provide for the majority of the positive effects that income can have on health. The incomes in some of the countries are so high that the income effect may have a significant negative component on life expectancy. Over consumption of foods, rich diet, use of motor vehicles and lack of exercise may all have a positive correlation with income, and so therefore a negative correlation with life span. These problems should be most obvious in our life expectancy data, as the negative health effects of income most likely involve goods that over long periods of consumption cause poor health status.

To further understand the interrelationship between pharmaceutical consumption and

health, we now will examine the coefficients on pharmaceuticals and our other health variables as they are related to measures of life expectancy at various ages. We have studied both the effects of pharmaceutical consumption on both males and females in the following models. All models presented in this section are weighted by population in thousands, as we feel that this should present the most consistent and correct results.

Dependent Variable: LNFEM1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	33.64278	8.41069	2.859	0.0606
Error	15	44.13231	2.94215		
C Total	19	77.77509			

Root MSE	1.71527	R-square	0.4326
Dep Mean	4.35115	Adj R-sq	0.2812
C.V.	39.42113		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.013556	0.00627926	2.159	0.0475
LNBEDS	0.000358	0.00882703	0.041	0.9681
LNPHARM	0.016685	0.00728890	2.289	0.0370

LNPHYCP	-0.011844	0.00965943	-1.226	0.2390
INTERCEP	4.275446	0.11409906	37.471	0.0001

The most important result we immediately observe is that we find a decline in the size of the coefficient of pharmaceuticals when we study life expectancy at age 1 for females. This may be showing to some degree the untreatability of diseases that occur in childhood. We also observe that the model does not have as high an explanatory power as our model of life expectancy at age 0. We must be cautious in directly comparing our life expectancy at age 0 to our models of life expectancy at later ages, as we were unable to observe data for all of our countries at later periods in the life cycle.

Dependent Variable: LNFEM20

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	43.14217	10.78554	2.457	0.0906
Error	15	65.84245	4.38950		
C Total	19	108.98462			

Root MSE	2.09511	R-square	0.3959
Dep Mean	4.07744	Adj R-sq	0.2348
C.V.	51.38305		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.015260	0.00766979	1.990	0.0652
LNBEDS	-0.001817	0.01078175	-0.169	0.8684
LNPHARM	0.020404	0.00890300	2.292	0.0368
LNPHYCP	0.013516	0.01179848	-1.146	0.2699
INTERCEP	3.973171	0.13936596	28.509	0.0001

At age 20, the coefficient on pharmaceuticals has again increased in magnitude and is significant at the 5 per cent level. We seem to observe that this factor can have some significant impact on increasing life expectancy in young adulthood for females.

Dependent Variable: LNFEM40

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	92.82182	23.20546	2.448	0.0915
Error	15	142.21001	9.48067		
C Total	19	235.03183			

Root MSE	3.07907	R-square	0.3949
Dep Mean	3.68210	Adj R-sq	0.2336
C.V.	83.62264		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.025127	0.01127185	2.229	0.0415
LNBEDS	-0.010494	0.01584533	-0.662	0.5178
LNPHARM	0.033446	0.01308424	2.556	0.0219
LNPHYCP	-0.014921	0.01733956	-0.861	0.4030
INTERCEP	3.521661	0.20481833	17.194	0.0001

Moving further along in the life cycle, we again observe an increase in the size of the pharmaceutical coefficient. We also note again that only two of our health inputs are significant for females at age 40; pharmaceutical consumption and auxiliary health workers per capita.

Dependent Variable: LNFEM60

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	420.41289	105.10322	4.262	0.0168
Error	15	369.92745	24.66183		
C Total	19	790.34034			

Root MSE 4.96607 R-square 0.5319

Dep Mean 3.08552 Adj R-sq 0.4071

C.V. 160.94771

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.061024	0.01817978	3.357	0.0043
LNBEDS	-0.044319	0.02555610	-1.734	0.1034
LNPHARM	0.065067	0.02110288	3.083	0.0076
LNPHYCP	0.001414	0.02796607	0.051	0.9604
INTERCEP	2.916678	0.33034065	8.829	0.0001

By the age of 60, health for females is over 3 times as responsive to changes in current consumption of pharmaceuticals as it was in the first year of life. This radical shift may be caused by the impact of pharmaceuticals on treating and controlling diseases that occur in the geriatric population. If this is the case, we can be successful in expanding life expectancy for older female residents by consuming more pharmaceuticals.

The most interesting results we will observe may be linked to the comparison between the models for life expectancy at various ages for both females and males. The male models follow. All are weighted by population.

Dependent Variable: LNMAL0

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	167.24989	41.81247	4.197	0.0177
Error	15	149.42502	9.96167		
C Total	19	316.67491			

Root MSE	3.15621	R-square	0.5281
Dep Mean	4.25805	Adj R-sq	0.4023
C.V.	74.12347		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.006229	0.01155426	0.539	0.5977
LNBEDS	0.018941	0.01624232	1.166	0.2618
LNPHARM	0.014769	0.01341205	1.101	0.2882
LNPHYCP	-0.043796	0.01777398	-2.464	0.0263
INTERCEP	4.038025	0.20994977	19.233	0.0001

In the first male life expectancy model, we observe that the health coefficients have very little explanatory power. The only significant coefficient is the number of physicians per capita, and that exhibits the incorrect sign. As we have a different size sample in this model than in our life expectancy at age 0 for females, we must be cautious in comparing

this model directly with the female model.

Dependent Variable: LNMAL1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	117.67627	29.41907	3.660	0.0284
Error	15	120.56532	8.03769		
C Total	19	238.24160			

Root MSE	2.83508	R-square	0.4939
Dep Mean	4.25829	Adj R-sq	0.3590
C.V.	66.57797		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.002008	0.01037867	0.194	0.8492
LNBEDS	0.010171	0.01458974	0.697	0.4964
LNPHARM	0.012428	0.01204744	1.032	0.3186
LNPHYCP	-0.043103	0.01596557	-2.700	0.0165
INTERCEP	3.988464	0.18858839	21.149	0.0001

The comparison between female and male life expectancy at age one is very striking.

In the female model, pharmaceutical consumption , along with auxiliary health workers per capita have significant coefficients. In the male model, in marked contrast, we observe that the only significant coefficient is again physicians per capita, which exhibits an incorrect sign.

Dependent Variable: LNMAL20

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	183.52085	45.88021	3.604	0.0299
Error	15	190.94577	12.72972		
C Total	19	374.46662			

Root MSE	3.56787	R-square	0.4901
Dep Mean	3.95894	Adj R-sq	0.3541
C.V.	90.12202		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	-0.002674	0.01306127	-0.205	0.8405
LNBEDS	0.009812	0.01836079	0.534	0.6009
LNPHARM	0.016278	0.01516137	1.074	0.3000
LNPHYCP	-0.056192	0.02009223	-2.797	0.0135

INTERCEP	3.562108	0.23733335	15.009	0.0001

At age 20, male expectation of life still does not exhibit any strong relationship to our health inputs. This again is in marked contrast to life expectancy for females at age 20, where pharmaceutical consumption and auxiliary health personnel are both significant.

Dependent Variable: LNMAL40

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	237.82225	59.45556	2.304	0.1061
Error	15	387.00376	25.80025		
C Total	19	624.82601			

Root MSE	5.07939	R-square	0.3806
Dep Mean	3.52005	Adj R-sq	0.2155
C.V.	144.29884		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.009292	0.01859465	0.500	0.6245
LNBEDS	-0.000490	0.02613930	-0.019	0.9853

LNPHARM	0.034610	0.02158446	1.603	0.1297
LNPHYCP	-0.061969	0.02860426	-2.166	0.0468
INTERCEP	3.019070	0.33787910	8.935	0.0001

By the age of 40, life expectancy for males continues to not be as driven by health inputs as it is for females at 40. We note that the model has less explanatory power than the female life expectancy at age 40. The only significant explanatory variable is physicians per capita, which continues to exhibit the wrong sign. The significance level of physicians per capita has decreased from our models at age 0, age 1, and age 20. The pharmaceutical coefficient has increased in significance and now is significant at the 13% level. We note a continual improvement in the significance of pharmaceutical consumption as we move later in the life cycle for men from the age of one.

Dependent Variable: LNMAL60

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	311447.8083	77861.95208	11.365	0.0001
Error	18	123314.6227	6850.81237		
C Total	22	434762.4310			

Root MSE 82.76963 R-square 0.7164

Dep Mean 2.63395 Adj R-sq 0.6533

C.V. 3142.40917

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.603020	0.22664758	2.661	0.0159
LNBEDS	0.265633	0.39044124	0.680	0.5049
LNPHARM	0.496072	0.32849499	1.510	0.1484
LNPHYCP	0.342557	0.37885093	0.904	0.3778
INTERCEP	7.244197	4.61217704	1.571	0.1337

At the age of 60, the model is much more consistent with our a priori expectations than in the previous models since the age of one. The number of auxiliary health personnel has become a significant variable for males at the age of 60. We again observe that the coefficient on pharmaceuticals is significant at the 15% level and exhibits the correct sign. The significance of physicians per capita has dropped, and the sign has changed to the expected positive one.

