OPTIMAL MIX OF
HEALTH SECTOR EXPENDITURE

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EXECUTIVE SUMMARY

The World Bank's Health Sector Review in 1991 states that the lack of efficiency in the public sector health care system is perhaps caused by the use of *cost ineffective* options, systems and procedures and this is further reduced due to misallocation of resources, leakages, political influence, poor management and centralised financial, administrative and management authority. Thus *inefficiency* and *cost ineffectiveness* are perhaps the two basic impediments to a better health care system. Therefore, the government must address the issues which simply stated are:

should resources be allocate to build infrastructure, or increase the availability of other inputs, or a combination of both, or, even more importantly,

what should the wage policy be so that it becomes attractive for personnel to work in the rural areas,

can government afford the recurring expenditure liability of an uncontrolled expansion in physical infrastructure, and finally,

> *can the public sector handle the proposed accelerated expansion proposed by the Social Action Programme*

before a real improvement in the service is achieved.

This study attempts to address these specific issues. Thus the study objective is to develop a general optimization framework to address the issue of *cost-effectiveness* and *efficiency*. The study, estimates the optimal mix of *cost-effective* infrastructure, inputs, wages and expenditure requirements and the extent of *efficiency gains/loss* under alternative assumptions.

A comparison with some other countries in the region shows that Pakistan's performance in the health sector is unfavourable. For instance, the expenditure on health by the government is only 0.2 percent of the GNP compared to 0.7 percent for Bangladesh, 0.9 percent for Nepal and 1.4 percent for Sri Lanka, each with per capita incomes substantially below Pakistan's. The Life Expectancy is only 59 years compared to 71 years, the Crude Birth Rate is 41, Crude Death Rate is 11 and the Infant Mortality Rate is 97. Comparable figures for Sri Lanka are 71, 21, 6 and 18.

In setting up the optimisation model, the study starts with the premise that improvement in the public sector health care system can be achieved by reallocating funds to achieve a more *cost-effective* and *efficient* service delivery. The study, therefore, develops an optimisation model which identifies the optimal allocation of outputs (patients treated) and inputs (beds and doctors), and the impact of government prescribed wage policies on *efficiency gains*.

The estimation for optimisation starts with developing both the input supply and production functions for the public sector health care system separately for rural and urban areas. The

results of the input supply function suggests that the health professionals have an inelastic response to wage rate increases in the urban health facilities. In other words, the professionals will be less enthusiastic in offering their services for employment in the urban health facilities even if wages are increased. However, their response to such an increase for service in the rural health facilities would be positive. The production function estimates suggest that the role of the availability of physical infrastructure is more dominant in the output (patients treated) in both the urban and rural health facilities, Both results, however, capture the *technical efficiency* of inputs and do not address the issue of *cost-effectiveness* and *allocative efficiency*. These are answered through the *optimisation* approach.

The results of the optimisation model suggests that the number of doctors employed in the urban health facilities and paramedics in the rural health facilities in 1992 were very nearly at the optimum level. The model also suggests that doctors and nurses should have been employed in much larger numbers (15% and 40%) respectively, for the rural and urban health facilities and that this increase should have been accompanied by a 25 percent increase in their wages. In addition, the number of health facilities available in both the urban and rural areas would appear to be higher than the optimum levels. The summary of the estimates for 1992, in the case of Punjab, is contained in Table 1 which shows the actual and compares this to the optimum. The results imply that the saving of about Rs 70 million (based on a unit cost of Rs 18,000 per bed) in construction costs could have been more effectively used to meet the recurring costs of the other inputs.

The *efficiency gain* from the optimisation strategy in 1992 could have been of the order of 5 percent by the urban health facilities and 15 percent by those in the rural areas. The overall efficiency gains for the whole of Punjab in 1991-92 would have been of the order of 10 percent.

TABLE 1
ACTUAL VERSUS OPTIMAL NUMBERS IN PUNJAB, 1992

VARIABLES	ACTUAL	OPTIMAL
URBAN HEALTH FACILITIES		
Doctors	8,923	8,248
Nurses	4,859	6,688
Paramedics	10,318	11,886
Beds	22,101	18,192
RURAL HEALTH FACILITIES		
Doctors	3,259	3,850
Paramedics	11,793	12,965
Health Centres	532	609
URBAN HEALTH FACILITY WAGES		
Doctors	53,277	53,506
Nurses	23,622	28,907
Paramedics	17,446	18,259
RURAL HEALTH FACILITY WAGES	41,253	51,469
Doctors	15,732	16,222
Paramedics		

This optimisation strategy extended into the future suggests that *allocative efficiency* by the end of the Perspective Plan Period would be achieved by the following mix of expenditure:

VARIABLES	1992		2003	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
URBAN HEALTH FACILITIES				
Recurring Expenditure	82.0%	84.0%	79.3%	65.3%
Development Expenditure	18.0%	16.0%	82.1%	34.7%
RURAL HEALTH FACILITIES				
Recurring Expenditure	71.4%	72.6%	75.4%	71.0%
Development Expenditure	28.6%	27.4%	24.6%	29.0%

and that the overall efficiency gain would be about 14 percent by 2002-03.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

A recent study by the World Bank on Pakistan's Health sector (1991, p.3) noted:[1]

> *... inefficiency is widely regarded as a central problem in the health and population sectors in Pakistan...(especially) in the public sector. Resources are misallocated, in part because no investigation has typically been made into the cost-effectiveness of various options. Political influence and leakage of equipment and supplies further distort public sector allocations. Poor management and centralized financial, administrative and management authority reduces the efficiency of facility-level staff services.*

Since *inefficiency* and *cost-ineffectiveness* are considered to be the two crucial impediments facing the public health system in Pakistan, the major policy debate in this context should then address the problem of re-allocating the limited resources among inputs in the most economical way. In other words, given the limited available budget, should the public health department (*PHD*) go for an expanded infrastructure program (development expenditure) or hire more health personnel (recurring expenditure) or a combination of both so that there is a real improvement in the health services? Or, even more importantly, what type of wage policy should it adopt if more personnel are needed to work in rural health centres (*RHCs*), basic health units (*BHUs*) and hospitals, especially when there are shortages of competent nurses and doctors in the country?

Furthermore, if, historically or even in the future, there is more emphasis on development expenditure i.e., rapid expansion of *BHUs* or *RHCs* especially under the recently initiated *Social Action Program* (SAP), what implications will this program have on recurring budget? Will the present health system in the country be able or capable of handling such an accelerated expansion of facilities? That is, given the present institutionally fixed wages, will the health

1 The World Bank Report (1991): "Pakistan Health Sector Study: Key Concerns and Solutions."

system be able to attract enough doctors or nurses? All these public policy issues are critical for the *sustainability* of the basic health program in Pakistan and they cannot be addressed in isolation. A general optimization framework for the *Public Health System* (PHS) is needed where the input-output linkages consistent with the resource (budget) constraints and institutionally fixed wage policies are to be established.

In view of the above considerations, therefore, the objective of this study is:

a) To develop a general optimization framework in order to address the policy issue of *cost-effectiveness* and *efficiency* for the public health system;

b) Based on the above framework, to forecast an optimal mix of *cost-effective* inputs, wages and expenditure requirements (both recurring and development) of *PHS* covering up to the end of the *Perspective Plan* period, 2002-2003;

c) To estimate and compare the extent of *efficiency gains/loss* for *PHS* under alternative assumptions.

1.2 A COMPARISON OF HEALTH FACILITIES FOR SELECTED COUNTRIES

In order to get some international perspective on the amount that Pakistan spends on the health sector and her performance in terms of health indicators, this section provides a comparison of these indicators with selected countries in the region.

In recent years, many developing countries have invested heavily on the social sector including basic health. This is based on the premise that human capital is vital to the growth and development of a nation. Therefore, keeping the mass healthy is as important as providing them with basic education. Pakistan has had an impressive GDP growth rate of about 8 percent per annum in 1991-92, out of which only a meagre 0.2 percent was spent on the health sector by the

Central Government. When this figure is translated in monetary value, it amounts to only Rs. 2 per thousand rupee of GNP spent on the health sector. This amount is very little by any standard and, in fact, the picture is even more dismal when this figure is compared with those of other developing countries.

Table 1.1 shows the percentage of total central government expenditure on the health sector in relation to government expenditure and GNP for selected developing countries. Of the eight countries selected for comparison, Bangladesh and Sri Lanka appeared to have spent 4.8 percent of their government expenditure on health as opposed to only 1 percent by Pakistan. Even a small, poor country like Nepal spends more money (4.7%) than Pakistan on the health sector. In the list of countries considered, Pakistan's standing in terms of spending on health (either as a proportion of government expenditure or GNP) is the lowest which is very discouraging and disappointing.

TABLE 1.1
Central Government Expenditure on Health for Selected Developing Countries (1992)

Country	% of Total Central Govt. Expenditure on Health	% of GNP Spent on Health
PAKISTAN	1.0	0.2
BANGLADESH	4.8	0.7
NEPAL	4.7	0.9
INDIA	1.6	0.3
SRI LANKA	4.8	1.4
INDONESIA	2.4	0.5
EGYPT	2.8	1.1
PHILIPPINES	4.2	0.8

Source: World Development Report, 1994.

Low public expenditure on health facilities over the years is also reflected in the poor health status of the population in Pakistan. When various health indicators of Pakistan are compared with those of its close neighbours some startling health statistics emerge.

Table 1.2 reports health indicators on life expectancy, crude birth rate (*CBR*), crude death rate (*CDR*) and infant mortality rate (*IMR*) for selected developing countries. Sri Lanka and Malaysia have the highest life expectancy at birth of 71 years while, for Pakistan, the figure is only 59 years. In terms of *CBR*, Pakistan has the highest rate of 41 per thousand population, which is one of the reasons for the high population in the country. Sri Lanka again has the lowest crude birth rate at 21 per thousand population followed by Indonesia (25), Philippines (28) and Malaysia (29).

TABLE 1.2
BASIC SOCIAL INDICATORS FOR SELECTED DEVELOPING COUNTRIES (1991)

Country	Life Expectancy at Birth (in Years)	Crude[1] Birth Rate	Crude[2] Death Rate	Infant[3] Mortality Rate
PAKISTAN	59	41	11	97
BANGLADESH	51	34	13	103
NEPAL	53	38	13	101
INDIA	60	30	10	90
SRI LANKA	71	21	6	18
INDONESIA	60	25	9	74
EGYPT	61	32	9	59
PHILIPPINES	65	28	7	41
MALAYSIA	71	29	5	15

1 Per 1,000 population, 1991;
2 Per 1,000 population, 1991;
3 Per 1,000 population, 1991;
Source: World Development Report, 1993.

With respect to crude death rates (*CDR*), Pakistan's standing is a little better, however, it is still among one of the three highest countries (i.e. at 11 per thousand population) in the region. Comparing the infant mortality rates (*IMR*) across different countries, it appears that more than 97 babies per thousand newborns in Pakistan do not get to see the face of the earth as opposed to only 15 per thousand newborns in Malaysia.

Table 1.3 reports some interesting basic health and nutrition statistics for selected developing countries. The estimates of population per physician and per nursing person, respectively, are derived from the World Health Organization (WHO). Nursing persons include auxiliary nurses as well as para-professional personnel such as traditional birth attendants.

TABLE 1.3
INDICATORS OF BASIC HEALTH AND NUTRITION FOR SELECTED DEVELOPING COUNTRIES

Country	Population per[1] Physi-cian	Nurse	Babies with low[2] birth weight %	Prevalence[3] of Malnutrition (under 5 Yr.)	Daily Calorie[4] Supply (per capita)
PAKISTAN	2910	4900	25	57	2315
BANGLADESH	6730	8980	31	60	1927
NEPAL	32710	4680	n.a	n.a	2052
INDIA	2520	1700	30	n.a	2238
SRI LANKA	5520	1290	28	45	2400
INDONESIA	9460	1260	14	14	2579
EGYPT	770	780	7	13	3342
PHILIPPINES	6700	2740	18	19	2372
MALAYSIA	1930	1010	9	24	2730

1 1984
2 1985
3 1990
4 1986
n.a not available

Source: World Development Report.

Babies with low birth weights are children born weighing less than 2,500 grams. Low birth weight is frequently associated with maternal malnutrition. It tends to increase the risk of infant mortality and lead to poor growth in infancy and childhood, thus increasing the incidence of other forms of retarded development. Bangladesh has a rate of 31 percent which is the highest percentage of babies with low birth weight, followed by India (30%), Sri Lanka (28%) and Pakistan 25%.

Child malnutrition measures the percentage of children under five with a deficiency or an excess of nutrients that interfere with their health and genetic potential for growth. Malnutrition continues to be a major problem for third world countries. More than half of all children suffer stunting and wasting. Despite the increase in the growth of agriculture and industry, the prevalence of malnutrition in Pakistan remains unchanged. Countries like Indonesia, Philippines and Egypt have all dramatically lowered their rates of malnutrition in the last ten to twenty years.

In summary, based on a cross country comparison of various indicators, it is clear that Pakistan's performance in the health sector is less than adequate. Furthermore, Pakistan's spending for this sector is also one of the lowest in the region. In the present environment of high budget deficits, the critical issue facing the public sector should then pertain to designing *health policies* which must be *cost-effective* and *efficient*.