Dependent Variable: LNMAL80

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F

Model	4	1710.8596	427.7149	21.333	0.0001
Error	9	180.44891	20.04988		
C Total	13	1891.3085			

Root MSE	4.47771	R-square	0.9046
Dep Mean	1.85191	Adj R-sq	0.8622
C.V.	241.78906		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAUXCP	0.069395	0.01793936	3.868	0.0038
LNBEDS	-0.139761	0.02525233	-5.535	0.0004
LNPHARM	0.055615	0.02366577	2.350	0.0433
LNPHYCP	0.065157	0.02999116	2.173	0.0579
INTERCEP	1.711141	0.31949769	5.356	0.0005

At the age of 80, life expectancy for males is very well described by the variables in our model. At this point in the life cycle, we observe that males have a very short span to live on average. It appears however that we can alter the life span significantly during this period by increasing consumption of health inputs. We find that all of our health inputs are significant at the 10 per cent level.

The sign on hospital beds is conterintuative. This result may indicate that advanced

technology in the medical system actually lowers life expectancy at very advanced ages. The posited relationship may be that increase health capita encourages utilization, and so therefore more hopital inpatient time for the very elderly. This extra time in a hospital may undermine the patients mental state and lowers the level of physical activity. The outcome of these ineractions lowers the probibility further independent, productive living.

The results of our male and female life expectancy models point out some important differences in the sensitivity of males and females to health inputs. We observe that females are more effected by health inputs, and that effect starts at an earlier age. We believe that this may be linked to the needs of women for child birth facilities and birth control measures early in the life cycle. These needs, if met, can alter the life expectancy of women in a radical way. Left unmet these needs can contribute to early death and higher morbidity.

In contrast, males appear to not need much in the way of health goods and services early in life. For males, additions to gross consumption of health inputs have little effect on health outcomes. Only very late in life do health inputs have a direct effect on life expectancy for males.

Given the limited group of countries that were sampled in database 1, we felt it was necessary to develop a more comprehensive cross national database. We felt that we were censoring out the countries that should have the most interesting interrelationships

between health inputs and health outputs.

To examine some of these problems, we compiled database 2. Included were variables for educational levels (literacy rates) and nutritional status. Both protein consumption per day per capita and calorie consumption per day per capita were included in our sample. We will report protein consumption models, as they most closely match the analysis of later models. We elaborated on the analytical reasons for using protein consumption per capita in the data description for database 3.

DATABASE 2

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	7	33.7933	4.82761	22.036	0.0001
Error	37	8.10589	0.21908		
C Total	44	41.8992			

Root MSE	0.46806	R-square	0.8065
Dep Mean	3.24888	Adj R-sq	0.7699
C.V.	14.40674		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAGRI	0.252446	0.12803806	1.972	0.0562
LNAUXCP	-0.243532	0.15864955	-1.535	0.1333
LNGNP	-0.014930	0.16855642	-0.089	0.9299
LNLIT	-0.490284	0.25440521	-1.927	0.0617
LNPHARM	-0.086689	0.13272403	-0.653	0.5177
LNPHYCP	-0.037959	0.15293084	-0.248	0.8053
LNPRO	-0.469402	0.50861070	-0.923	0.3620
INTERCEP	5.421558	3.79933761	1.427	0.1620

The unweighted model of infant mortality rates for database 2 produces results that again are consistent with our expectations. We observe that the most important variables are percentage of the economically active population that is involved in agriculture and the literacy rate. Both of these have major impacts on the infant mortality rates. The pharmaceutical coefficient exhibits the correct sign, but is statistically insignificant.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	7	0.44506	0.06358	15.881	0.0001

Error	37	0.14813	0.00400	
C Total	44	0.59319		
Root MSE		0.06327	R-square	0.7503
Dep Mean		4.21125	Adj R-sq	0.7030
C.V.		1.50247		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAGRI	-0.045318	0.01730843	-2.618	0.0127
LNAUXCP	-0.008446	0.02144655	-0.394	0.6960
LNGNP	-0.012872	0.02278578	-0.565	0.5755
LNLIT	0.114759	0.03439099	3.337	0.0019
LNPHARM	0.005146	0.01794189	0.287	0.7759
LNPHYCP	0.006156	0.02067349	0.298	0.7676
LNPRO	0.127501	0.06875497	1.854	0.0717
INTERCEP	3.361730	0.51360177	6.545	0.0001

In our unweighted model of life expectancy at birth, we observe that the variables with the strongest impact are again literacy rate, the percentage of the population that is involved in agriculture and protein consumption per capita. We feel the stronger coefficient on protein consumption reflects the impact of nutrition on overall health status. The short term effects of poor nutrition may not be readily observable in infant

mortality, but the cumulative effects of poor diet on expectation of life at birth may be very important.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	6	2300826.85	383471.14	59.316	0.0001
Error	38	245665.39	6464.88		
C Total	44	2546492.24			

Root MSE	80.40447	R-square	0.9035
Dep Mean	3.68101	Adj R-sq	0.8883
C.V.	2184.30571		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAGRI	0.076313	0.14128070	0.540	0.5922
LNAUXCP	0.111355	0.19815956	0.562	0.5775
LNLIT	-1.314373	0.20983795	-6.264	0.0001
LNPHARM	-0.296480	0.11933968	-2.484	0.0175
LNPHYCP	-0.463435	0.10148399	-4.567	0.0001
LNPRO	0.865838	0.55431974	1.562	0.1266

INTERCEP	3.264868	3.58760181	0.910	0.3685

The weigted model of infant mortality rates indicates that our variables have some interesting interrelationships. We observe that the parameter estimates of physicians per capita, literacy rates and pharmaceutical consumption all have statistically significant effects. The only coefficient that seems somewhat perplexing is the protein consumption per capita. This may be due again, in part, to our use of countries that overall exhibit very high levels of nutrition. Therefore any positive effects of pharmaceutical consumption may be offset in part by increases in infant mortality caused by obesity in the population. We can observe that this model with the removal of GNP per capita actually has more explanatory power than the unweighted model of infant mortality rates with GNP.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	7	2305603.618	329371.945	50.591	0.0001
Error	37	240888.627	6510.50342		
C Total	44	2546492.244			

Root MSE	80.68769	R-square	0.9054
Dep Mean	3.68101	Adj R-sq	0.8875

C.V. 2191.99983

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAGRI	0.165940	0.17620895	0.942	0.3524
LNAUXCP	0.093913	0.19989746	0.470	0.6413
LNGNP	0.168710	0.19696142	0.857	0.3972
LNLIT	-1.372819	0.22135613	-6.202	0.0001
LNPHARM	-0.367058	0.14536748	-2.525	0.0160
LNPHYCP	-0.395324	0.12920683	-3.060	0.0041
LNPRO	0.607765	0.63262475	0.961	0.3429
INTERCEP	3.672079	3.63149109	1.011	0.3185

Weighting the infant mortality model by population also improves the overall results of the model. The pharmaceutical consumption per capita is very significant and has a very strong coefficient. The model gives us some indication again that pharmaceutical consumption has a consistent and measurable positive effect on health.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F

Model	6	38593.486	6432.248	67.199	0.0001
Error	38	3637.344	95.720		
C Total	44	42230.830			

Root MSE	9.78364	R-square	0.9139
Dep Mean	4.16758	Adj R-sq	0.9003
C.V.	234.75579		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAGRI	-0.000760	0.01719107	-0.044	0.9650
LNAUXCP	-0.039417	0.02411211	-1.635	0.1104
LNLIT	0.260234	0.02553314	10.192	0.0001
LNPHARM	0.020973	0.01452129	1.444	0.1569
LNPHYCP	0.058958	0.01234860	4.774	0.0001
LNPRO	-0.007249	0.06744978	-0.107	0.9150
INTERCEP	3.231556	0.43654039	7.403	0.0001

The weighted model of life expectancy at birth without GNP per capita exhibits some coefficients that are consistent with our expectations. We observe that both literacy rates and physicians per capita are statistically significant, and exhibit the correct signs. Pharmaceutical consumption is not significant, however it does exhibit the correct sign.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	7	38662.23	5523.18	57.266	0.0001
Error	37	3568.57	96.45		
C Total	44	42230.83			

Root MSE	9.82078	R-square	0.9155
Dep Mean	4.16758	Adj R-sq	0.8995
C.V.	235.64704		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
LNAGRI	-0.011515	0.02144701	-0.537	0.5946
LNAUXCP	-0.037324	0.02433022	-1.534	0.1335
LNGNP	-0.020244	0.02397287	-0.844	0.4038
LNLIT	0.267247	0.02694203	9.919	0.0001
LNPHARM	0.029442	0.01769319	1.664	0.1046
LNPHYCP	0.050785	0.01572622	3.229	0.0026
LNPRO	0.023718	0.07699898	0.308	0.7598
INTERCEP	3.182694	0.44200152	7.201	0.0001

Weighting the model by population and including all of our relevant variables gives us some measure of the overall coefficient on pharmaceutical consumption. We are again encouraged by the correct sign on the coefficient of pharmaceuticals and an improvement in significance over our model without GNP. Physicians per capita and literacy rate retain their high level of significance. We also note that this model explains the majority of the variation that we observe in life expectancy at birth. The possible cause of the counterintuitive coefficients on auxiliary health personnel may be caused by a high degree of multicollinearity in the model. This may also be undermining the significance of our other coefficients.

The results from our first two databases, although they provided some basic insights into the relationship between pharmaceuticals and health, were mixed in statistical significance. We felt it was important to increase the number of observations and to control for more of the regional variation. We therefore constructed database 3.

For our third database, we will use four different measures of health; 1) infant mortality rate, 2) life expectancy at birth, 3) life expectancy at age 15 for females, 4) child death rates. Infant mortality and child death rates are negative measures of health and life expectancy is a positive measure of health. The expected signs on the coefficients of the explanatory variables, with the exception of percentage of the population involved in agriculture, for the infant mortality rates are all negative: nutrition, pharmaceutical consumption per capita, physicians per capita, auxiliary health personnel per capita,

hospital beds per capita and the literacy rate. The expected sign on national dichotomous variables are positive for the most part. The expectation is that most countries exhibit an infant mortality rate higher than The United States. The time dichotomous variables should exhibit a positive sign for years prior to 1980 and a negative sign for 1985.

DATABASE 3

Infant Mortality Rates

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	106	301.45791	2.84394	144.033	0.0001
Error	200	3.94901	0.01975		
C Total	306	305.40692			

Root MSE	0.14052	R-square	0.9871
Dep Mean	3.72641	Adj R-sq	0.9802
C.V.	3.77084		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	0.382991	0.11390557	3.362	0.0009

DUM65	0.274692	0.08039764	3.417	0.0008
DUM70	0.197957	0.05878385	3.368	0.0009
DUM75	0.118517	0.03518896	3.368	0.0009
DUM85	-0.175938	0.03854875	-4.564	0.0001
LNAGRI	0.269243	0.09498694	2.835	0.0051
LNAUXCP	-0.043860	0.02255022	-1.945	0.0532
LNBEDS	0.101912	0.06079278	1.676	0.0952
LNGNP	-0.079927	0.04748348	-1.683	0.0939
LNLIT	0.241635	0.05981373	4.040	0.0001
LNPHARM	-0.016734	0.02687196	-0.623	0.5342
LNPHYCP	-0.018567	0.03346532	-0.555	0.5796
LNPRO	-0.118570	0.15085522	-0.786	0.4328
INTERCEP	2.699291	0.83612300	3.228	0.0015

The model with dichotomous variables presents some consistent results. A good number of explanatory variables, namely, GNP per capita, auxiliary health personnel percentage of the population involved in agriculture, and hospital beds per capita are all significant and all the coefficents, with the exception of hospital beds per capita exhibit signs that follow our a priori expectations. We are concerned by the lack of explanatory power of our other variables and the inconsistent signs on the coefficients. The effects of literacy rates are particularly disturbing. The country variables and time variables

seem to be basically correct, and the model has reasonable explanatory power. We believe that these results appears to present evidence that our model with country specific variables is overdetermined. It also appears to have a good deal of multicollinearity.

To estimate our coefficients more precisely we again will estimate a weighted model, with weights based upon population in thousands.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	13	8283457.530	637189.041	180.698	0.0001
Error	293	1033197.529	3526.271		
C Total	306	9316655.059			

Root MSE	59.38242	R-square	0.8891
Dep Mean	3.76897	Adj R-sq	0.8842
C.V.	1575.56062		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	0.197744	0.13726431	1.441	0.1508
DUM65	0.060400	0.10230791	0.590	0.5554

DUM70	0.046666	0.08114008	0.575	0.5656
DUM75	0.064105	0.06021057	1.065	0.2879
DUM85	-0.257028	0.06920598	-3.714	0.0002
LNAGRI	0.255731	0.04706717	5.433	0.0001
LNAUXCP	-0.043187	0.03671598	-1.176	0.2405
LNBEDS	-0.283296	0.04951225	-5.722	0.0001
LNGNP	-0.171526	0.06887507	-2.490	0.0133
LNLIT	-0.098720	0.06923103	-1.426	0.1549
LNPHARM	-0.033498	0.04880148	-0.686	0.4930
LNPHYCP	-0.013514	0.03931728	-0.344	0.7313
LNPRO	0.310348	0.16222959	1.913	0.0567
INTERCEP	1.249976	1.16909683	1.069	0.2859

In this first weighted model, we are not controlling for country specific variables. We observe that by weighting the model, the coefficients return the expected signs for the most part. The only significant coefficient that does not exhibit the correct sign is protein consumption per capita. Possibly, the overall effect of protein consumption on infant mortality rates is negative, but the marginal benefits of additional protein consumption, given income, is positive. We may be showing an obesity or poor diet effect when we already control for income. The other alternative is that the high level of multicollinearity has cause the sign on protein consumption to be incorrect. We can

see by graph 4 that the relationship between infant mortality rates and protein consumption shows a considerable range of dispersion in the lower ranges of consumption. Therefore, this may lower the explanatory power of protein consumption on infant mortality.

Dependent Variable: LNINF

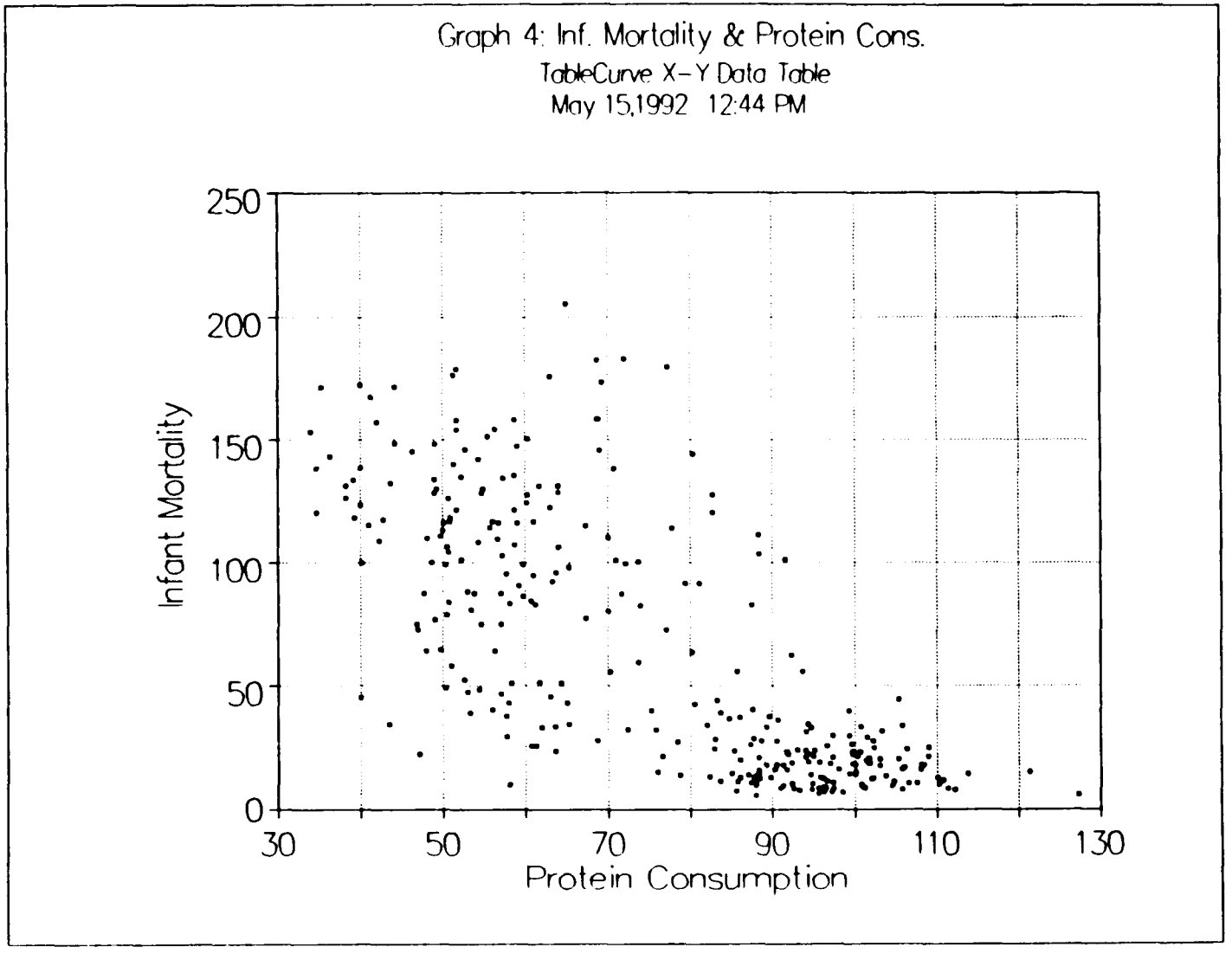
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	12	8261587.435	688465.620	191.844	0.0001
Error	294	1055067.624	3588.665		
C Total	306	9316655.059			