CHAPTER TWO

COST COMPOSITION OF PRIVATE SECTOR HEALTH FACILITIES: A SAMPLE SURVEY RESULT

2.1 INTRODUCTION

The objective of the field survey is to gain information on the level and composition of costs and output of medical facilities in the private sector. This information could then be used as a basis of comparison with public sector medical facilities and would enable us to gauge the level of efficiency of the government in providing health care.

Section 2.2 outlines the design and setup of the survey, Section 2.3 presents the results of the survey on the level and composition of costs and output facilities, while section 2.4 analyzes these results and presents conclusions.

2.2 DESIGN AND SETUP OF DATA COLLECTION

The field survey was limited to the urban sector, specifically Karachi and Lahore, and to medical facilities located in lower-middle-class neighbourhoods within these two cities. It was felt that medical facilities in lower-middle-class areas would be comparable in quality to the average government medical facility.

A total of twenty four medical facilities were surveyed, with seventeen of these in Karachi and seven in Lahore. Data was gathered on the following categories: type of medical facility (hospital, maternity home, clinic, and dispensary); nature of ownership and management (private or non-profit); number of beds, laboratories, operation theatres; number of doctors, nurses, and other medical and non-medical staff; number of daily outpatients, operations, and delivery cases; occupancy rates of beds; the level of charges of beds, doctors, laboratories and other medical services; and the cost structure of the various medical facilities.

2.3 LEVEL AND COMPOSITION OF COSTS AND OUTPUT FACILITIES

Table 2.1 provides a comparison of government and sampled private medical facilities. Due to the smallness of the sample size it was not deemed feasible to differentiate the private medical facility by city and type. Therefore, data from the twenty four sampled facilities was aggregated to compute the wage rate of doctors and nurses, and the average outpatients treated daily by doctors and nurses, and the recurring expenditure per hospital bed. The average wage rates of doctors in the sample was calculated by dividing the total wage bill of doctors by the total number of doctors employed in the facility. The wage rate of nurses was calculated similarly. In the case of self-employed doctors, such as those having their own clinic, the salary was assumed to be equal to the yearly income from the number of outpatients treated. The recurring expenditure per hospital bed in the sample was calculated by dividing the total non-salary recurring expenditure, which included expenditure on durable goods, supplies, and maintenance, by the total number of hospital beds. The figure for outpatients per doctor is the total number of outpatients treated daily divided by the total number of doctors. The wage rates of doctors and nurses employed by the government is the average for the four provinces, the figures for the outpatients per doctor and nurse is the average for Punjab and Sindh, while the figure for the recurring expenditure per bed is that for Punjab. The figure for nurses in the public sector includes lady health visitors.

Before proceeding to the comparative analysis, the following points need to be made. First, the number of private medical facilities sampled was very small and therefore, it would not be reasonable to assume that the survey provided a complete picture of private medical facilities in Karachi and Lahore. Second, the survey was limited to the two largest cities and therefore, provides no information on private facilities in smaller urban areas. Third, the data on government medical facilities is not totally reliable.

2.4: Analysis of Cost Composition and Output Facilities

Sample survey data in Table 2.1, indicates that doctors and nurses in private sampled medical facilities treat more outpatients daily, and are paid on average less, than their counterparts in public sector medical facilities. This seems to indicate that public sector medical personnel are underutilsed and that the government is considerably less efficient in providing health care than the private sector.

TABLE 2.1

A COMPARISON OF COST AND OUTPUT OF GOVERNMENT AND SAMPLED PRIVATE MEDICAL FACILITIES (1993-94)

	Wage Rate of Doctors[1]	Wage Rate of Nurses[1]	Recurring Exp Per Bed[2]	Number of Out Patient Per Doctor Per Day	Number of Out Patient Per Nurse Per Day
PRIVATE HOSPITALS	5,100	1,550	12,700	23.7	25.6
NON-PROFIT HOSPITALS	3,800	N.A	11,600	25.5	20.8
GOVERNMENT HOSPITALS	5,372	1,969	22,000	3.7	5.36

Notes:
1. **Rupees per month**
2. **Rupees per annum (Non-salary Expenditure)**
3. **N.A. stands for not available**

It has to be said that this conclusion is at most tentative. Apart from the limitations in the survey mentioned above, the comparative analysis had another serious drawback. The wage rate obtained for both the government and the sampled private medical facilities is not a true indication of the total yearly income of doctors and nurses. A majority of doctors and nurses in the private and public sector augment their earnings by doing part-time work in clinics in addition to their regular job. In fact, it appears that for most doctors the motivation for working in hospitals is to develop a clientele for their private practise. The earnings from part-time work are not captured by the survey or by the statistics on the public health sector.

Our small sample raises an important question. It appears that the wages paid to doctors in hospitals is not considerably more than the wage rate of the unskilled or semi-skilled worker. It is certainly not more than that of the average graduate who works in the corporate sector as a clerk. One then has to ask why there is such a high supply of doctors in the market. In the absence of significant monetary incentives, why would individuals spend a considerable amount of time and energy in medical college? In other words, we need to know whether the labour market is operating rationally or not.

To answer this, one would need to get information on the expected earnings of a doctor over his or her lifetime, and compare this with the expected earnings of individuals in other occupations. One would need a survey which gives a more realistic figure for the average wage rate of doctors - that is, one that takes into consideration the wages earned from part-time work. One would also need information on the wages earned by doctors of different ages, as well as information on the wage rates in some other occupations. In addition, we need to know the costs of hiring these personnel.

Statistics do not provide an indepth picture of the public sector. A survey would be needed which would give us an idea of the quality of health care provided by the public sector. For example, one would need to know whether the low figure of the outpatients per doctor is due to overstaffing, neglect, or a low demand for government health facilities. Once the qualitative, as well as the quantitative aspects of the public sector, as well as information on the market, have been taken into consideration, one can talk about reform and policy changes.

CHAPTER THREE

AN OPTIMIZATION PUBLIC POLICY MODEL FOR HEALTH FACILITIES

3.1 INTRODUCTION

Lack of *cost-effectiveness* and *inefficient* allocation of resources combined with institutionally fixed wage rates makes the plight of the health system even more arduous in Pakistan where the allocation of public funds for this sector are already one of the lowest in the region as indicated earlier. In order to understand this seemingly difficult public policy issue on health system, one needs to identify and disentangle the linkages (be it simple or complex) between the outputs and inputs of the health facility. Any policy recommendations (be it wage or expenditure policies) in this context, if they are to improve the *efficiency* and *cost-effectiveness* of the health system will be meaningful when this input-output link is established consistent with resource allocations.

This chapter is thus devoted in developing a public policy optimization model for the health system with a view to examine theoretically: a) whether a flexible wage policy for health professionals may lead to an improvement in the public health system (in terms of higher output); b) the condition(s) required to attain higher *efficiency gains* for an alternative health system; c) *cost effective* optimal expansion paths for inputs and output of health facilities; and d) issue of optimal allocation between recurring (health professionals) and development expenditures.

3.2 DIAGRAMMATIC APPROACH OF A SIMPLE OPTIMIZATION PUBLIC HEALTH MODEL

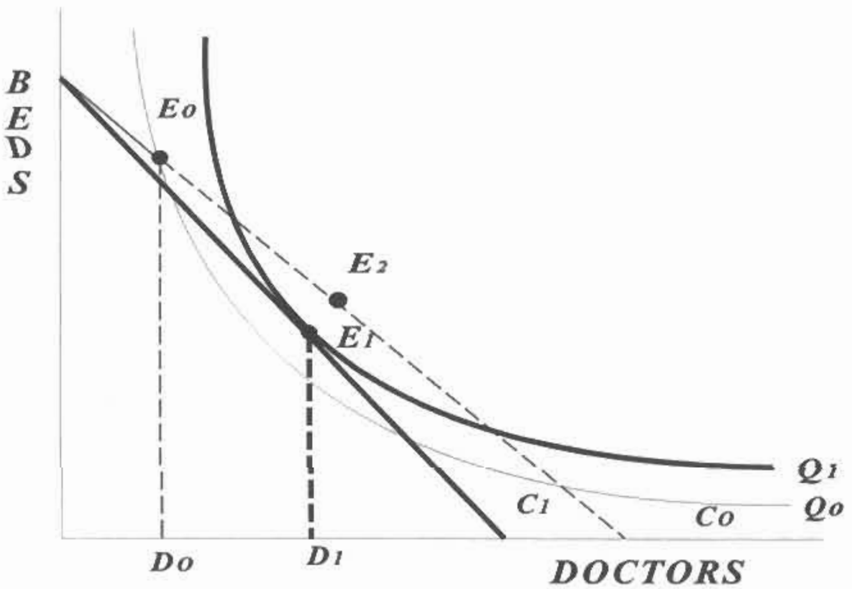
In the following, we develop a theoretical optimal allocation model for the health sector under institutionally fixed wage rates for health professionals. In order to keep the analysis simple and, at the same time, realistic, we assume that the health facility produces output [e.g., total patients treated (*Q*)] using two inputs, namely, infrastructure [represented by beds (*B*)] and medical professionals [e.g., doctors (*D*)]. In addition, the supply of personnel is assumed to be finitely elastic as there does not exist an unlimited inflow of doctors and, especially at the institutionally set low wage rates, many of these health professionals are reluctant to offer their services to the public health system. The public sector is assumed to be able to set the wage rates of doctors and other government personnel (supposedly below the market rate) because their share (in terms of total expenditure) within the health sector is very large. Thus, the public sector, represented by the provincial health department (*PHD*) then, can be labelled as a *monopsonist*. Due to limited public funds allocated to the health and other social sectors, the basic task of *PHD* (acting as a *monopsonist*) in this context is to maximize the output of the health facility subject to the available budgeted resources (*TC*). Assuming a well-behaved production technology, *c* as the unit cost of a hospital bed (*B*) and $\overline{w}$ as the fixed wage rate for doctors, the optimal health input allocation problem of *PHD* can be illustrated with the help of a diagram as given in Figure 3.1. Essentially, the diagram consists of isoquant (*Q*) and isocost ($\overline{C}$) curves for various combination of *Bs* and *Ds*.[1]

With institutionally fixed wages for doctors ($\overline{w}$) and unit price per beds (*c*), the initial isocost

[1] For the convenience of non-technical reader, *isoquant* is defined as the combination of various inputs (e.g., doctors and beds) that can be used to produce a given level of output (e.g., patients treated). On the other hand, *isocost* line shows, for given input prices, the different combination of inputs the producer can allocate so that the available funds are completely exhausted. The slope of the *isocost* line is simply the relative price of two inputs [e.g., -*w/c*] while for *isoquant* the slope represents the *marginal rate of technical substitution* (MRTS) between the two inputs. The optimal allocation of inputs can be achieved at a point where *MRTS*=*w/c*. This allocation of inputs will be *efficient* and *cost effective* as the producer at this point is expected to maximize output for given total cost and input prices. [For more details, reader may refer to Henderson and quandt (1980)].

line is given by C_o with slope $(=-\overline{w}/c)$ in Figure 3.1. It is, however, important to note that **not all points** (particularly E_o, on the broken portion of C_o) on this isocost are feasible. Given the inelastic supply of doctors, the number of professionals offering their services will simply not **exceed** D_o. Therefore, the equilibrium in this case will be established at E_o as shown in Figure 3.1, which is neither *efficient* nor *optimal* though the available budgeted resources are completely utilized. Here obviously, more beds and fewer doctors are employed to produce an *inefficient* Q_o level of output [i.e., patients treated].

FIGURE 3.1
OPTIMAL ALLOCATION OF HEALTH INPUTS WITH INSTITUTIONALLY FIXED WAGE RATES



On the other hand, however, if *PHD* adopts a more *flexible wage policy* and allows the wage rate of doctors to increase from $\overline{w}$ to w_1 then the availability of doctors will increase from D_o to D_1. It is interesting to note that even though the *isocost* line has pivoted inwards (due to higher wages) from C_o to C_1, the output (patients treated), however, has increased from Q_o to Q_1. In fact, the new equilibrium level attained at E_1 is at a higher *isoquant* that is both *optimal* as well as *cost effective*.[2] The above simple example leads us to make the following proposition that:

Proposition 1: ***It is possible for the public health policy maker to be cost efficient and, at the same time, achieve a higher output (in terms of more patients treated) even with the same available budget provided the public sector adopts a flexible wage policy for health professionals (be it doctors, nurses or paramedics).***

3.3 OPTIMIZATION CONDITIONS UNDER A MONOPSONISTIC PUBLIC HEALTH SYSTEM

It was argued earlier that the *monopsonosistic* equilibrium output, such as E_2 in Figure 3.1, will not be feasible under an institutionally fixed wage system. However, in order to explore alternatives (other than flexible wages) under which the *monopsonist PHD* may achieve equilibrium at a higher output level, we explicitly need to derive the *first order conditions* (*FOCs*) of the present health system. By comparing these *FOCs* with those of the standard *competitive* producer we may be able to establish the extent of divergence between them and thus propose the condition(s) which will lead to an improvement in the output for *PHD*.