Root MSE	59.90547	R-square	0.8868
Dep Mean	3.76897	Adj R-sq	0.8821
C.V.	1589.43851		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	0.281731	0.13422892	2.099	0.0367
DUM65	0.176197	0.09193391	1.917	0.0563
DUM70	0.130617	0.07445611	1.754	0.0804
DUM75	0.091880	0.05968979	1.539	0.1248


Graph 4: Inf. Mortality & Protein Cons.
TableCurve X-Y Data Table
May 15,1992 12:44 PM
250
200
150
100
50
0
Infant Mortality
30
50
70
90
110
130
Protein Consumption

DUM85	-0.250458	0.06976482	-3.590	0.0004
LNAGRI	0.322589	0.03900028	8.271	0.0001
LNAUXCP	-0.060381	0.03637862	-1.660	0.0980
LNBEDS	-0.314822	0.04828826	-6.520	0.0001
LNLIT	-0.108849	0.06972022	-1.561	0.1195
LNPHARM	-0.104315	0.04001018	-2.607	0.0096
LNPHYCP	0.011867	0.03830788	0.310	0.7569
LNPRO	0.185615	0.15566355	1.192	0.2341
INTERCEP	0.420568	1.13052686	0.372	0.7102

The removal of GNP per capita increases the size of the coefficient on pharmaceutical consumption and improves its significance. The majority of coefficients increase the absolute value of their coefficients. The model retains its excellent explanatory power.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	106	9252730.26	87289.90808	273.102	0.0001
Error	200	63924.803	319.62401		

C Total 306 9316655.06

Root MSE 17.87803 R-square 0.9931

Dep Mean 3.76897 Adj R-sq 0.9895

C.V. 474.34786

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	0.223858	0.08649341	2.588	0.0104
DUM65	0.255586	0.06311643	4.049	0.0001
DUM70	0.201465	0.04522496	4.455	0.0001
DUM75	0.108419	0.02579415	4.203	0.0001
DUM85	-0.131127	0.02795722	-4.690	0.0001
LNAGRI	0.502192	0.08307343	6.045	0.0001
LNAUXCP	-0.017186	0.01844559	-0.932	0.3526
LNBEDS	0.061485	0.04814668	1.277	0.2031
LNGNP	-0.028916	0.04001081	-0.723	0.4707
LNLIT	0.348288	0.06526677	5.336	0.0001
LNPHARM	-0.044806	0.02378801	-1.884	0.0611
LNPHYCP	-0.039287	0.02722058	-1.443	0.1505
LNPRO	-0.021796	0.11795986	-0.185	0.8536
INTERCEP	0.908095	0.79128125	1.148	0.2525

In our second weighted model with country dichotomous variables, we are again examining infant mortality rates. We observe that the overall regression equation is statistically significant. The F statistic is quite high. R^2 is also very high at .99314. This indicates that our model is, at the very least, a reasonable model for infant mortality rates.

All of our time variables are statistically significant at the 1 per cent level of significance, and display the correct sign; positive for all except 1985, which is negative.

The country dichotomous variables, for the most part, exhibit the correct signs and are very significant. The coefficients are extremely strong for the African regions, especially region 3: North Africa, region 2: Mid Africa, and region 5: West Africa. We feel that this is most likely due to the high level of endemic diseases in these regions, possibly coupled with political instability. Countries that stand out in these regions are Liberia with 103 per cent and Sierra Leone with 117 per cent more infant mortality than the United States, holding our other variables constant. The strongest country variable is for Afghanistan, which exhibited the highest level of infant mortality; 205 per 1000 live births.

The health variables, for the most part, have good results. Pharmaceutical consumption per capita and the number of auxiliary health personnel both have the correct sign and are significant. We feel that this is due to the fact that auxiliary

personnel are indicative of the availability of health services for the majority of the population. Pharmaceuticals appear to be altering the health outcomes in an important way. The number of hospital beds per capita exhibits an incorrect sign. This runs counter to the sign that you observe on hospital beds when you run a regression on infant mortality with hospital beds as the only explanatory variable. It is quite possible that the presence of GNP per capita may be causing this unexpected result. This also may be due to the high level of multicollinearity between physicians per capita, auxiliary health personnel per capita and hospital beds per capita.

Percentage of population involved in agriculture is very significant, and has the correct sign. Our feeling is that this is reflecting the ruralness effects on health and also the economic development effect. Decreasing the percentage of the economically active population working in agriculture by 10% would yield a 5.02% decrease in infant mortality rates. While this is a variable that tends to change slowly over time, we can see that the level of economic development has important ramifications for health. This variable has tended to decrease over time, and a proper economic development program could decrease it even more.

The literacy variable is statistically significant, but exhibits the wrong sign. We feel that this may be due to our using infant mortality as our measure of health. We may find that the parameters that effect infant mortality have not been captured in literacy of the region. For example the three cleans at birth; clean hands on deliverer, a clean place to

put the baby, and a clean cutting instrument to cut the umbilical cord may have major effects on reducing neonatal mortality.[64] The variables that probably capture some of these effects are the percentage of population involved in agriculture, and the auxiliary health workers per capita. Another problem may be that some developed countries with very high literacy rates have very poor infant mortality rates (The United States is a glaring example).

Overall we feel this model gives us a good indication that pharmaceuticals can help reduce our infant mortality rates, and that pharmaceuticals seem to be very cost effective for improving infant health.

GNP per capita controls for some of the differences in income across nations. So, it should show us, to some degree, the pure allocation effect of choosing more of our health goods holding income constant. The coefficient on GNP per capita is statistically insignificant, but it exhibits the correct negative sign. A 10 per cent increase in GNP per capita causes a .2 per cent decrease in infant mortality rates.

Of course the proper question at this point is (given that you have additional revenues to allocate in a society), which form of health care or other goods do you purchase if you want to have the maximum impact on infant mortality for the expenditures made. The effect of a 10 per cent increase in pharmaceutical consumption

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[64] See instruction for proper delivery in WHO The community Health Worker (1987). Also see the commentary on the 'three cleans' in The State of The Worlds Children 1991 by UNICEF p 8.

decreases infant mortality rates by .45 per cent. This may seem to be a small percentage change, however, it is important to remember that a 10 per cent change in pharmaceutical consumption is a much smaller change in monetary value than a 10 per cent change in GNP per capita. For an example of this let us use Indonesia. Their GNP per capita is U.S. $540.00 in 1985. Their pharmaceutical consumption per capita is U.S. $3.52, so a 10 per cent change is U.S. $0.35. To decrease infant mortality by .45 per cent, the amount of increase in GNP that is needed is 15.45 per cent or in this case U.S. $83.43. We can easily see that if the goal of international agencies is to increase health, pharmaceuticals are less costly than attempts to increase domestic consumer income. The total cost for a 10 per cent increase in the Indonesian pharmaceuticals program would be approximately U.S. $58,103,000.00. The GNP cost would be approximately U.S. $13,765,950,000.00. Again both expenditures yield the same .4481 per cent decline in infant mortality or .47 of the 80.6 infant deaths per thousand live births in 1985. Other inputs into health may also yield the same decrease. For auxiliary health personnel, the net increase is 26.03 per cent in the number of auxiliary health personnel per capita, or a numerical increase in auxiliary personnel of approximately 32,002 workers. Obviously, the cost of training and paying for this amount of auxiliary health personnel would be very large. We therefore have some indication that pharmaceutical consumption may be the most cost effective way of reducing infant mortality.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	105	9252563.312	88119.651	276.355	0.0001
Error	201	64091.747	318.864		
C Total	306	9316655.059			

Root MSE	17.85677	R-square	0.9931
Dep Mean	3.76897	Adj R-sq	0.9895
C.V.	473.78387		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	0.242760	0.08234656	2.948	0.0036
DUM65	0.280373	0.05292209	5.298	0.0001
DUM70	0.220154	0.03705764	5.941	0.0001
DUM75	0.115202	0.02399743	4.801	0.0001
DUM85	-0.127700	0.02751944	-4.640	0.0001
LNAGRI	0.519448	0.07947342	6.536	0.0001
LNAUXCP	-0.017608	0.01841442	-0.956	0.3401
LNBEDS	0.054802	0.04719414	1.161	0.2469
LNLIT	0.351040	0.06507807	5.394	0.0001
LNPHARM	-0.053846	0.02020968	-2.664	0.0083

LNPHYCP	-0.040991	0.02708607	-1.513	0.1318
LNPRO	-0.039886	0.11513628	-0.346	0.7294
INTERCEP	0.677158	0.72303116	0.937	0.3501

We can observe in this model that the removal of GNP per capita and the inclusion of our country dichotomous variables does not produce overall consistent results. The model is somewhat of an improvement over the weighted model with GNP per capita, as both R^2 and the F statistic are improved over the model with GNP. The only significant health variable is pharmaceutical consumption; significance improves on its coefficient. Literacy rates have a perplexing sign, and are extremely significant. We feel overall that the model with country dichotomous variables is overdetermined, and so therefore is not extremely consistent with our a priori expectation. We still have not undermined our original assumption as pharmaceutical consumption remains significant.