Assuming the supply of doctors as a function of wages [$D=D(w)$] and output [patients treated (Q)] being produced by doctors and beds, the optimization problem of the monopsonistic *PHD* will simply entail the maximization of the following:

$$(1) \qquad Max: \quad Q = Q\left[D(w);\ B\right];$$

$$(2) \qquad subject\ to: \quad C = wD(w) + (m+c)B:$$

[2] It should be noted that E_2 on the old *isocost* line C_o is also an equilibrium point for a fixed monosonistic wage rate which is both *efficient* and at a higher output level. However, to attain such a level of output, the producer (PHD) must be able to exert enough monopsony power to hire the required level of doctors. Here we argue that such a situation will be difficult if not impossible to achieve particularly when there are alternatives available to supirior qualified health professionals within (in the private sector) and outside the country.

where m is the unit recurring cost per bed. Other variables in the above model are as defined earlier. Writing the *Lagrangian* function of the above, we get:

$$(3) \qquad \mathcal{L}(w,B,\lambda) \;=\; Q\left| D(w)\,;\,B \right| \;+\; \lambda\left| C_o \,-\, wD(w) \,-\, (m+c)B \right|;$$

where λ is the *Lagrangian* multiplier. The maximization of the above *Lagrangian* will yield the following three first order conditions (*FOC*):

$$(4) \qquad \frac{\partial \mathcal{L}}{\partial w} \;=\; \frac{\partial Q}{\partial D} \bullet \frac{\partial D}{\partial w} \,-\, \lambda\left[w\frac{\partial D}{\partial w} + D \right] \;=\; 0\,;$$

$$(5) \qquad \frac{\partial \mathcal{L}}{\partial B} \;=\; \frac{\partial Q}{\partial B} \,-\, \lambda(c+m) \;=\; 0\,;$$

$$(6) \qquad \frac{\partial \mathcal{L}}{\partial \lambda} \;=\; C_o \,-\, wD \,-\, (c+m)B \;=\; 0;$$

From the first two *FOCs*, we have

$$(7) \qquad \frac{\dfrac{\partial Q}{\partial D}}{\dfrac{\partial Q}{\partial B}} \;=\; \frac{w\dfrac{\partial D}{\partial w} + D}{(c+m)\dfrac{\partial D}{\partial w}} \;=\; \frac{w}{(c+m)}\left[1 \,+\, \frac{D}{w\dfrac{\partial D}{\partial w}} \right]$$

If we define the marginal rate of technical substitution (*MRTS*) between doctors and beds as:

$$(8) \qquad MRTS_{D,B} \;=\; \frac{\partial Q / \partial D}{\partial O / \partial B};$$

and the elasticity of supply of doctors with respect to wages (ξ^S_D) as:

$$(9) \qquad \xi_D^S = \frac{w}{D} \bullet \frac{\partial D}{\partial w};$$

then the above optimization problem of the *monopsonistic PHD* will require that

$$(10) \qquad MRTS_{D,B} = \frac{w}{(c+m)} \left[1 + \frac{1}{\xi_D^S} \right].$$

The above optimization condition simply states that, for the *monopsonistic PHD*, $MRTS_{D,B}$ should not only be equated to the ratio of relative prices $[w/(c+m)]$, as for the standard competitive producer, but it should now be equated to a weighted relative price. The weight factor includes the supply elasticity of doctors (ξ_D^S). It is interesting to note that, depending on how large the magnitude of (ξ_D^S), the above optimization condition for *monopsony* can be equivalent to that of the competitive producer. This leads us to make our second proposition that:

Proposition 2: ***The optimal condition(s) for the monopsonistic producer (PHD) can be equivalent to those of the competitive producer as long as the price (wage rate) elasticity of supply of the monopsonistic input (doctors) is infinitely elastic.***

Whether or not the above proposition is valid in the case of *PHD* is a matter of empirical investigation and we relegate this to the next chapter where we report our results on estimated elasticities for inputs.

3.4 EFFICIENCY GAIN/LOSS FOR THE MONOPSONISTIC PRODUCER

Based on a simple model constructed earlier we can also analytically compute and compare the *efficiency* gain/loss (in terms of output) of the *monopsonistic PHD* under alternative scenarios. Suppose that, at a given point in time, the actual allocation of inputs by *PHD* is such that the size of the infrastructure in the form of beds (*B*) is greater than that of the optimal *monopsonist*. In the following, we can demonstrate that halting or reducing the growth of infrastructure building and optimally reallocating the resources towards health professionals may lead to an improvement in the health facilities. In fact, what is more interesting now is that the *monopsonist PHD* with fixed beds (named as *constrained monopsonist*) will be able to achieve an even higher level of output as compared to the standard *monopsonist*.

If we define O_c^* and O_s^*, respectively, as the optimal level of outputs for the *constrained* and *standard monopsonists*, then the expression for efficiency *gain/loss* (*E*) can be written as:

$$(11) \qquad E = \left[\frac{O_c^*}{O_u^*} - 1 \right].$$

Obviously, a positive value for *E* will lead to an efficiency gain in favour of the *constrained monopsonist* and *vice-versa*. By substituting the optimal values for O_c^* and O_s^* (obtained from the optimization model) in the above equation, we can obtain an explicit expression for *E*.

If the supply elasticity and the share of doctors (π^{D}) and nurses (π^{B}) are assumed to be fixed in magnitude as a simplifying assumption and the production function is assumed to be *Cobb-Douglas*, then the two optimal outputs (*standard* and *constrained*) and their corresponding input demand functions obtained through the optimization procedure can be written as:[3]

Standard Monopsonist

$$(12) \qquad O_s^* = A_o (D_s^*)^{\alpha} (B_s^*)^{\beta};$$

$$(13) \qquad B_s^* = \frac{\pi^B}{(m+c)} (\overline{C} + cB_{-1});$$

$$(14) \qquad D_s^* = \left[\pi^D (\overline{C} + cB_{-1}) \right]^{\frac{\gamma}{1+\gamma}};$$

Constrained Monopsonist

$$(15) \qquad O_c^* = A_o (D_c^*)^{\alpha} (\overline{B})^{\beta};$$

$$(16) \qquad D_c^* = (\overline{C} - m\overline{B})^{\frac{\gamma}{1+\gamma}};$$

where γ is the supply elasticity of doctors and α and β, respectively, are the output elasticities of doctors and beds. Substituting these optimals, we get the following explicit expression for E that contains entities that are either exogenous [e.g., $\overline{C}$ and $\overline{B}$] or fixed in values [e.g., share of doctors (π^D), m, and c]:

$$(17) \qquad E = \left[\frac{(\overline{C} - m\overline{B})}{\pi_D(\overline{C} + cB_{-1})} \right]^{\alpha} \bullet \left(\frac{\overline{B}}{B^*} \right)^{\beta};$$

Thus, for E to be greater than one, the above equation should be written as:

---

[3] Note that in the case of constrained monopsonist, since the number of beds are fixed at $\overline{B}$ ($=B_{-1}$), the budget constraint will now be changed to $\overline{C} = wD + m\overline{B}$.

(18) $$\left(\frac{wD_c^*}{wD_s^*}\right) \rangle \left(\frac{B_s^*}{\overline{B}}\right)^{\frac{\beta}{\alpha}}.$$

This leads us to make our third proposition that:

Proposition 3: ***Constrained monopsonist PHD with fixed infrastructure (beds) may have positive efficiency gains (E>1) relative to those of a standard monopsonist as long as the fixed number of beds ($\overline{B}$) exceeds the optimal (B_s^*) and, at the same time, the total allocation of expenditure on doctors by the constrained monopsonist is greater than that of the standard case.***

These three propositions have important implications for public health policies and they are summarized below:

a) In general, given limited budgeted resources available, a proper ***cost-effective*** allocation between ***recurring*** (health professional) and ***development*** expenditures (infrastructure) can lead to higher efficiency gains for health facilities;

b) In the case where *PHD* acts as a *monopsonist* and there is an inelastic supply of health professionals, adopting a ***flexible wage policy*** rather than institutionally set wages may not only attract more of these professionals but it is also possible to attain a higher output for the health system which will be both ***cost effective*** and ***efficient***.

c) In the event that the existing allocation of ***infrastructure*** (beds) exceeds the optimal level, then a ***policy of consolidating*** the infrastructure and diverting the limited available resources towards recurring outlays can lead to *efficiency gains* which, in fact, will **exceed** those of the optimal cost-effective producer.

In order to test these theoretical propositions and also to obtain the size and magnitude of these efficiency gains for *PHD*, the next chapter develops an empirical simulation model based on provincial data for Pakistan.

CHAPTER FOUR

OPTIMAL EXPENDITURES MIX AND EFFICIENCY GAINS FOR HEALTH SECTOR: SOME SIMULATION RESULTS

4.1 INTRODUCTION

This chapter reports simulation forecast results, both historical and *ex-ante*, based on optimization strategies subject to available resources for the public health system in Pakistan. Estimated optimal mix of expenditures on inputs in this context are *efficient* and *cost-effective*. Thus, a comparison of the actual available data on health output with the forecasted values will enable us to compute the *efficiency gain/loss* for alternative optimal health policies. In addition, the simulation forecast results will provide us with an opportunity to test the validity of the propositions made in the previous chapter.

Long-term forecasts generated by the model covering up to the end of perspective plan period 2002-03 will be useful for policy makers in establishing the optimal requirements of physical health inputs (e.g., doctors, nurses, paramedics and beds), expenditure allocations (both development and recurring) and the wage policy under alternative health strategies.

The organization of rest of the chapter is as follows. Simulation results estimated in this study are based on an optimization model whose algebraic solution at times is complex. In Section 4.2, we, therefore, explain the optimization process, definition of key variables and the underlying assumptions with the help of a simple flow chart diagram while the detailed algebraic derivations are relegated to *Appendix A*. Section 4.3 presents the discussion on simulation results and ensuing policy implications. Before extending the model to simulation results for all four provinces combined, we also report results for Punjab in Sections 4.3.1 and 4.3.2. This gives us an occasion to test the forecasting power of our model by comparing the simulated values with those of the actual data. The discussion on simulation results for all four provinces are presented in Section 4.3.3.

4.2 FLOW CHART DESCRIPTION OF THE OPTIMIZATION MODEL

Simulation results in this chapter are based on an extended version of the optimization model developed in Chapter 3. In order to get an intuitive understanding and deeper insight into the extended model for the health system, we describe the optimization process and its linkages between outputs, inputs and the cost constraints with the help of a flow chart diagram as given in Figure 4.1. Detailed algebraic derivation and the optimal solution for health outputs and inputs are given in *Technical Appendix A*.

Prior to discussing the optimizing process, we give a brief explanation of various outputs, inputs, supply functions of professionals and cost variables.

Output

With a view to cover a broad spectrum, we have considered four categories of health facilities namely, general hospitals (*GHPs*), dispensaries (*DIPs*), rural health centres (*RHCs*) and basic health units (*BHUs*). The former two facilities are primarily of urban character [hereafter named as urban health facilities system (*UHFs*)] and the latter two cater to the rural areas [hereafter named as rural health facilities system (*RHFs*)]. Output produced by these facilities [e.g., patients treated (*PT*)] may not only differ from each other but even within a given system there are differences such as inpatients (*IP*) and outpatients (*OP*). Thus, to get a combined output for the entire health system, an aggregate index of patients treated (*IPT*) has been generated. Aggregation of *IPT* has been done at different stages. First, the outpatients of *OHPs* and *DISs* were linearly added to compute a combined total outpatient for *UHFs* (named as *OUHFs*).

Second, the total inpatient data for *UHFs* is then added geometrically to *OUHFs* to generate a composite index of patients treated for the urban health system (*PTUHF*). Finally, since the health output for the rural system only consists of outpatients (named as *PTRHFs*), this output is then added (again geometrically) to *PTUHF* to create the composite index for total patients treated for the entire health system (termed as ***PTHS)***. The geometric weights attached to urban and rural health outputs may reflect societies' preference towards these two health systems with respect to services delivered (or valued).

Inputs

Four major inputs namely, *doctors, nurses, paramedics, and beds*, are considered for the treatment of patients in our health optimization problem. Other inputs, e.g. administrative and lower level staff in the health system, are excluded from the analysis as the personnel do not contribute directly towards the treatment of patients. As for equipment and other infrastructure, *beds* are used as a proxy for them.

In the rural health system, as nurses were not employed in either *RHCs* or *BHUs* for earlier years, therefore (whenever available), nurses were added to paramedics and we have proxied this by paramedics. As for health infrastructure, both *RHCs* and *BHUs* are added geometrically to arrive at *RHFs*.

Input Supply Function

Supply of health personnel is expected to respond to its wages and the number of registered professionals in their respective professions. We have considered wages to be different between urban and rural areas for the same type of profession. Although the basic salary structure for a given type of professional is fixed whether he/she is located in urban or rural areas, the difference may arise due to the allowance component of the salary and\or due to variations in personnel holding different grade scales for similar jobs. The number of registered professionals is, however, the same for rural or urban areas as the pool of professional comes from the same source.

Wages and Unit Costs

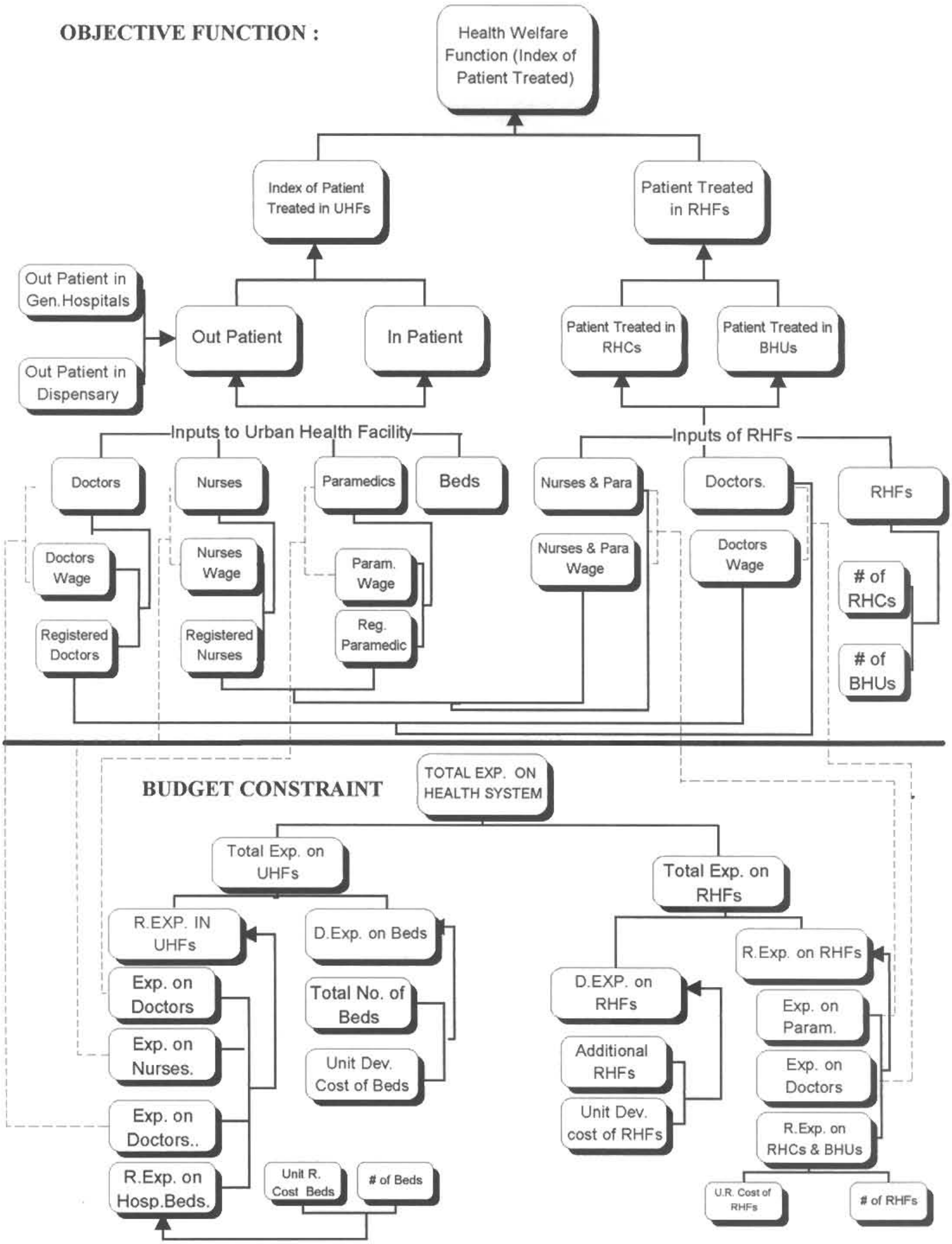
Total budgeted cost of the health system is assumed to be divided into expenditures incurred by urban and rural facilities. Within a given facility, costs are again divided into recurring and development expenditures. A part of the recurring outlay is expended for expenditures on health professionals while the remaining recurring budget is allocated to the beds running cost which also includes salaries of nonprofessional staff. Development costs are simply the expenditures incurred for additional infrastructure again proxied by additional beds.

Optimization Problem

Figure 4.1 presents a schematic flow diagram of the optimization problem of the public health system. The upper half of the diagram outlines the objective function (aggregate index of patients treated) while the lower half describes the available budget constraint faced by the public health system. The basic optimization process, as shown in Figure 4.1, entails the maximization of the index of total patients treated (also termed as the welfare function) subject to the available budgeted funds. It is important to note that the optimization strategy, presented in Figure 4.1, simultaneously maximizes the output of both *UHFs* and *RHFs* represented by the welfare function of the health system as shown in the upper half of Figure 4.1. In addition, the budget constraint is assumed not to be limited to each facility, but rather an overall budget for the entire health system (given in the lower half of Figure 4.1) is expected to be satisfied. The

FIGURE 4.1

OPTIMIZATION PROBLEM FOR MONOPSONISTIC HEALTH SYSTEM



advantage of suchan aggregated optimization approach is that now reallocation is possible not only between inputs within a given facility (e.g., whether to hire more nurses and have fewer beds in *RHFs*) but substitution is also possible between outputs (patients treated) produced by *UHFs* and *RHF*. For example, for given input prices and total available resources, the *cost-effective* optimal strategy (to achieve higher output) may require that more patients be treated in *RHFs* rather than *UHF* with additional paramedics. It is now possible with this optimization approach for not only a reallocation of funds to take place from other inputs to paramedics within *RHFs*[1] but, interestingly enough, additional funds may now be reallocated from *UHF* to *RHF* so that the overall aggregated output (or the welfare function) of the entire health system is maximized.

Given the estimated supply elasticities, share of inputs, unit costs, predetermined and exogenous variables, this global optimization approach will yield expansion paths for inputs, prices (wage rates and unit costs) and outputs of the health system that will be *optimal*, *efficient* and *cost-effective*. A detailed derivation and explicit solution for these optimal expansion paths are given in *Technical Appendix A*.

4.3 SIMULATION RESULTS FOR THE PUBLIC HEALTH SYSTEM

In this section, we report estimated simulation results based on an extended model developed for the public health system. Basic parameters (e.g., elasticities, output share, etc.) used for simulation purposes, in this study, were estimated employing health sector data on Punjab.[2]

However, given that Punjab is the largest province in the country, in terms of population, these

1 A reallocation will simply mean a movement along the isoquant without neccesarily increasing the output.

2 A discussion on data sources, definition of variables and ensuing problems and anamolies on it are given in *Appendix B*.

parameters are likely to be representative of the other provinces as well. Thus, using these basic estimated parameters for Punjab, all simulation forecasts (whether for Punjab or all four provinces combined) are undertaken. Although the focus of this study is to generate optimal expansion paths for all four provinces combined, we have also produced simulation results for Punjab as well. Simulation results for Punjab will be useful because they provide us an opportunity to test the forecasting power of our model at the provincial level before extending it to the combined provincial data.

Thus, after discussing the estimated parameter values for wage and output elasticities for different health professionals, we then present the simulation results, *historical* and *ex-ante*, for Punjab, and subsequently, for all four provinces combined. Since there is a plethora of numbers generated by the simulation model, in order to describe these numbers more effectively, only the broad policy oriented results are discussed in the main text.

4.3.1 Estimated Wage Elasticities and Production Functions

Estimated *ordinary least squares* (OLS) parameter values of the supply function for health professionals based on *RHFs* and *UHFs* of Punjab are given in Table 4.1. The supply function for each professional included its respective wage rate and the number of registered professionals. Since the function used is in logarithmic form, the parameters estimated in this context simply represent elasticities. For instance, in case of doctors in *RHFs,* the estimated parameter value of 1.47 in Table 4.1 represents the doctors' supply elasticity with respect to wage rates. Analysing the results in Table 4.1, it is interesting to note that health professionals in *UHFs* have inelastic wage elasticities (less than one). This implies that these professionals, often, will be less enthusiastic in offering their services in response to a wage rate increase. These results have important implications in terms of interpreting the *Propositions* made earlier.

TABLE 4.1

ESTIMATED SUPPLY FUNCTIONS OF HEALTH PERSONNEL FOR PUNJAB

VARIABLES	RURAL HEALTH FACILITIES (RHFs)		URBAN HEALTH FACILITY (UHFs)		
	DOCTORS	PARAMEDICS	DOCTORS	NURSES	PARAMEDICS
CONSTANT	-15.450 (-3.572)*	-8.108 (-8.585)*	0.295 (0.202)	-3.917 (-3.182)*	1.587 (2.149)*
DOCTORS NOMINAL WAGE	1.472 (1.761)*		0.659 (2.258)*		
NURSES NOMINAL WAGE				0.253 (0.440)	
PARAMEDICS NOMINAL WAGE		1.078 (3.239)*			0.498 (2.909)*
REGISTERED DOCTORS	0.759 (1.849)*		0.127 (0.780)		
REGISTERED NURSES				0.979 (1.956)*	
REGISTERED PARAMEDICS		0.715 (2.021)*			0.271 (2.737)*
R^2	0.969	0.987	0.949	0.932	0.976
DW	0.69	1.057	2.386	1.837	2.44
OBSERVATIONS	1977-92	1977-92	1977-92	1977-92	1977-92

Notes: 1. Numbers in paranthesis are t-values.
2. Paramedics in rural health facility includes Nurses & Paramedics
3. Asterisk indicates, significance of the estimated parameter at 10 percent or less level of significance

Obviously, with an inelastic supply of health professionals, an institutionally fixed wage policy will not be copious enough to attract them towards the public health system.

Table 4.2 reports the estimated parameter values for health output (patients treated) production functions of both *RHFs* and *UHFs*. These estimated regression results in Table 4.2 suggest that, for both *RHFs* and *UHFs*, the role of infrastructure (in terms of large parameter values for beds as compared to other inputs) in the production process is more dominant than other remaining inputs, namely, health professionals. Analysing the health problem on the basis of production function alone, in this case, may suggest that resources be diverted towards building of infrastructure in order to improve health facilities. However, it should be noted that a production function approach may tell us only about the *technical efficiency* of the inputs. Whether a *technically efficient* input is also *cost-effective* can be established if the problem is analysed within a broader optimization framework where the available cost constraints are also considered. Inputs derived from the optimization approach will not only be *optimal* but, more importantly, they will be *cost-effective*. Distribution of health inputs through this optimization principle will ensure the *allocative efficiency* of the health system. In the next section, we first discuss the optimization simulation results based on the data of the *Punjab* province and then present results for all four provinces combined.

4.3.2 Estimated Gain/Loss of Efficiency in Health Output for Punjab

Based on the estimated supply and output elasticities from Tables 4.1 and 4.2, respectively, and exogenously given profile for total cost and total stock of registered health professionals, we can now directly compute the optimal expansion paths for inputs, outputs and the distribution of recurring and development expenditures for both *UHFs* and *RHFs* using the expressions given in *Technical Appendix A*.

TABLE 4.2
ESTIMATED PRODUCTION FUNCTIONS FOR RHFs & UHFs : PUNJAB

VARIABLES	RURAL HEALTH FACILITIES (RHFs)	URBAN HEALTH FACILITIES (RHFs)
CONSTANT	1.373 (5.205)*	-6.449 (-12.97)*
DOCTORS	0.129 (0.929)	0.353 (8.024)*
NURSES		0.105 (2.132)*
PARAMEDICS	0.36 (3.095)*	0.29 (4.836)*
BEDS		0.701 (6.194)*
RHF	0.561 (1.948)*	
R^2	0.995	0.999
DW	2.297	1.196
OBSERVATIONS	1977-92	1977-92

Notes :
1. Numbers in paranthesis are t-values.
2. Paramedics in rural health facility includes Nurses & Paramedics
3. Asterisk indicates, significance of the estimated parameter at 10 percent or less level of significance

Historical Simulation Results: Historical simulation results (between 1981-1992) for optimal expansion paths of health personnel, physical infrastructure, wages structure, outputs efficiency and share of expenditures along with their corresponding observed figures are presented in Tables 4.3 to 4.5. These simulation results are useful in that they give us an opportunity to test the forecasting power of the model by comparing it with actual observed data. Analysing the results in these tables carefully, several interesting points can be made:

- Optimal forecasts of the number of doctors (in *UHFs*) and paramedics (in *RHFs*) and their corresponding salaries are reasonably close to the actual figures of 1992 as shown in Table 4.3. However, in case of nurses in *UHFs* and doctors in *RHFs*, the optimal *cost-effective* simulation strategy for 1992 suggests that these professionals should have been hired in a much larger number with a substantially increased salary as reported in Table 4.4. For instance, an additional forty percent (or 1,829) more nurses for urban facilities and over fifteen percent (or 591) more doctors for rural areas should have been hired by the *Punjab Public Health Department* (*PPHD*) with roughly a twenty-five percent increase in their salaries [i.e. Rs. 28,907 p.a. for nurses and Rs. 51,469 for doctors] if the *PPHD* was to improve the *efficiency* and *cost effectiveness* of the health system. It is important to **note** that these increased expenditures will simply be generated by virtue of *efficient re-allocation* of the existing funds available to *PPHD*.