Life Expectancy at Birth

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	106	10.95685	0.10337	217.808	0.0001
Error	200	0.09492	0.00047		

C Total 306 11.05176

Root MSE 0.02178 R-square 0.9914

Dep Mean 4.11852 Adj R-sq 0.9869

C.V. 0.52895

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	-0.103952	0.01765911	-5.887	0.0001
DUM65	-0.063862	0.01246428	-5.124	0.0001
DUM70	-0.032033	0.00911343	-3.515	0.0005
DUM75	-0.014481	0.00545545	-2.654	0.0086
DUM85	0.028935	0.00597632	4.842	0.0001
LNAGRI	0.072211	0.01472610	4.904	0.0001
LNAUXCP	0.002054	0.00349603	0.587	0.5575
LNBEDS	0.004982	0.00942488	0.529	0.5977
LNGNP	0.016990	0.00736150	2.308	0.0220
LNLIT	0.059277	0.00927310	6.392	0.0001
LNPHARM	0.005803	0.00416604	1.393	0.1652
LNPHYCP	0.006069	0.00518823	1.170	0.2435
LNPRO	0.018733	0.02338753	0.801	0.4241
INTERCEP	3.728914	0.12962659	28.767	0.0001

The unweighted model of life expectancy at birth with the country dichotomous variables exhibits three very important relationships. Literacy rates, GNP per capita and percentage of the population that is involved in agriculture all have significant effects on life expectancy at birth. The country specific variables are, for the most part, significant and exhibit the correct signs. We are very encouraged by these results as this model places many restrictions on the effects of the variables and has very few degrees of freedom. The variables with significant coefficients in this model are most likely the ones with the most robust effects. The inconsistent sign on the percentage of the population that is involved in agriculture may be linked to the interrelationship between it and GNP per capita. We again may be observing that this may be measuring the positive effects of rural life.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	13	259429.93	19956.14829	315.859	0.0001
Error	293	18511.91	63.18058		
C Total	306	277941.84			

Root MSE	7.94862	R-square	0.9334
Dep Mean	4.11505	Adj R-sq	0.9304
C.V.	193.15971		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	-0.055304	0.01837349	-3.010	0.0028
DUM65	-0.041015	0.01369440	-2.995	0.0030
DUM70	-0.014026	0.01086099	-1.291	0.1976
DUM75	-0.009789	0.00805947	-1.215	0.2255
DUM85	0.020020	0.00926355	2.161	0.0315
LNAGRI	-0.003618	0.00630017	-0.574	0.5662
LNAUXCP	0.001779	0.00491461	0.362	0.7176
LNBEDS	0.033294	0.00662745	5.024	0.0001
LNGNP	0.004527	0.00921926	0.491	0.6238
LNLIT	0.102327	0.00926690	11.042	0.0001
LNPHARM	0.010670	0.00653231	1.633	0.1035
LNPHYCP	0.030751	0.00526281	5.843	0.0001
LNPRO	0.044079	0.02171521	2.030	0.0433
INTERCEP	3.910192	0.15648921	24.987	0.0001

In this first weighted model of life expectancy at birth from database 3, we see that by weighting by population, our results increase in significance, as expected, and all of our variables exhibit the correct sign. The time dichotomous variables exhibit the correct

signs, and we also note that their effects on life expectancy are not extremely strong. We are intrigued by the small size of the coefficient on pharmaceuticals. Even though the coefficient is very small, it is important to again remember that a 1 per cent change in the per capita expenditures on pharmaceuticals is usually a much lower amount of resources than a 1 per cent change in the other variables. We observe that the literacy effect is very significant and produces very important increases in life expectancy. This is consistent with work by Grossman and others. The coefficient on GNP per capita is not significant in our model. This poses an interesting question as to whether GNP per capita belongs in our model as an explanatory variable. We will see that its removal improves the significance of pharmaceutical consumption, does not change the magnitude of the pharmaceutical coefficient and does not lower the explanatory power of the model in a significant way.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	12	259414.696	21617.891	343.046	0.0001
Error	294	8527.141	63.017		
C Total	306	277941.837			

Root MSE	7.93836	R-square	0.9333
Dep Mean	4.11505	Adj R-sq	0.9306

C.V. 192.91024

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	-0.057521	0.01778731	-3.234	0.0014
DUM65	-0.044070	0.01218259	-3.617	0.0004
DUM70	-0.016241	0.00986653	-1.646	0.1008
DUM75	-0.010522	0.00790977	-1.330	0.1845
DUM85	0.019846	0.00924486	2.147	0.0326
LNAGRI	-0.005383	0.00516811	-1.042	0.2985
LNAUXCP	0.002233	0.00482070	0.463	0.6436
LNBEDS	0.034126	0.00639890	5.333	0.0001
LNLIT	0.102594	0.00923895	11.105	0.0001
LNPHARM	0.012539	0.00530194	2.365	0.0187
LNPHYCP	0.030081	0.00507636	5.926	0.0001
LNPRO	0.047371	0.02062771	2.296	0.0224
INTERCEP	3.932081	0.14981143	26.247	0.0001

The weighted model of life expectancy at birth without GNP per capita as an explanatory variable exhibits extremely consistent results for our health variables. We observe that all of our explanatory variable have consistent signs and all, except for

auxiliary health personnel and percentage of the population involved in agriculture are significant. This model has a very a very high R^2, and so seems to explain a large part of the variation in infant mortality rates. We feel that this model is capturing the majority of the variation in life expectancy at birth, so we therefore have some indication that the inclusion of GNP per capita may only be blurring the total picture regarding inputs into health. We believe that this model stands as significant proof that gross pharmaceutical expenditures have a positive impact on health.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	106	275513.710	2599.18593	214.090	0.0001
Error	200	2428.128	12.14064		
C Total	306	277941.837			

Root MSE	3.48434	R-square	0.9913
Dep Mean	4.11505	Adj R-sq	0.9866
C.V.	84.67311		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	-0.124135	0.01685715	-7.364	0.0001

DUM65	-0.088813	0.01230109	-7.220	0.0001
DUM70	-0.044319	0.00881413	-5.028	0.0001
DUM75	-0.021329	0.00502716	-4.243	0.0001
DUM85	0.036489	0.00544873	6.697	0.0001
LNAGRI	0.105955	0.01619061	6.544	0.0001
LNAUXCP	0.012896	0.00359496	3.587	0.0004
LNBEDS	0.000546	0.00938355	0.058	0.9537
LNGNP	0.015880	0.00779791	2.036	0.0430
LNLIT	0.046358	0.01272018	3.644	0.0003
LNPHARM	0.005966	0.00463617	1.287	0.1997
LNPHYCP	0.004537	0.00530516	0.855	0.3935
LNPRO	0.064540	0.02298981	2.807	0.0055
INTERCEP	3.567980	0.15421689	23.136	0.0001

In model 5, with the addition of country dichotomous variables, we have again modeled life expectancy at birth. The model is statistically significant, with both high R^2 and a significant F statistic. The overall results are consistent with our previous models. Pharmaceutical consumption has a very small coefficient, but it does exhibit the correct sign. Pharmaceutical consumption is not statistically significant at the 10 per cent level. The only coefficient that has surprising results is the coefficient on percentage of the economically active population involved in agriculture. We feel that this may be due to

the number of variables in the model. If we looked at the gross effects of percentage of population in agriculture, we would expect a negative coefficient. In this case, given the number of explanatory variables, economic development and ruralness are measured more by the individual country variables and GNP per capita. Therefore possibly the only unique effect of the percentage of the population involved in agriculture may be some positive benefit to rural life, such as healthful country living.

Life expectancy at birth, is not a variable that can assume any value. The lower limit would be zero years, the upper limit approximately 168 years for an individual.[65] It is impossible for a population to realize either of these extreme limits on average. Therefore the value of average life expectancy at birth will range in between approximately 35 years and 85 years.[66] By 1987, no country has successfully increased life expectancy at birth for females above 81.4 years[67]. The ramifications of this are that we might expect more variation in the life expectancy at lower values, as these observations may be very responsive to changes in health or socioeconomic conditions. We therefore expect that the variation of our estimates may decrease as the level of life expectancy reaches its upper limit.[68]

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[65] The upper limit reported here is for Shirali Mislimov from Alexander Leaf, writing for the National Geographic Society, January 1973.

[66] Sheehan and Hopkins (1979) estimate that the point of convergence for life expectancy is approximately 75 years p 34.

[67] This value is reported for Japan in OECD (1990) p 185.

[68] Adelman (1963) used a model of health production which is equivalent to ours. Her model was divided into different age groups on 5 year intervals. She observed that the explanatory power of the same type of socioeconomic variables on explaining intercountry differences in death rates decreases as the age

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	105	275463.358	2623.461	212.758	0.0001
Error	201	2478.479	12.331		
C Total	306	277941.837			

Root MSE	3.51152	R-square	0.9911
Dep Mean	4.11505	Adj R-sq	0.9864
C.V.	85.33345		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	-0.134515	0.01619336	-8.307	0.0001
DUM65	-0.102425	0.01040707	-9.842	0.0001
DUM70	-0.054583	0.00728734	-7.490	0.0001
DUM75	-0.025054	0.00471907	-5.309	0.0001
DUM85	0.034607	0.00541167	6.395	0.0001
LNAGRI	0.096478	0.01562836	6.173	0.0001
LNAUXCP	0.013128	0.00362118	3.625	0.0004

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of the group increased. From age 35 onward to age 74 the explanatory power of her model fell.

LNBEDS	0.004216	0.00928068	0.454	0.6501
LNLIT	0.044846	0.01279753	3.504	0.0006
LNPHARM	0.010930	0.00397421	2.750	0.0065
LNPHYCP	0.005472	0.00532645	1.027	0.3055
LNPRO	0.074476	0.02264142	3.289	0.0012
INTERCEP	3.694807	0.14218329	25.986	0.0001

Removing GNP per capita from the model of life expectancy at birth and again including the country dichotomous variables, increases the numerical value of the coefficient of pharmaceutical consumption. The removal of GNP per capita does not lower the explanatory power of the model in a major way. The coefficient on pharmaceuticals is remarkably consistent between our four weighted models of infant mortality rates. The coefficient ranges between .005 and .012539. The model that has the highest likelihood of being overdetermined, the model with country specific dichotomous variables and also GNP per capita, exhibits the smallest coefficient. The models that seem to us to present the most reasonable scenarios all have coefficients near .011. We therefore feel confident that the true elasticity of life expectancy at birth for pharmaceuticals is near that point. This has significant importance to projections regarding the value of pharmaceuticals as inputs into health.

Limiting The Time Periods

To test whether the results we are reporting were for the large part effected by price and quality changes in both pharmaceutical consumption per capita and GNP per capita, we subsetted the data to only contain two time periods. We felt that the later years offered much more information in the cross section, as the data tends to censor out the less developed countries prior to 1967. We selected 1980 and 1985 to use in our subsample. This also offers the advantage of presenting results that are much more up to date.

The following two models use data from 1980 and 1985 only. This reduces the sample size to 106 observations.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	8	4363046.249	545380.781	176.474	0.0001
Error	98	302861.499	3090.423		
C Total	106	4665907.747			

Root MSE	55.59158	R-square	0.9351
Dep Mean	3.55111	Adj R-sq	0.9298
C.V.	1565.46927		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM85	-0.164065	0.07095753	-2.312	0.0229
LNAGRI	0.305463	0.05840532	5.230	0.0001
LNAUXCP	0.033334	0.05972074	0.558	0.5780
LNBEDS	-0.436573	0.07203883	-6.060	0.0001
LNLIT	-0.246682	0.14067604	-1.754	0.0826
LNPHARM	-0.149740	0.06092785	-2.458	0.0157
LNPHYCP	0.007612	0.05600362	0.136	0.8922
LNPRO	0.283879	0.24387232	1.164	0.2472
INTERCEP	0.562561	1.70373788	0.330	0.7420

The weighted model of infant mortality rates does not have as consistent results as the life expectancy at birth model. The signs on protein consumption, physicians per capita and auxiliary health personnel per capita are counterintuitive. The rest of the coefficients are consistent with our previous work. We therefore feel that the coefficient on pharmaceuticals is correct and the negative results on infant mortality are not upset by lowering the sample size and limiting the number of years in our model.

Changing to this smaller sample and removing GNP per capita decreases slightly the overall statistical significance of the model. It also increases the significance on most of

the coefficients. The time dummy for 1985 is very significant and it exhibits the correct sign. The coefficient on pharmaceuticals remains very significant, and also increases slightly in absolute value. This is contrary to the effect we would expect if the relationship between pharmaceutical consumption and infant mortality was driven merely by price increases. The shorter time span should have less price effects, so the coefficient should lose explanatory power.

Overall, however, we observe that the decrease in the number of years in our sample does not significantly alter our primary result; increases in gross pharmaceutical consumption per capita have a negative effect on infant mortality rates. This is consistent with our original results for infant mortality rates. We therefore conclude that the larger data base is consistent for the most part, and the results drawn from it appear correct.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	8	95687.055	11960.882	209.524	0.0001
Error	98	5594.433	57.086		
C Total	106	101281.488			

Root MSE	7.55553	R-square	0.9448
Dep Mean	4.14887	Adj R-sq	0.9403

C.V. 182.11063

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM85	0.017893	0.00964394	1.855	0.0666
LNAGRI	-0.014359	0.00793795	-1.809	0.0735
LNAUXCP	0.000204	0.00811673	0.025	0.9800
LNBEDS	0.021751	0.00979090	2.222	0.0286
LNLIT	0.157036	0.01911948	8.213	0.0001
LNPHARM	0.001918	0.00828079	0.232	0.8173
LNPHYCP	0.037868	0.00761153	4.975	0.0001
LNPRO	0.015762	0.03314504	0.476	0.6354
INTERCEP	3.865452	0.23155746	16.693	0.0001

The reduction of the number of observations lowers the overall power of the model, however, not in a significant way. All of the coefficients exhibit the correct a priori signs. The coefficient for pharmaceutical consumption per capita is very small but it does have the correct sign, unfortunately, it is not significant. Overall the effect of pharmaceuticals in this model is very small. We feel that the model as stated here has insufficient data to properly explain the unique contribution of the independent variables on life expectancy data. This model is, nevertheless, an excellent model of life

expectancy, and it does explain the vast majority of the variation in infant mortality rates. It cannot however distinguish the individual contribution of the independent variables.

The limited time period models do not prove as confidently and consistently the effects of health inputs on aggregate health. Yet they do not in any significant way disprove or undermine our previous results. We therefore feel confident that we are not observing only time changes in monetary value over time in our pharmaceutical variables.

Rural Water Supply and Health

In the following models, we are attempting to assess the impact of water supply on health. We were able to collect a subsample of 152 countries that had reported values for water supply. We also collected data on total water supply, however, the results are not significantly different, and the overall analysis remains the same. The dependent variable life expectancy at age 15 for females could not be tested with water supply, as observations for life expectancy for females at age 15 and rural water supply were not overlapping in a significant way.

Dependent Variable: LNINF

Analysis of Variance

	Sum of	Mean

Source	DF	Squares	Square	F Value	Prob > F
Model	11	3783800.264	343981.842	124.538	0.0001
Error	141	389451.6638	2762.06854		
C Total	152	4173251.9278			

Root MSE	52.55539	R-square	0.9067
Dep Mean	4.18326	Adj R-sq	0.8994
C.V.	1256.32519		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM70	0.101990	0.09002664	1.133	0.2592
DUM75	-0.000327	0.07118564	-0.005	0.9963
DUM85	-0.211538	0.08294368	-2.550	0.0118
LNAGRI	0.459214	0.05436674	8.447	0.0001
LNAUXCP	-0.051034	0.04108370	-1.242	0.2162
LNBEDS	-0.066253	0.05648957	-1.173	0.2428
LNLIT	-0.276984	0.08529602	-3.247	0.0015
LNPHARM	-0.090811	0.05255541	-1.728	0.0862
LNPHYCP	-0.050076	0.04464081	-1.122	0.2639
LNPRO	0.058858	0.20597942	0.286	0.7755
LNRURWAT	0.051317	0.04129337	1.243	0.2160

INTERCEP	2.174581	1.36251785	1.596	0.1127

The addition of rural water supply has little explanatory power for infant mortality rates. The addition of this variable has not changed the regression results in any significant way. Rural water supply exhibits an incorrect a priori sign, and is insignificant. This result seems counterintuitive, in that we expect rural water supply to have some effect in improving health. Some of the explanation may lie in the correlation between rural water supply and other variables, such as percentage of the population involved in agriculture. The other possible explanation is the exact interrelationship of the variables. Infant mortality is a measure of deaths in the first year of life, given that you are born alive. For a significant portion of this first year, the majority of babies are breast fed. This means that the probability of contracting a water based illness should be lower in the first year of life. We expect that if we changed the dependent variable to child deaths below the age of 5 years, the results might change.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	11	112223.587	10202.1443	153.731	0.0001
Error	141	9357.29753	66.36381		
C Total	152	121580.88483			

Root MSE	8.14640	R-square	0.9230
Dep Mean	4.04832	Adj R-sq	0.9170
C.V.	201.22929		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM70	-0.018096	0.01395467	-1.297	0.1968
DUM75	-0.007135	0.01103420	-0.647	0.5189
DUM85	0.028806	0.01285677	2.241	0.0266
LNAGRI	-0.018450	0.00842717	-2.189	0.0302
LNAUXCP	0.012730	0.00636822	1.999	0.0475
LNBEDS	0.008054	0.00875622	0.920	0.3592
LNLIT	0.112373	0.01322139	8.499	0.0001
LNPHARM	0.000989	0.00814640	0.121	0.9035
LNPHYCP	0.033878	0.00691959	4.896	0.0001
LNPRO	0.038242	0.03192804	1.198	0.2330
LNRURWAT	0.006937	0.00640072	1.084	0.2803
INTERCEP	3.902800	0.21119841	18.479	0.0001

This model exhibits less explanatory power than the full sample for life expectancy. However, the inclusion of rural water supply produces some interesting results.