- Analysing the forecasted results for health infrastructure in Table 4.3, it is interesting to note that the optimal requirements of rural health facilities (*RHCs* and *BHUs*) for 1992 are greater than the actual values [609 as opposed to 532]. However, in case of *UHFs*, simulation results suggest that there is an over construction of infrastructure (in terms of beds) for urban health facilities. For example, in 1992, Punjab had over 22,000 beds in

TABLE 4.3

HEALTH PERSONNEL AND PHYSICAL INFRASTRUCTURE: A HISTORICAL SIMULATION FOR PUNJAB

VARIABLES	YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
						URBAN HEALTH FACILITY							
DOCTORS	ACTUAL	2,947	3,226	3,475	4,809	5,263	3,972	4,093	4,157	6,160	6,808	7,311	8,923
	OPTIMAL	***3,606***	***3,939***	***4,258***	***4,533***	***6,016***	***5,718***	***6,072***	***7,152***	***6,969***	***7,481***	***7,336***	***8,248***
NURSES	ACTUAL	1,554	1,754	1,799	2,413	2,445	2,500	2,954	4,156	4,009	4,363	4,506	4,859
	OPTIMAL	***2,112***	***2,309***	***2,474***	***2,698***	***3,547***	***3,717***	***4,000***	***4,535***	***4,819***	***5,484***	***5,877***	***6,688***
PARAMEDICS	ACTUAL	3,934	4,355	4,462	6,050	6,616	5,954	8,760	8,891	6,671	7,322	8,215	10,318
	OPTIMAL	***5,097***	***5,554***	***5,974***	***6,393***	***8,264***	***8,199***	***8,718***	***10,165***	***9,993***	***10,704***	***10,637***	***11,886***
BEDS	ACTUAL	13,785	14,514	15,488	15,565	17,642	18,087	18,569	19,913	20,130	21,008	21,378	22,101
	OPTIMAL	***9,177***	***11,170***	***12,120***	***14,136***	***11,627***	***13,688***	***13,548***	***12,956***	***17,504***	***16,752***	***17,501***	***18,192***
						RURAL HEALTH FACILITY							
DOCTORS	ACTUAL	250	308	661	919	1,185	1,570	2,134	2,396	2,871	3,157	3,161	3,259
	OPTIMAL	***863***	***1,023***	***1,191***	***1,358***	***2,125***	***2,019***	***2,259***	***2,935***	***2,877***	***3,251***	***3,201***	***3,850***
PARAMEDICS	ACTUAL	2,837	2,960	4,728	6,772	7,772	8,515	6,497	9,144	11,977	11,972	12,260	11,793
	OPTIMAL	***3,486***	***3,948***	***4,387***	***4,839***	***7,265***	***7,096***	***7,783***	***9,807***	***9,658***	***10,869***	***10,871***	***12,965***
RURAL HEALTH FACILITY	ACTUAL	161	199	235	260	295	327	361	396	452	487	499	532
	OPTIMAL	***178***	***152***	***180***	***241***	***320***	***285***	***335***	***429***	***381***	***485***	***625***	***609***

TABLE 4.4

WAGE STRUCTURE AND UNIT COST FOR HEALTH FACILITIES : A HISTORICAL SIMULATION FOR PUNJAB (IN CURRENT PRICES)

VARIABLES	YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	URBAN HEALTH FACILITY												
DOCTORS	ACTUAL	22,361	21,467	23,244	32,280	33,183	34,003	36,549	48,105	47,831	50,302	51,859	53,277
	OPTIMAL	***20,767***	***22,701***	***24,512***	***25,793***	***38,300***	***34,538***	***36,832***	***46,167***	***43,465***	***47,453***	***45,405***	***53,506***
NURSES	ACTUAL	9,561	10,424	11,307	12,210	13,134	14,081	15,045	16,030	17,035	18,056	19,101	23,622
	OPTIMAL	***15,533***	***16,970***	***18,486***	***18,985***	***28,462***	***23,277***	***24,494***	***31,897***	***27,536***	***28,361***	***24,832***	***28,907***
PARAMEDICS	ACTUAL	7,028	6,053	6,484	6,697	9,763	10,903	9,277	10,344	10,638	12,884	14,295	17,446
	OPTIMAL	***7,226***	***7,918***	***8,592***	***8,992***	***13,710***	***11,844***	***12,615***	***15,975***	***14,905***	***16,308***	***15,398***	***18,259***
UNIT COST BEDS :													
RECURRING	ACTUAL	15	16	17	22	28	33	38	42	44	42	45	47
DEVELOPMENT	(THOUSAND)	7	6	6	1	26	6	7	26	3	15	7	18
	RURAL HEALTH FACILITY												
DOCTORS	ACTUAL	14,813	18,586	16,801	19,671	24,285	25,380	25,902	25,112	30,125	32,822	35,034	41,253
	OPTIMAL	***38,969***	***39,246***	***39,354***	***38,661***	***48,682***	***43,924***	***44,454***	***50,523***	***47,270***	***49,026***	***46,734***	***51,469***
PARAMEDICS	ACTUAL	4,030	6,917	6,331	6,636	8,332	8,562	8,937	9,311	11,400	12,539	13,174	15,732
	OPTIMAL	***10,238***	***10,794***	***11,340***	***11,514***	***15,113***	***13,263***	***13,693***	***16,045***	***14,945***	***15,564***	***14,602***	***16,222***
UNIT COST R.H.Fs.													
RECURRING	ACTUAL	262	404	449	489	527	576	599	610	617	612	633	621
DEVELOPMENT	(THOUSAND)	382	499	438	252	574	486	424	568	599	507	183	489

various *UHFs* whereas the optimal strategy only required a little over 18,000 as shown in Table 4.3. Obviously, for a given unit average development cost of Rs. 18,000 per bed in 1992 as reported in Table 4.4, the additional 3,909 (=22101-18192) beds costed *PPHD* over Rs. 70 million [=3909x18000]. This sizeable sum of money could have been potentially saved from health infrastructure projects to meet other recurring obligations (e.g., buying medicine or hiring competent doctors, nurses, etc.) by simply adopting a *cost-effective* approach.

- Another important result as shown in Table 4.5 is the efficiency *gain/loss* which is simply the percentage deviation of health output under *cost-effective* strategy in relation to the corresponding actual values. It appears that there are substantial year to year variations in *efficiency gains* for both health facilities. However, comparing the most recent (1991-92) figures across different health facilities, it appears from Table 4.5 that *UHFs* could have achieved about 5 percent *efficiency gains* by adopting the *cost-effective* strategy while the *gains* for *RHFs* were as high as 15 percent. It is important to note that the entire *Punjab* health system consisting of both urban and rural facilities had *efficiency gains* of about **10 percent** in 1992.

Putting these historical simulation results into a broader public policy perspective, we may conclude that the *Punjab Public Health Department,* by adopting a *cost-effective* approach in allocating its available funds for development and recurring outlays and, at the same time, pursuing a selective flexible wage policy particularly for nurses in urban hospitals and doctors for rural areas, could have improved the provision of health services.

TABLE 4.5

EFFICIENCY GAIN/LOSS FOR HEALTH FACILITY: A HISTORICAL SIMULATION FOR PUNJAB

Variables			1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
			URBAN HEALTH FACILITIES (UHFs)											
Health Output	**Composite Index**	***Actual***	158	196	222	376	460	374	502	661	766	926	1,053	1,422
		Optimal	***179***	***240***	***289***	***367***	***505***	***565***	***626***	***778***	***986***	***1,114***	***1,181***	***1,491***
Efficiency (Gain/Loss)			13.21%	22.82%	30.50%	-2.43%	9.75%	51.00%	24.56%	17.75%	28.85%	20.35%	12.19%	4.84%
			Rural Health Facilities (RHFs)											
Health Output For RHCs	**Patient Treated**	***Actual***	2,714	3,223	4,873	6,200	7,330	8,516	8,902	10,637	12,889	13,699	13,980	14,367
		Optimal	***4,140***	***4,137***	***4,831***	***5,955***	***8,666***	***8,011***	***9,183***	***11,895***	***11,109***	***13,390***	***15,136***	***16,491***
Efficiency (Gain/Loss)			52.52%	28.36%	-0.85%	-3.95%	18.24%	-5.93%	3.15%	11.83%	-13.81%	-2.25%	8.27%	14.78%
Total Output Health System	**Composite Index**	***Actual***	584	710	919	1,366	1,644	1,575	1,885	2,373	2,806	3,197	3,459	4,121
		Optimal	***758***	***890***	***1,056***	***1,323***	***1,867***	***1,913***	***2,153***	***2,728***	***3,005***	***3,497***	***3,818***	***4,504***
Total Efficiency(Gain/Loss)			29.85%	25.34%	15.01%	-3.13%	13.58%	21.46%	14.21%	14.99%	7.09%	9.37%	10.37%	9.30%

Ex-Ante Forecast (1993-2003): Tables 4.3-4.5 show that there were more beds for urban hospitals in *Punjab* than they should have had in 1992 if the system had operated under *a cost-efficient* approach. A pertinent public policy question that may arise in this context is what should the *PPHD* do or what options are available to them so that there is a real improvement in the system in terms of *positive efficiency gains*? Obviously, one thing *PPHD* possibly *cannot* or *should not* do, is to dismantle its existing infrastructure. In fact, in future, the growth in infrastructure building programs (in terms of new hospital beds) undertaken by *PPHD* should be slowed down or perhaps halted at the current level. Adopting such a policy will enable the *PPHD* to achieve the optimal mix of inputs in due course of time so that with each year gone by the population growth and the normal wear and tear of capital will gradually bring the existing number of beds closer to the optimal value.

In the following we present *ex-ante* simulation results for *Punjab*, relying on two strategies: a) *standard strategy* based on normal optimization approach adopted earlier; and b) *constrained strategy* based on an optimization problem in which the beds in *UHFs* are now fixed at the *baseline* year 1992 level until they become equal to those of the *standard strategy*. The simulation results for *standard strategy* are reported in Tables 4.6(A)-4.8(A) while forecasts for *constrained strategy* are given in Tables 4.6(B)-4.8(B). We have also presented results outlining the optimal mix of expenditure shares in Table 4.9.

It should be noted that the future data under the headings of ***actuals*** in Tables 4.6(A) & (B) and 4.9, respectively, do not exist in published documents. They are, however, generated in this study by simply taking the annual compound growth rates of the past five to ten years of actual historical data on these variables for *Punjab*. The underlying behaviour in projecting these actual data is predicated on the presumption that the *Punjab Public Health Department* continues to

TABLE 4.6(A)

HEALTH PERSONNEL AND PHYSICAL INFRASTRUCTURE: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	URBAN HEALTH FACILITY												
DOCTORS	ACTUAL	8,923	9,486	10,083	10,883	11,528	12,208	12,926	13,683	14,482	15,323	16,211	17,145
	OPTIMAL	8,248	8,756	9,295	9,867	10,475	11,120	11,804	12,531	13,303	14,122	14,991	15,914
NURSES	ACTUAL	4,859	5,282	5,741	6,336	6,862	7,431	8,045	8,708	9,424	10,196	11,029	11,927
	OPTIMAL	6,688	7,226	7,807	8,435	9,113	9,846	10,638	11,494	12,418	13,417	14,496	15,661
PARAMEDICS	ACTUAL	10,318	10,854	11,416	12,193	12,780	13,392	14,031	14,697	15,392	16,116	16,870	17,655
	OPTIMAL	11,886	12,577	13,308	14,082	14,901	15,767	16,684	17,654	18,681	19,767	20,917	22,133
BEDS	ACTUAL	22,101	23,093	24,126	25,594	26,645	27,733	28,861	30,027	31,235	32,484	33,775	35,110
	OPTIMAL	18,192	19,085	20,024	22,174	23,024	23,910	24,836	25,804	26,814	27,870	28,974	30,129
	RURAL HEALTH FACILITY												
DOCTORS	ACTUAL	3,259	3,540	3,846	4,241	4,591	4,968	5,375	5,814	6,288	6,799	7,350	7,943
	OPTIMAL	3,850	4,260	4,712	5,213	5,768	6,381	7,059	7,809	8,639	9,558	10,574	11,697
PARAMEDICS	ACTUAL	11,793	13,075	14,493	16,314	18,020	19,902	21,975	24,259	26,775	29,546	32,596	35,952
	OPTIMAL	12,965	14,203	15,559	17,045	18,673	20,456	22,410	24,551	26,896	29,465	32,280	35,364
RURAL HEALTH FACILITY	ACTUAL	532	565	601	649	688	728	771	817	865	915	969	1,025
	OPTIMAL	609	647	689	722	770	823	879	938	1,003	1,071	1,145	1,224

TABLE 4.6(B)

HEALTH PERSONNEL AND PHYSICAL INFRASTRUCTURE: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	URBAN HEALTH FACILITY												
DOCTORS	ACTUAL	8,923	9,486	10,083	10,883	11,528	12,208	12,926	13,683	14,482	15,323	16,211	17,145
	OPTIMAL	8,248	8,407	9,055	9,867	10,475	11,120	11,804	12,531	13,303	14,122	14,991	15,914
NURSES	ACTUAL	4,859	5,282	5,741	6,336	6,862	7,431	8,045	8,708	9,424	10,196	11,029	11,927
	OPTIMAL	6,688	7,078	7,703	8,435	9,113	9,846	10,638	11,494	12,418	13,417	14,496	15,661
PARAMEDICS	ACTUAL	10,318	10,854	11,416	12,193	12,780	13,392	14,031	14,697	15,392	16,116	16,870	17,655
	OPTIMAL	11,886	12,145	13,012	14,082	14,901	15,767	16,684	17,654	18,681	19,767	20,917	22,133
BEDS	ACTUAL	22,101	23,093	24,126	25,594	26,645	27,733	28,861	30,027	31,235	32,484	33,775	35,110
	OPTIMAL	18,192	22,101	22,101	22,174	23,024	23,910	24,836	25,804	26,814	27,870	28,974	30,129
	RURAL HEALTH FACILITY												
DOCTORS	ACTUAL	3,259	3,540	3,846	4,241	4,591	4,968	5,375	5,814	6,288	6,799	7,350	7,943
	OPTIMAL	3,850	4,012	4,534	5,213	5,768	6,381	7,059	7,809	8,639	9,558	10,574	11,697
PARAMEDICS	ACTUAL	11,793	13,075	14,493	16,314	18,020	19,902	21,975	24,259	26,775	29,546	32,596	35,952
	OPTIMAL	12,965	13,470	15,036	17,045	18,673	20,456	22,410	24,551	26,896	29,465	32,280	35,364
RURAL HEALTH FACILITY	ACTUAL	532	565	601	649	688	728	771	817	865	915	969	1,025
	OPTIMAL	609	585	645	722	770	823	879	938	1,003	1,071	1,145	1,224

follow the future course of actions based on their health polices and practices of the recent past in matters concerning setting wages, hiring health professionals, annual development plans, etc. Comparing these actual data with the simulated ones generated by our optimization model will not only enable us to examine the extent of divergence between optimal and sub-optimal health inputs within and across different health facilities but, more importantly, the above analysis will allow us to compute the size of *ex-ante efficiency gain/loss* of the optimal approach by simply calculating the yearly percentage deviation between optimal and actual outputs of a given health facility.