Physicians per capita and auxiliary health personnel per capita remain statistically significant, and have the correct signs as in our previous model. The coefficient on rural water supply is insignificant. This makes logical sense in that the probability of contracting a water borne or water vectored disease is much higher for a person over their whole life span as opposed to an infant during the first year of life. This result makes clear some of the empirical shortcomings of infant mortality as a measure of the productive human capital. We are concerned that by focusing too heavily on infant mortality as our health outcome, we may be pointed toward solutions that help in the short run, but do not improve the overall situation with regard to labor productivity.

Dependent Variable: LNINF

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	94 4	163367.879	44291.148	259.902	0.0001
Error	58	9884.04875	170.41463		
C Total	152	4173251.9278			

Root MSE	13.05430	R-square	0.9976
Dep Mean	4.18326	Adj R-sq	0.9938
C.V.	312.06013		

Parameter Estimates

	Parameter	Standard	T for H0:

Variable	Estimate	Error	Parameter=0	Prob > |T|
DUM70	0.236349	0.04819687	4.904	0.0001
DUM75	0.119216	0.03057634	3.899	0.0003
DUM85	-0.222470	0.03147395	-7.068	0.0001
LNAGRI	-0.008639	0.15613536	-0.055	0.9561
LNAUXCP	0.000406	0.02029214	0.020	0.9841
LNBEDS	0.031358	0.05815668	0.539	0.5918
LNLIT	0.067153	0.09353646	0.718	0.4757
LNPHARM	-0.046749	0.02723164	-1.717	0.0914
LNPHYCP	-0.028091	0.03001378	-0.936	0.3532
LNPRO	-0.307129	0.21560814	-1.424	0.1597
LNRURWAT	0.066570	0.02210823	3.011	0.0039
INTERCEP	3.598733	1.10341913	3.261	0.0019

Weighting the model with rural water supply and including our country specific dichotomous variables produces results that again seem to confirm our a priori expectation. We observe that pharmaceutical consumption is the only coefficient that is statistically significant. This concerns us, in that we may have censored our sample in a biased way when we collected data on rural water supply. Rural water supply is significant, however it exhibits the incorrect sign in this case. We therefore are not convinced that rural water supply is a significant variable in determining infant mortality

rates. As we pointed out in our previous model, we suspect that there may be no clear cut inter relationship between infant mortality and water supply. It is also quite possible that our country variables are picking up the unique contribution of water supply to infant mortality. However we have disproved that to some extent in our previous model.

Dependent Variable: LNLIFE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	94	121411.911	1291.616	443.346	0.0001
Error	58	168.974	2.913		
C Total	152	121580.885			

Root MSE	1.70685	R-square	0.9986
Dep Mean	4.04832	Adj R-sq	0.9964
C.V.	42.16197		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM70	-0.073923	0.00630174	-11.731	0.0001
DUM75	-0.032180	0.00399786	-8.049	0.0001
DUM85	0.040469	0.00411522	9.834	0.0001

LNAGRI	0.098370	0.02041471	4.819	0.0001
LNAUXCP	0.012055	0.00265320	4.544	0.0001
LNBEDS	-0.006516	0.00760399	-0.857	0.3950
LNLIT	-0.009971	0.01222990	-0.815	0.4182
LNPHARM	0.014107	0.00356054	3.962	0.0002
LNPHYCP	0.013471	0.00392430	3.433	0.0011
LNPRO	0.110410	0.02819078	3.917	0.0002
LNRURWAT	0.004499	0.00289065	1.556	0.1251
INTERCEP	3.716985	0.14427214	25.764	0.0001

With this model of life expectancy at birth, we again include our dichotomous country variables and also rural water supply. We again observe that this model is reasonably consistent with our previous models of life expectancy at birth. The coefficients on auxiliary health personnel, physicians per capita, pharmaceutical consumption and, surprisingly, protein consumption all exhibit the correct signs and are extremely significant. Protein consumption has a rather strong coefficient in this model. We are somewhat perplexed by the sign on the significant coefficient on percentage of the population involved in agriculture. We expect a negative coefficient as in our previous models. We believe that the country variables are again picking up the unique negative effects of having a large rural sector, and leaving only a small positive effect of country life. We have again reinforced the supposition that pharmaceuticals have a positive and measurable effect on aggregate measures of health.

Life Expectancy at Age 15 for Females

This next group of models is related to the availability of data for life expectancy at age 15 for females. An important technical point is that the use of this subsample clearly introduces some regional bias into the data, as this subset has eliminated many of the regions that were previously represented. Africa, East Asia, South Asia, Tropical South America, and the Caribbean are some of the most glaring omissions. This makes us very cautious in our interpretation of any results.

Dependent Variable: LNFEM15

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	11	785.01803	71.36528	12.116	0.0001
Error	84	494.78137	5.89025		
C Total	95	1279.79940			

Root MSE	2.42698	R-square	0.6134
Dep Mean	4.13087	Adj R-sq	0.5628
C.V.	58.75245		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|

DUM60	-0.030200	0.00829232	-3.642	0.0005
DUM65	-0.027687	0.00680740	-4.067	0.0001
DUM70	-0.018471	0.00580787	-3.180	0.0021
DUM75	-0.011079	0.00458519	-2.416	0.0178
LNAGRI	0.000184	0.00282788	0.065	0.9481
LNAUXCP	-0.004153	0.00340029	-1.221	0.2254
LNBEDS	0.010043	0.00759001	1.323	0.1894
LNLIT	0.028383	0.04573066	0.621	0.5365
LNPHARM	0.011935	0.00363774	3.281	0.0015
LNPHYCP	-0.007633	0.00655806	-1.164	0.2478
LNPRO	0.019170	0.01475917	1.299	0.1975
INTERCEP	3.862955	0.23894290	16.167	0.0001

The weighted model of life expectancy at age 15 for females has reasonable explanatory power. Unfortunately, only one coefficient is significant; pharmaceutical consumption. We feel that the high degree of multicollinearity caused the variables to lack significance, even though the model seems quite reasonable. The only possible solution to this problem may be to collect more data to expand the sample size.

Dependent Variable: LNFEM15

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	41	1218.43109	29.71783	26.150	0.0001
Error	54	61.36831	1.13645		
C Total	95	1279.79940			

Root MSE	1.06604	R-square	0.9520
Dep Mean	4.13087	Adj R-sq	0.9156
C.V.	25.80680		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	-0.038552	0.01213578	-3.177	0.0025
DUM65	-0.037913	0.00865027	-4.383	0.0001
DUM70	-0.023684	0.00632523	-3.744	0.0004
DUM75	-0.012575	0.00356237	-3.530	0.0009
LNAGRI	-0.021834	0.00868965	-2.513	0.0150
LNAUXCP	-0.000952	0.00294370	-0.324	0.7476
LNBEDS	-0.006274	0.00901354	-0.696	0.4894
LNLIT	-0.215731	0.11191533	-1.928	0.0592
LNPHARM	0.001741	0.00415773	0.419	0.6771
LNPHYCP	-0.014823	0.00665230	-2.228	0.0301

LNPRO	0.010465	0.01068195	0.980	0.3316
INTERCEP	4.991094	0.48356547	10.321	0.0001

In this model, weighted by population and including the country specific variables, we have some indication that we have done serious damage to the data by censoring it in such a biased way. The significance of the majority of the explanatory variables are lost. Pharmaceutical consumption is insignificant, but it does retain the correct sign. The only significant explanatory variable in this model are the country specific variables and percentage of the population involved in agriculture The coefficients on the other health variables concern us. The loss of significance is probably indicative of a loss of information in this model. All in all, we are extremely uneasy about drawing results from this subsample.

Child Death Rates

For our fourth measure of health we used child death rates. We were able to collect a subsample with 158 valid observations. Fortunately, the sample is less censored than the life expectancy at age 15 for females; more regions are represented. This should hopefully avoid some of the problems we encountered in our previous data set.

Dependent Variable: LNCHILD

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	12	697426.31	58118.860	5.469	0.0001
Error	146	1551509.035	10626.774		
C Total	158	2248935.354			

Root MSE	103.08625	R-square	0.3101
Dep Mean	9.08930	Adj R-sq	0.2534
C.V.	1134.14901		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	0.723012	0.26821980	2.696	0.0079
DUM65	0.113557	0.18533933	0.613	0.5410
DUM70	-1.512842	2.05486284	-0.736	0.4628
DUM75	-0.465677	0.45716337	-1.019	0.3101
DUM85	-0.129237	0.12606144	-1.025	0.3070
LNAGRI	-0.185356	0.09602815	-1.930	0.0555
LNAUXCP	0.245397	0.09799427	2.504	0.0134
LNBEDS	-0.606534	0.11904673	-5.095	0.0001
LNLIT	-0.205618	0.17916118	-1.148	0.2530
LNPHARM	0.117446	0.09352951	1.256	0.2112

LNPHYCP	0.336900	0.09392781	3.587	0.0005
LNPRO	-1.541120	0.40332785	-3.821	0.0002
INTERCEP	17.358162	2.83567811	6.121	0.0001

In the first weighted model of child death rates, we observe that the coefficient on pharmaceuticals has the incorrect sign. The one dominant variable in this model is protein consumption per capita. Nutritional status seems to have a very important effect on child death rates. This is consistent with our expectations, as one of the most critical inputs into child health is adequate weaning foods for children. The majority of poor countries have inadequate supplies of high protein, high calorie foods for children when they are being weaned. This is posited as one of the major factors in child deaths. Our results confirm this relationship and indicate that for improvements in child death rates, we must increase protein consumption. The model has some explanatory power, however some coefficients exhibit incorrect signs and/or are not statistically significant. We therefore feel that the high correlation between the explanatory variables may be causing some of the incorrect signs to appear. The removal of the percentage of the population involved in agriculture causes the sign of pharmaceuticals to change and the magnitude of the coefficient to increase.