Considering 1991-92 as the ***baseline*** year, future projections are made up to the end of the Perspective Plan period (2002-03). In addition, forecasts for all monetary variables are measured in current rupees. Having computed the actual projected data on health inputs (between 1992-93 to 2002-03) based on the methodology explained above, the corresponding actual health output variable is generated using the underlying estimated production technology parameters reported in Table 4.2.

Focusing on the broad policy issues, the simulation results for *Punjab* as reported in Tables 4.6(A) & (B) and 4.9, respectively, reveal some interesting facts. Halting the growth of beds for *UHFs* at the 1992 level generates *efficiency gains* for this *facility* which is even higher than that of the optimal [10.85% for *UHFs* in 1992-93 in Table 4.8(B) as opposed to 4.9% in Table 4.8(A)]. Furthermore, this efficiency gain experienced by *UHSs* is not limited to itself but interestingly enough the gains of one sector spill over to the other facilities so much so that the gains of the entire health system in Punjab amount to about 8.5 percent in 1993 as shown in

3 Forecasting the actual health outputs based on the estimated production function, reported in Table 4.2, will not be unreasonable as the predictive power of these equations are very high (99%).

TABLE 4.7(A)

WAGE STRUCTURE AND UNIT COST FOR HEALTH FACILITIES : AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB (IN CURRENT PRICES)

VARIABLES	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	URBAN HEALTH FACILITY												
DOCTORS	ACTUAL	53,277	56,534	59,978	64,614	68,311	72,205	76,305	80,622	85,166	89,945	94,972	100,257
	OPTIMAL	53,506	57,743	62,315	67,248	72,573	78,318	84,519	91,211	98,433	106,226	114,636	123,713
NURSES	ACTUAL	23,622	25,442	27,396	29,955	32,143	34,484	36,988	39,666	42,529	45,589	48,857	52,348
	OPTIMAL	28,907	30,652	32,502	34,463	36,543	38,748	41,086	43,566	46,195	48,983	51,939	55,073
PARAMEDICS	ACTUAL	17,446	18,713	20,069	21,855	23,356	24,956	26,660	28,474	30,406	32,461	34,647	36,973
	OPTIMAL	18,259	19,768	21,402	23,171	25,087	27,160	29,406	31,836	34,468	37,317	40,402	43,742
UNIT COST BEDS :													
RECURRING	ACTUAL	47	51	56	56	62	68	75	83	91	100	111	122
DEVELOPMENT	(THOUSAND)	18	20	22	25	27	30	33	37	40	45	49	54
	RURAL HEALTH FACILITY												
DOCTORS	ACTUAL	41,253	43,844	46,589	50,270	53,230	56,354	59,649	63,124	66,788	70,648	74,715	78,998
	OPTIMAL	51,469	53,298	55,193	57,155	59,187	61,290	63,469	65,725	68,061	70,481	72,986	75,581
PARAMEDICS	ACTUAL	15,732	17,336	19,099	21,366	23,457	25,748	28,256	31,003	34,009	37,299	40,897	44,833
	OPTIMAL	16,222	16,964	17,740	18,552	19,401	20,288	21,216	22,186	23,201	24,262	25,371	26,531
UNIT COST R.H.Fs.													
RECURRING	ACTUAL	621	666	714	778	832	888	949	1,014	1,082	1,156	1,233	1,316
DEVELOPMENT	(THOUSAND)	489	529	573	629	679	732	789	850	916	987	1,063	1,145

TABLE 4.7(B)

WAGE STRUCTURE AND UNIT COST FOR HEALTH FACILITIES : AN EX-ANTE ACTUAL VS CONSTRAI NED OPTIMAL FORECAST FOR PUNJAB (IN CURRENT PRICES)

VARIABLES	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		URBAN HEALTH FACILITY											
DOCTORS	ACTUAL	53,277	56,534	59,978	64,614	68,311	72,205	76,305	80,622	85,166	89,945	94,972	100,257
	OPTIMAL	53,506	54,296	59,890	67,248	72,573	78,318	84,519	91,211	98,433	106,226	114,636	123,713
NURSES	ACTUAL	23,622	25,442	27,396	29,955	32,143	34,484	36,988	39,666	42,529	45,589	48,857	52,348
	OPTIMAL	28,907	28,256	30,840	34,463	36,543	38,748	41,086	43,566	46,195	48,983	51,939	55,073
PARAMEDICS	ACTUAL	17,446	18,713	20,069	21,855	23,356	24,956	26,660	28,474	30,406	32,461	34,647	36,973
	OPTIMAL	18,259	18,483	20,495	23,171	25,087	27,160	29,406	31,836	34,468	37,317	40,402	43,742
UNIT COST BEDS :													
RECURRING	ACTUAL	47	51	56	56	62	68	75	83	91	100	111	122
DEVELOPMENT	(THOUSAND)	18	20	22	25	27	30	33	37	40	45	49	54
		RURAL HEALTH FACILITY											
DOCTORS	ACTUAL	41,253	43,844	46,589	50,270	53,230	56,354	59,649	63,124	66,788	70,648	74,715	78,998
	OPTIMAL	51,469	51,095	53,711	57,155	59,187	61,290	63,469	65,725	68,061	70,481	72,986	75,581
PARAMEDICS	ACTUAL	15,732	17,336	19,099	21,366	23,457	25,748	28,256	31,003	34,009	37,299	40,897	44,833
	OPTIMAL	16,222	16,151	17,187	18,552	19,401	20,288	21,216	22,186	23,201	24,262	25,371	26,531
UNIT COST R.H.Fs.													
RECURRING	ACTUAL	621	666	714	778	832	888	949	1,014	1,082	1,156	1,233	1,316
DEVELOPMENT	(THOUSAND)	489	529	573	629	679	732	789	850	916	987	1,063	1,145

TABLE 4.8(A)

EFFICIENCY GAIN/LOSS FOR HEALTH FACILITY: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB

Variables			1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
			URBAN HEALTH FACILITIES (UHFs)											
Health Output	Composite Index	*Actual*	1,422	1,646	1,904	2,287	2,623	3,007	3,446	3,946	4,517	5,168	5,909	6,753
		Optimal	*1,491*	*1,726*	*2,000*	*2,412*	*2,771*	*3,185*	*3,661*	*4,210*	*4,840*	*5,567*	*6,403*	*7,367*
Efficiency (Gain/Loss)			4.84%	4.90%	5.03%	5.45%	5.66%	5.93%	6.27%	6.67%	7.16%	7.72%	8.36%	9.08%
			RURAL HEALTH FACILITIES (RHFs)											
Health Output For RHCs	Patient Treated	*Actual*	14,367	15,602	16,939	18,690	20,217	21,865	23,642	25,558	27,623	29,849	32,246	34,827
		Optimal	*16,491*	*17,927*	*19,491*	*21,028*	*22,901*	*24,943*	*27,170*	*29,598*	*32,246*	*35,134*	*38,286*	*41,724*
Efficiency (Gain/Loss)			14.78%	14.90%	15.06%	12.51%	13.28%	14.08%	14.92%	15.81%	16.73%	17.71%	18.73%	19.81%
Total Output Health System	Composite Index	*Actual*	4,121	4,631	5,204	6,011	6,711	7,490	8,356	9,320	10,390	11,579	12,898	14,362
		Optimal	*4,504*	*5,066*	*5,699*	*6,530*	*7,321*	*8,209*	*9,206*	*10,324*	*11,581*	*12,992*	*14,577*	*16,357*
Total Efficiency(Gain/Loss)			9.30%	9.39%	9.53%	8.64%	9.10%	9.60%	10.16%	10.78%	11.46%	12.20%	13.01%	13.89%

TABLE 4.8(B)

EFFICIENCY GAIN/LOSS FOR HEALTH FACILITY: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB

Variables			1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
			URBAN HEALTH FACILITIES (UHFs)											
Health Output	Composite	*Actual*	1,422	1,646	1,904	2,287	2,623	3,007	3,446	3,946	4,517	5,168	5,909	6,753
	Index	*Optimal*	*1,491*	*1,824*	*2,078*	*2,412*	*2,771*	*3,185*	*3,661*	*4,210*	*4,840*	*5,567*	*6,403*	*7,367*
Efficiency (Gain/Loss)			4.84%	10.85%	9.16%	5.45%	5.66%	5.93%	6.27%	6.67%	7.16%	7.72%	8.36%	9.08%
			RURAL HEALTH FACILITIES (RHFs)											
Health Output	Patient	*Actual*	14,367	15,602	16,939	18,690	20,217	21,865	23,642	25,558	27,623	29,849	32,246	34,827
For RHCs	Treated	*Optimal*	*16,491*	*16,517*	*18,487*	*21,028*	*22,901*	*24,943*	*27,170*	*29,598*	*32,246*	*35,134*	*38,286*	*41,724*
Efficiency (Gain/Loss)			14.78%	5.86%	9.14%	12.51%	13.28%	14.08%	14.92%	15.81%	16.73%	17.71%	18.73%	19.81%
Total Output	Composite	*Actual*	4,121	4,631	5,204	6,011	6,711	7,490	8,356	9,320	10,390	11,579	12,898	14,362
Health System	Index	*Optimal*	*4,504*	*5,026*	*5,680*	*6,530*	*7,321*	*8,209*	*9,206*	*10,324*	*11,581*	*12,992*	*14,577*	*16,357*
Total Efficiency(Gain/Loss)			9.30%	8.53%	9.15%	8.64%	9.10%	9.60%	10.16%	10.78%	11.46%	12.20%	13.01%	13.89%

TABLE 4.9

MIX OF EXPENDITURE SHARES FOR HEALTH FACILITIES : AN EX-ANTE ACTUAL VS OPTIMAL* FORECAST FOR PUNJAB

VARIABLES	1992		2003	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL HEALTH EXPENDITURE	***100.0%***	***100.0%***	***100.0%***	***100.0%***
URBAN HEALTH FACILITY				
TOTAL EXPENDITURE:	***70.9%***	***65.3%***	***65.8%***	***65.3%***
RECURRING EXPENDITURE:	***82.0%***	***84.0%***	***79.3%***	***82.1%***
DOCTORS	26.2%	25.8%	23.6%	26.3%
NURSES	6.3%	11.3%	8.6%	11.5%
PARAMEDICS	9.9%	12.7%	9.0%	13.0%
BEDS	57.6%	50.3%	58.8%	49.2%
DEVELOPMENT EXPENDITURE :	***18.0%***	***16.0%***	***20.7%***	***17.9%***
RURAL HEALTH FACILITY				
TOTAL EXPENDITURE	***29.1%***	***34.7%***	***34.2%***	***34.7%***
RECURRING EXPENDITURE:	***71.4%***	***72.6%***	***75.4%***	***71.0%***
DOCTORS	20.7%	25.2%	17.5%	25.7%
PARAMEDICS	28.5%	26.7%	44.9%	27.3%
RURAL HEALTH FACILITY	50.8%	48.1%	37.6%	46.9%
DEVELOPMENT EXPENDITURE :	***28.6%***	***27.4%***	***24.6%***	***29.0%***

* **Expenditure shares for standard and constrained optimization produces same results.**

Table 4.8(B). In addition, it takes about three years for the *standard* optimization strategy to achieve the level of beds equivalent to those fixed at the 1992 level for Punjab. What is more crucial to note here is that by adopting a *constrained strategy* i.e., arresting the growth of excess infrastructure building and reallocating its resources towards other inputs, namely nurses in *RHFs*, the *PPHD* can not only improve its existing health services but interestingly enough it can outperform the standard optimizing output.

The efficiency gains for *RHFs* in Punjab are even more pronounced and reach a level of about 20 percent by the year 2003 followed by a 14 percent for the entire health system as shown in Tables 8(A) and 8(B). All these benefits are expected to be possible with the same budget that the *Punjab* government would have allocated to its health departments for that year by simply re-allocating the resources.

Analysing the results on the mix of expenditure shares in Table 4.9, the optimal model suggests a greater allocation of funds towards *RHCs* (34.7% as opposed to 29.1% for 1992) while in the case of *UHFs* the optimal share is less than the actual (65.3% as opposed to 70.9%). Within a given facility, the share of recurring expenditure dominates that of development outlays and it decreases slightly by the year 2003.

4.3.3 Ex- Ante Optimal Expansion Paths and Estimated Efficiency Gain/Loss in Health Output for All Four Provinces Combined (National)

Having discussed the *ex-ante* simulation results for *Punjab*, in this section, we extend the analysis to national data consisting of all four provinces combined between the period 1993-2003. *Baseline* national data in majority of the cases were obtained by simply aggregating

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4 It should be noted that the national data in this study includes neither Federal nor Federally Administered Tribal Teritories (*FATA*).

figures for all four provinces, however, wherever the numbers were not available or discrepancies were observed between different sources, information from *Economic Survey* was considered after making appropriate adjustments.[5] Future growth projections for actual national variables (e.g., wages, unit costs, etc.), were assumed to follow *Punjab* data. Like Punjab, two types of *Ex-Ante* simulation forecasts (*standard* and *constrained*) were generated for the national data. Results based on *standard* optimization are reported in Tables 4.10(A)-4.12(A) while *constrained* simulations are given in Tables 4.10(B)-4.12(B). In addition, the optimal shares of expenditure mix are given in Table 13.

An analysis of the simulation results in the above tables reveals several interesting facts that have important implications for *Public Health Policies* in Pakistan. The salient features of the results are summarised below:

Infrastructure

- Actual number of beds in *UHFs* appeared to be greater than what an *optimal optimization strategy* would stipulate by over 15 percent. However, by the end of the *Perspective Plan* period (2002-03), this figure may come down to about 11 percent as shown in Table 10.A. It is important to note that **if the *Public Health Department* (*PHD*) were to adopt a policy of slowing down the growth of health infrastructure (in terms of beds) and re-allocate the existing resources then our results suggest that it is possible for the *PHD* to attain an *efficiency gain* of about 13 percent for *UHFs* in 1993 as reported in Table 4. 12(B).**

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5 Since *Economic Survey* data, particularly on registered personnel, also includes private sector information along with *Federal* and *FATA*, appropriate adjustments were therefore made to provincial public sector data.

TABLE 4.10(A)

HEALTH PERSONNEL AND PHYSICAL INFRASTRUCTURE: AN EX-ANTE

ACTUAL VS STANDARD OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		URBAN HEALTH FACILITY											
DOCTORS	ACTUAL	23,528	25,028	26,620	28,309	30,100	31,998	34,010	36,141	38,397	40,786	43,315	45,989
	OPTIMAL	22,044	23,401	24,842	26,371	27,995	29,719	31,549	33,491	35,553	37,743	40,066	42,533
NURSES	ACTUAL	10,981	11,944	12,990	14,125	15,357	16,693	18,141	19,712	21,415	23,259	25,257	27,421
	OPTIMAL	15,634	16,891	18,249	19,717	21,303	23,016	24,867	26,867	29,027	31,362	33,884	36,609
PARAMEDICS	ACTUAL	31,350	33,000	34,732	36,548	38,452	40,448	42,541	44,732	47,027	49,430	51,943	54,572
	OPTIMAL	33,458	35,403	37,462	39,640	41,946	44,385	46,966	49,697	52,587	55,645	58,881	62,305
BEDS	ACTUAL	50,138	52,421	54,800	57,277	59,856	62,540	65,332	68,236	71,254	74,390	77,647	81,028
	OPTIMAL	43,196	45,285	47,480	49,785	52,207	54,753	57,429	60,242	63,201	66,314	69,590	73,038
		RURAL HEALTH FACILITY											
DOCTORS	ACTUAL	10,083	10,961	11,913	12,945	14,065	15,279	16,594	18,020	19,563	21,235	23,044	25,001
	OPTIMAL	9,605	10,626	11,755	13,005	14,387	15,916	17,608	19,480	21,551	23,841	26,376	29,179
PARAMEDICS	ACTUAL	20,900	23,186	25,718	28,522	31,625	35,061	38,862	43,067	47,717	52,859	58,541	64,820
	OPTIMAL	22,726	24,896	27,273	29,878	32,731	35,857	39,282	43,034	47,145	51,648	56,582	61,988
RURAL HEALTH FACILITY	ACTUAL	1,274	1,356	1,442	1,534	1,632	1,735	1,845	1,961	2,084	2,215	2,353	2,499
	OPTIMAL	1,465	1,558	1,656	1,761	1,873	1,992	2,120	2,255	2,400	2,555	2,720	2,897

TABLE 4.10(B)

HEALTH PERSONNEL AND PHYSICAL INFRASTRUCTURE: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	URBAN HEALTH FACILITY												
DOCTORS	ACTUAL	23,528	25,028	26,620	28,309	30,100	31,998	34,010	36,141	38,397	40,786	43,315	45,989
	OPTIMAL	22,044	22,776	24,499	26,326	27,995	29,719	31,549	33,491	35,553	37,743	40,066	42,533
NURSES	ACTUAL	10,981	11,944	12,990	14,125	15,357	16,693	18,141	19,712	21,415	23,259	25,257	27,421
	OPTIMAL	15,634	16,659	18,120	19,700	21,303	23,016	24,867	26,867	29,027	31,362	33,884	36,609
PARAMEDICS	ACTUAL	31,350	33,000	34,732	36,548	38,452	40,448	42,541	44,732	47,027	49,430	51,943	54,572
	OPTIMAL	33,458	34,588	37,016	39,581	41,946	44,385	46,966	49,697	52,587	55,645	58,881	62,305
BEDS	ACTUAL	50,138	52,421	54,800	57,277	59,856	62,540	65,332	68,236	71,254	74,390	77,647	81,028
	OPTIMAL	43,196	50,138	50,138	50,138	52,207	54,753	57,429	60,242	63,201	66,314	69,590	73,038
	RURAL HEALTH FACILITY												
DOCTORS	ACTUAL	10,083	10,961	11,913	12,945	14,065	15,279	16,594	18,020	19,563	21,235	23,044	25,001
	OPTIMAL	9,605	10,209	11,516	12,971	14,387	15,916	17,608	19,480	21,551	23,841	26,376	29,179
PARAMEDICS	ACTUAL	20,900	23,186	25,718	28,522	31,625	35,061	38,862	43,067	47,717	52,859	58,541	64,820
	OPTIMAL	22,726	24,031	26,782	29,810	32,731	35,857	39,282	43,034	47,145	51,648	56,582	61,988
RURAL HEALTH	ACTUAL	1,274	1,356	1,442	1,534	1,632	1,735	1,845	1,961	2,084	2,215	2,353	2,499
FACILITY	OPTIMAL	1,465	1,455	1,599	1,753	1,873	1,992	2,120	2,255	2,400	2,555	2,720	2,897

- Furthermore, the re-allocation of resources from urban health development expenditure may take place not only towards other urban recurring activities (e.g., more medicine and health personnel) but, interestingly enough, these resources can now be diverted towards rural health facilities. In fact, the our analysis suggests that some of these funds could be transferred towards the development of rural infrastructure (in terms of either upgrading *BHUs* to *RHCs* or outright construction of new *BHUs*).

Health Personnel

- In terms of health personnel, the optimization model predicted a *faster* growth for doctors in *RHFs* during the entire plan period (*11.1%* p.a.), which is to be induced by raising their salaries by a ***substantial*** amount particularly in the earlier years (over 15%). However, once enough doctors are attracted towards *RHFs*, the model predicts modest salary increases towards the latter part of the plan for the health system to be *cost-effective*.

- As for the doctors in the *UHFs*, *cost-effective* strategy suggests roughly the same number of doctors as the actuals but with significantly higher salaries by the end of the plan period. This result can be rationalized since, in urban areas, enough opportunities and alternatives are available to the doctors (in private hospitals or clinics). Thus, to improve urban health facilities in the long-run, *PHD* should hire fewer good quality doctors and pay them well.

- If *PHD* were to pursue its wage policies for nurses at the existing pattern, then the optimization model predicts severe shortages of nurses to the extent of over forty percent in 1992-93. Shortages will persist even at the end of the plan period 2002-2003. This

TABLE 4.11(A)

WAGE STRUCTURE AND UNIT COST FOR HEALTH FACILITIES : AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR ALL PROVINCES COMBINED (IN CURRENT PRICES)

VARIABLES	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
							URBAN HEALTH FACILITY						
DOCTORS	ACTUAL	54,303	57,657	61,208	64,968	68,946	73,156	77,607	82,314	87,288	92,544	98,094	103,954
	OPTIMAL	49,862	53,810	58,070	62,668	67,630	72,984	78,763	84,999	91,728	98,991	106,828	115,286
NURSES	ACTUAL	24,438	26,335	28,376	30,570	32,928	35,462	38,183	41,105	44,242	47,608	51,219	55,091
	OPTIMAL	30,801	32,660	34,630	36,720	38,936	41,286	43,778	46,419	49,221	52,191	55,341	58,680
PARAMEDICS	ACTUAL	17,975	19,292	20,703	22,213	23,830	25,559	27,409	29,388	31,502	33,762	36,175	38,753
	OPTIMAL	16,155	17,490	18,936	20,501	22,196	24,031	26,017	28,168	30,497	33,017	35,747	38,702
UNIT COST BEDS :													
RECURRING	ACTUAL	49	54	58	63	69	75	81	88	96	104	113	122
DEVELOPMENT	(THOUSAND)	19	21	24	26	29	32	35	39	43	48	53	59
							RURAL HEALTH FACILITY						
DOCTORS	ACTUAL	42,114	44,786	47,620	50,625	53,811	57,187	60,764	64,551	68,561	72,805	77,294	82,041
	OPTIMAL	51,389	53,216	55,107	57,066	59,095	61,195	63,371	65,623	67,956	70,371	72,873	75,463
PARAMEDICS	ACTUAL	16,651	18,360	20,240	22,309	24,586	27,090	29,843	32,870	36,197	39,852	43,866	48,274
	OPTIMAL	23,049	24,104	25,207	26,360	27,566	28,827	30,146	31,524	32,966	34,474	36,050	37,698
UNIT COST R.H.Fs.													
RECURRING	ACTUAL	640	687	737	791	848	910	976	1,046	1,122	1,202	1,288	1,380
DEVELOPMENT	(THOUSAND)	508	550	596	645	699	756	819	886	958	1,036	1,121	1,211

TABLE 4.11(B)

WAGE STRUCTURE AND UNIT COST FOR HEALTH FACILITIES : AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR ALL PROVINCES COMBINED (IN CURRENT PRICES)

VARIABLES	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	URBAN HEALTH FACILITY												
DOCTORS	ACTUAL	54,303	57,657	61,208	64,968	68,946	73,156	77,607	82,314	87,288	92,544	98,094	103,954
	OPTIMAL	49,862	51,646	56,858	62,503	67,630	72,984	78,763	84,999	91,728	98,991	106,828	115,286
NURSES	ACTUAL	24,438	26,335	28,376	30,570	32,928	35,462	38,183	41,105	44,242	47,608	51,219	55,091
	OPTIMAL	30,801	30,934	33,678	36,593	38,936	41,286	43,778	46,419	49,221	52,191	55,341	58,680
PARAMEDICS	ACTUAL	17,975	19,292	20,703	22,213	23,830	25,559	27,409	29,388	31,502	33,762	36,175	38,753
	OPTIMAL	16,155	16,724	18,505	20,443	22,196	24,031	26,017	28,168	30,497	33,017	35,747	38,702
UNIT COST BEDS :													
RECURRING	ACTUAL	49	54	58	63	69	75	81	88	96	104	113	122
DEVELOPMENT	(THOUSAND)	19	21	24	26	29	32	35	39	43	48	53	59
	RURAL HEALTH FACILITY												
DOCTORS	ACTUAL	42,114	44,786	47,620	50,625	53,811	57,187	60,764	64,551	68,561	72,805	77,294	82,041
	OPTIMAL	51,389	51,739	54,316	56,963	59,095	61,195	63,371	65,623	67,956	70,371	72,873	75,463
PARAMEDICS	ACTUAL	16,651	18,360	20,240	22,309	24,586	27,090	29,843	32,870	36,197	39,852	43,866	48,274
	OPTIMAL	23,049	23,327	24,786	26,305	27,566	28,827	30,146	31,524	32,966	34,474	36,050	37,698
UNIT COST R.H.Fs.													
RECURRING	ACTUAL	640	687	737	791	848	910	976	1,046	1,122	1,202	1,288	1,380
DEVELOPMENT	(THOUSAND)	508	550	596	645	699	756	819	886	958	1,036	1,121	1,211

excruciating situation of nurses in the present setup in Pakistan is due to a combination of many factors. Obviously, one of the important reasons is the present low salary structure and, in this regard, the **optimization model suggests an immediate boost in nurses' salary by over 25 percent**. Another reason is the social stigma attached to this profession particularly in the public sector health system. It needs to be emphasised that, even in the Defence Medical Services in Pakistan, nurses are not only paid reasonable salaries but, more importantly, they are accorded an honourable status in the military hierarchy. For instance, a nurse would begin her career in the Armed Forces as a commissioned officer while, in the public health system, the starting level is only at the BSP grade 11 that is far below the category of an officer (BSP 17).