Dependent Variable: LNCHILD

Analysis of Variance

Sum of Mean

Source	DF	Squares	Square	F Value	Prob > F
Model	93	2247702.976	24168.849	1274.751	0.0001
Error	65	1232.378	18.960		
C Total	158	2248935.354			

Root MSE	4.35427	R-square	0.9995
Dep Mean	9.08930	Adj R-sq	0.9987
C.V.	47.90543		

Parameter Estimates

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
DUM60	-0.127974	0.03248414	-3.940	0.0002
DUM65	-0.087951	0.02248304	-3.912	0.0002
DUM70	-0.144971	0.11518728	-1.259	0.2127
DUM75	0.000090	0.05347496	0.002	0.9987
DUM85	0.031439	0.00871060	3.609	0.0006
LNAGRI	0.082908	0.02759168	3.005	0.0038
LNAUXCP	-0.005107	0.00791789	-0.645	0.5212
LNBEDS	-0.030432	0.01937779	-1.570	0.1212
LNLIT	0.067361	0.02114687	3.185	0.0022
LNPHARM	0.013249	0.00865720	1.530	0.1308
LNPHYCP	0.010717	0.02116943	0.506	0.6144

LNPRO	0.119812	0.0685686	1.747	0.0853
INTERCEP	8.480315	0.42892016	19.771	0.0001

Weighting the model and including the country dichotomous variables produces results that are more consistent with our previous models. The coefficients, for the most part, are not very consistent with our expectations. Protein consumption per capita and literacy rates are very significant, however they both exhibit the incorrect signs. The only consitent and significant coefficent is the percentage of the population that is involved in agriculture.

This model of child deaths (age 1-5 years) allows us to remove neonatal mortality from our model. This is important, as it has been shown that this is linked to mother's health status more than post neonatal mortality. We can observe that this model, while having less statistical significance than our original infant mortality model, has results that confirm our original suppositions and results. While pharmaceutical consumption is less significant, it does exhibit the correct sign, but has less explanatory power than in our original infant mortality model.

The overall low effects of pharmaceutical consumption on child death rates may, in part, reflect the lower sensitivity of child death to changes in health status. The smaller sample size may also be part of the explanation. We continue to observe that pharmaceutical consumption has less effect in this model than in our previous models of

life expectancy or infant mortality.

VI. CONCLUSIONS

We are encouraged by some of our results. The effects of pharmaceuticals on health appear to be positive for the most part. The results reported with regard to infant mortality rates, life expectancy at birth and life expectancy at age 15 for females all tend to support our a priori analysis. Infant mortality tends to be the most sensitive to small changes in health status. Therefore, we expect any health input that is not extremely powerful to exhibit an impact on infant mortality first. We do not expect to see radical changes in the other measures of health, as these are more affected by lifestyle and societal issues than is infant mortality.

In our models we have found some basic preliminary results regarding health and pharmaceutical consumption. We find across nations and time that there appears to be a relationship between the apparent consumption of pharmaceutical products and certain forms of health. The clearest result appears related to infant mortality rates. The infant mortality rates appear to improve in response to additional consumption of pharmaceuticals. This is a significant result, as the infant mortality rate is a major contributor to the overall death rate. Correspondingly, Malenbaum showed that infant mortality is a prime detriment of the fertility rates. Therefore we have some evidence that increases in pharmaceutical consumption can improve health status and lower birth

rates.

The health elasticity of pharmaceuticals appears to range from approximately .012 to .14. For infant mortality, this is clearly not as strong as some of the other health inputs in some of our models. Literacy rates also may have a much stronger impact in other models. The interesting result is the consistent fashion with which pharmaceuticals seem to alter health outcomes.

We are somewhat concerned about the low explanatory power of pharmaceutical consumption on our other measures of health. We believe that some of the problems lie in the collection of macroeconomic data, and also in the cultural factors that affect these outcomes. To the extent that we can observe, one of the primary determinants of health status is the availability of rural health workers. This result is merely a validation of results from a number of previous works.[69]

Our study of observable differences in the effects of gross pharmaceutical consumption on life expectancy for males and females is extremely important. The quite consistent differences that we observe clearly indicate that expenditures on pharmaceuticals must be very narrowly targeted. We observed that increased consumption had significant positive effects earlier in the life cycle for females, and these effects were more pronounced than was observable in males.

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[69] See Sheehan and Hopkins (1979) and Carrin (1984).

These results indicate that the kinds of pharmaceuticals consumed may be very important. It also may indicate that the observable effects we see in both infant mortality and life expectancy at birth may be related to women's health. The positive pharmaceutical effects disappear when we examine child mortality. The dependence of the first two measures on mother's health is quite clear. We also observe no codifiable relationship between pharmaceuticals and child mortality. We therefore conclude that the most significant effects of pharmaceuticals seem to be linked to consumption by women.

To estimate the extent to which pharmaceuticals affect health outcomes, one must proceed with caution, as one must include the effects of patient compliance and also the effects of pharmaceuticals on the use of the medical services that are available. Persons may choose not to attend rural health centers if they lack drugs, so other educational effects are prevented[70] If this is important, and it appears that it is, then the availability of pharmaceuticals, more than their active ingredients, are important to the provision of health.

The overall stability of the health elasticity with respect to the pharmaceutical expenditures leads us to believe that there is some systematic effect that is separate and distinct from GNP per capita.

Meaning of our Findings

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[70] WHO (1985) p 195.

The extent to which pharmaceuticals affect infant mortality rates may cause some short term dislocation in the economy. Since parents in many parts of the developing world tend to view children as important for support in their old age, the number of children that a couple has is driven to a large extent by the subjective probability of the parents regarding the survival to adulthood. If we follow the recommendations of The Basic Needs Approach to economic development, we will increase consumption of health inputs, which will tend to disrupt the outcomes that parents expect. The result of this is an increased population.

Our results regarding rural water supply are quite interesting. We find that these results reinforce our original infant mortality results in a very important way. The rural water supply is a reasonable measure of the basic sanitary conditions in a country. Therefore, our result that pharmaceuticals can have an important impact on infant mortality, controlling for sanitation measures, is extremely interesting. The satisfaction of basic sanitary conditions still leaves open a role for medical interventions that can improve health. This blunts some of the arguments of the opponents of pharmaceutical consumption, who feel that pharmaceutical manufacturers are only claiming health gains that were the direct result of investments in sanitary infrastructure. This is shown in our model to be a claim that should be questioned. The impact of rural water supply has some explanatory power, however it still does not dominate the pharmaceutical effect.

Further Research

The effects of pharmaceutical consumption is not subdivided into neat independent health measures as our models have portrayed. When a society consumes health goods, the aggregate effects of all of the positive and negative health relationships are produced. Increased aggregate consumption of pharmaceuticals lowers both infant mortality and increases life expectancy for the same expenditure.

The logical next step in this study would be to control for changes in prices directly through a price index for pharmaceuticals. That would remove, for the most part, any of the ambiguity of price changes in the pharmaceutical market. As we stated before, we should also try then to control for the quality changes over time.

Given the quality of the aggregated data that we are using, we feel that this is not the best course of action. A dissaggregate study of pharmaceutical consumption and its effects on measurable levels of health in developing countries may be the most productive. To study a given region or village would allow us to measure the health inputs and the actual outcomes.

We have been unable to measure, in this study, the effects of health outcomes on labor productivity. The overall conclusions we have drawn are based upon the background studies such as Wheeler (1980) and Malenbaum (1970) that found health to be a labor augmenting factor in production. We have not attempted to re-prove these results at this point. The important theoretical underpinnings of these results do make us

interested in exploring this problem. One possible way of studying output effects would be to look at the rate of change of GNP per capita over our study period. One problem to this methodology is the measurement of the capital stock that is used in the productions process. Wheeler (1980) points to one possible measure, namely total investment divided by national output. We think this methodology has merit, and we plan to pursue it in a further study.

We have also studied the effects of pharmaceuticals on health, given different age groups. We find that the effects of pharmaceuticals in raising expectations of life increases as the age level increases. Clearly an area that deserves more study is the differences we observe between men and women with regard to pharmaceutical consumption. Is this effect observable at the micro level, and what mix of drugs in particular causes this effect? This area seems to be a rich and valuable area for further research. We plan to develop this area more in the future.

In some ways we have succeeded in raising more difficult questions than providing stable and definitive answers. We can only defend this on the grounds that we have explored a relationship that has been ignored in other health production functions. Given that our results clearly show that pharmaceutical consumption has a positive effect on a number of measures of health status, we question the omission of it from future health production functions studies.

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