Expenditure Pattern

- The critical public policy issue that deserves some discussion in this context is the availability of funds to meet the future recurring expenditure obligations for the health system. Our optimization model predicts recurring outlays of over 4.5 and 2.5 times that of development expenditures for *UHFs* and *RHFs*, respectively, in 1992-93. These figures are expected to remain high until the end of the *Perspective Plan period*. Many plans formulated in the past emphasised the establishment of infrastructure in terms of opening new hospitals, *RHSs,* and *BHUs* without giving due consideration towards the recurring expenditures [e.g. health personnel and other inputs (medicine, x-ray films, etc.)]. **What is crucial for the long-term sustainability of the *Public Health System* is the commitment from the policy makers for provision of steady inflow of funds to meet *recurring expenditure.***

TABLE 4.12(A)
EFFICIENCY GAIN/LOSS FOR HEALTH FACILITY: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

Variables			1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
			URBAN HEALTH FACILITIES (UHFs)											
Health Output	**Composite**	***Actual***	**13,182**	15,279	17,703	20,504	23,737	27,469	31,773	36,733	42,447	49,025	56,591	65,288
	Index	***Optimal***	***14,288***	***16,539***	***19,145***	***22,164***	***25,660***	***29,710***	***34,402***	***39,838***	***46,138***	***53,439***	***61,902***	***71,713***
Efficiency (Gain/Loss)			8.40%	**8.25%**	**8.15%**	**8.10%**	**8.10%**	**8.16%**	**8.27%**	**8.45%**	**8.69%**	**9.00%**	**9.39%**	**9.84%**
			RURAL HEALTH FACILITIES (RHFs)											
Health Output	**Patient**	***Actual***	**35,027**	38,061	41,351	44,918	48,783	52,972	57,508	62,421	67,738	73,493	79,717	86,448
For RHCs	**Treated**	***Optimal***	***38,055***	***41,357***	***44,948***	***48,854***	***53,104***	***57,728***	***62,760***	***68,237***	***74,198***	***80,688***	***87,755***	***95,450***
Efficiency (Gain/Loss)			8.65%	**8.66%**	**8.70%**	**8.76%**	**8.86%**	**8.98%**	**9.13%**	**9.32%**	**9.54%**	**9.79%**	**10.08%**	**10.41%**
Total Output	**Composite**	***Actual***	**20,664**	23,250	26,154	29,411	33,063	37,157	41,743	46,880	52,629	59,060	66,252	74,288
Health System	**Index**	***Optimal***	***22,422***	***25,212***	***28,350***	***31,882***	***35,856***	***40,328***	***45,362***	***51,028***	***57,408***	***64,592***	***72,682***	***81,794***
Total Efficiency(Gain/Loss)			8.51%	8.44%	8.40%	8.40%	8.45%	8.54%	8.67%	8.85%	9.08%	9.37%	9.71%	10.10%

TABLE 4.12(B)

EFFICIENCY GAIN/LOSS FOR HEALTH FACILITY: AN EX-ANTE

ACTUAL VS CONSTRAINED FORECAST FOR ALL PROVINCES COMBINED

Variables			URBAN HEALTH FACILITIES (UHFs)											
			1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Health Output	Composite	*Actual*	13,182	15,279	17,703	20,504	23,737	27,469	31,773	36,733	42,447	49,025	56,591	65,288
	Index	*Optimal*	*14,288*	*17,210*	*19,572*	*22,229*	*25,660*	*29,710*	*34,402*	*39,838*	*46,138*	*53,439*	*61,902*	*71,713*
Efficiency (Gain/Loss)			8.40%	12.64%	10.56%	8.42%	8.10%	8.16%	8.27%	8.45%	8.69%	9.00%	9.39%	9.84%
			RURAL HEALTH FACILITIES (RHFs)											
Health Output	Patient	*Actual*	35,027	38,061	41,351	44,918	48,783	52,972	57,508	62,421	67,738	73,493	79,717	86,448
For RHCs	Treated	*Optimal*	*38,055*	*39,157*	*43,703*	*48,683*	*53,104*	*57,728*	*62,760*	*68,237*	*74,198*	*80,688*	*87,755*	*95,450*
Efficiency (Gain/Loss)			8.65%	2.88%	5.69%	8.38%	8.86%	8.98%	9.13%	9.32%	9.54%	9.79%	10.08%	10.41%
Total Output	Composite	*Actual*	20,664	23,250	26,154	29,411	33,063	37,157	41,743	46,880	52,629	59,060	66,252	74,288
Health System	Index	*Optimal*	*22,422*	*25,120*	*28,322*	*31,881*	*35,856*	*40,328*	*45,362*	*51,028*	*57,408*	*64,592*	*72,682*	*81,794*
Total Efficiency(Gain/Loss)			8.51%	8.04%	8.29%	8.40%	8.45%	8.54%	8.67%	8.85%	9.08%	9.37%	9.71%	10.10%

TABLE 4.13

MIX OF EXPENDITURE SHARES FOR HEALTH FACILITIES : AN EX-ANTE ACTUAL VS OPTIMAL* FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	1992		2003	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL HEALTH EXPENDITURE	100.0%	100.0%	100.0%	100.0%
URBAN HEALTH FACILITY				
TOTAL EXPENDITURE:	71.3%	65.3%	66.4%	65.3%
RECURRING EXPENDITURE:	82.7%	83.7%	79.4%	81.1%
DOCTORS	27.8%	25.8%	26.1%	26.7%
NURSES	5.8%	11.3%	8.2%	11.7%
PARAMEDICS	12.3%	12.7%	11.5%	13.1%
BEDS	54.0%	50.2%	54.1%	48.6%
DEVELOPMENT EXPENDITURE :	17.3%	16.3%	20.6%	18.9%
RURAL HEALTH FACILITY				
TOTAL EXPENDITURE	28.7%	34.7%	33.6%	34.7%
RECURRING EXPENDITURE:	71.0%	72.4%	74.0%	70.9%
DOCTORS	26.7%	25.2%	23.8%	25.8%
PARAMEDICS	21.9%	26.8%	36.3%	27.4%
RURAL HEALTH FACILITY	51.3%	48.0%	40.0%	46.8%
DEVELOPMENT EXPENDITURE :	29.0%	27.6%	26.0%	29.1%

* Expenditure shares for standard and constrained optimization produces same results.

Efficiency Gains

- A crucial part of our analysis in this study is to investigate whether by becoming more *cost-effective* it is possible for the *Public Health Departments* to improve their provision of basic health facilities. The optimization results in Table 4.12(A) suggest that over 8 percent *efficiency gains* can be made at the national level for both *UHFs* and *RHFs*. In fact, Table 4.12(B) clearly supports the *proposition* made earlier that, by reallocating resources within *UHFs* from development to recurring expenditures, reasonable *efficiency gains* of over twelve percent were attained in 1992-93. **The *efficiency gains* for the combined health system were also in the order of eight to 10 percent.**

CHAPTER FIVE

POLICY RECOMMENDATIONS AND OUTPUT FOR SOCIAL PLANNING MODEL

Pakistan's share of total health expenditure to gross national product has never exceeded 0.8 percent per annum [*Economic Survey (1992-93)*], which is significantly lower than many of its neighbouring countries in the region. If the future is any reflection of past history, then one does not expect substantial public funds to be forthcoming and diverted towards this sector in the immediate or medium term future especially when the country is already experiencing large and increasing budgetary deficits. Prudent public policy research in this context, based on a realistic pragmatic approach, should then be geared towards an investigation into measures to improve the present *Public Health System* (*PHS*) through an *efficient, cost-effective* reallocation of health inputs within the existing limited budget. This study has examined these health policy issues within the context of an optimization framework for *PHS* and forecasted future (up to 2002-03) *efficient* optimal mix of health inputs (doctors, nurses, paramedics), outputs (patients treated for urban and rural health facilities), expenditures (development and recurrent) and wage policies (health personnel) under alternative scenarios. Comparing the projected actual health outputs (based on historical growth rates) with those of optimal values, *efficiency gains* were also computed. Based on these simulation results, this study makes policy recommendations for *PHS* and some of the important ones are summarized below:

Recommendations

- Our optimization model predicts an excess build-up of infrastructure (measured in terms of beds) in the present *urban health facilities* while, in the *rural* areas, there is a paucity of *RHCs* and *BHUs*. **We recommend that the growth of health infrastructure building in the urban areas be slowed down in the short-run (two to three years)**

and some of the resources be reallocated toward the rural sector.

- Our optimal forecasts suggest that both more nurses and doctors should be hired in *UHFs* and *RHFs,* respectively, during the entire plan period though, in terms of percentage, the demand for nurses will exceed that of doctors in *RHFs*. **We recommend that not only attractive wage policies be formulated for these personnel but, more importantly, like the Armed Forces, the status of nurses in the Public Health System be elevated by giving them higher BPS.**

- There is a shift in focus from development towards recurring expenditure as predicted by the optimization model. **It is, therefore, recommended that for every rupee of development expenditure incurred, *PHD* <u>must</u> plan or keep provisions for recurring outlays.** This is critical from the point of view of long-term sustainability of *PHS*.

It is important to note that all this reallocation of resources is feasible within the projected actual budget and, interestingly enough, it will also lead to *efficiency gains* in the order of 8 to 10 percent for the entire *Public Health System*.

Detailed numbers for the two types of optimal forecasts (up to 2002-03) of health inputs, outputs, wages and expenditures for *UHFs, RHFs,* and *PHS* are given in Tables 5.1 and 5.2, respectively.

TABLE 5.1

STANDARD OPTIMAL EXPENSION PATHS FOR HEALTH FACILITIES

ALL PROVINCES COMBINED (BASED ON HISTORICAL GROWTH RATES)

Variables		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Growth
		URBAN HEALTH FACILITIES (UHFs)												
Doctors	Numbers	***22,044***	23,401	24,842	26,371	27,995	29,719	31,549	33,491	35,553	37,743	40,066	42,533	6.2%
	Wage Rate	***49,862***	53,810	58,070	62,668	67,630	72,984	78,763	84,999	91,728	98,991	106,828	115,286	7.9%
Nurses	Numbers	***15,634***	16,891	18,249	19,717	21,303	23,016	24,867	26,867	29,027	31,362	33,884	36,609	8.0%
	Wage Rate	***30,801***	32,660	34,630	36,720	38,936	41,286	43,778	46,419	49,221	52,191	55,341	58,680	6.0%
Paramedics	Numbers	***33,458***	35,403	37,462	39,640	41,946	44,385	46,966	49,697	52,587	55,645	58,881	62,305	5.8%
	Wage Rate	***16,155***	17,490	18,936	20,501	22,196	24,031	26,017	28,168	30,497	33,017	35,747	38,702	8.3%
Beds	Numbers	***43,196***	45,285	47,480	49,785	52,207	54,753	57,429	60,242	63,201	66,314	69,590	73,038	4.9%
	URC ('000)	***49***	54	58	63	69	75	81	88	96	104	113	122	
	UDC ('000)	***19***	21	24	26	29	32	35	39	43	48	53	59	
Total Rec Exp.	Millions	***4,257***	4,863	5,556	6,347	7,251	8,283	9,462	10,808	12,346	14,102	16,107	18,396	14.2%
Total Dev. Exp	Millions	***827***	961	1,116	1,296	1,506	1,749	2,031	2,358	2,738	3,178	3,690	4,283	
Total Exp.(GH)	Millions	***5,084***	5,824	6,672	7,643	8,757	10,032	11,493	13,166	15,083	17,280	19,796	22,679	16.1%
Health Output (GH)		***14,288***	16,539	19,145	22,164	25,660	29,710	34,402	39,838	46,138	53,439	61,902	71,713	15.8%
		RURAL HEALTH FACILITIES (RHFs)												
Doctors	Numbers	***9,605***	10,626	11,755	13,005	14,387	15,916	17,608	19,480	21,551	23,841	26,376	29,179	10.6%
	Wage Rate	***51,389***	53,216	55,107	57,066	59,095	61,195	63,371	65,623	67,956	70,371	72,873	75,463	3.6%
Paramedics	Numbers	***22,726***	24,896	27,273	29,878	32,731	35,857	39,282	43,034	47,145	51,648	56,582	61,988	9.6%
	Wage Rate	***23,049***	24,104	25,207	26,360	27,566	28,827	30,146	31,524	32,966	34,474	36,050	37,698	4.6%
RHFs	Numbers	***1,465***	1,558	1,656	1,761	1,873	1,992	2,120	2,255	2,400	2,555	2,720	2,897	6.4%
	URC ('000)	***640***	687	737	791	848	910	976	1,046	1,122	1,202	1,288	1,380	
	UDC ('000)	***508***	550	596	645	699	756	819	886	958	1,036	1,121	1,211	
Total Rec. Exp	Millions	***1,955***	2,235	2,556	2,922	3,341	3,821	4,368	4,995	5,711	6,529	7,465	8,535	14.3%
Total Dev. Exp	Millions	***745***	857	987	1,137	1,309	1,507	1,735	1,998	2,300	2,648	3,048	3,509	15.1%
Total Exp.(RHFs)	Millions	***2,700***	3,093	3,543	4,059	4,650	5,328	6,103	6,992	8,010	9,177	10,513	12,044	14.6%
Health Output (RHFs)		***38,055***	41,357	44,948	48,854	53,104	57,728	62,760	68,237	74,198	80,688	87,755	95,450	9.6%
Total Exp.	Millions	***7,783***	8,917	10,215	11,703	13,407	15,359	17,596	20,158	23,094	26,457	30,309	34,723	14.6%
Total Health Output		***22,422***	25,212	28,350	31,882	35,856	40,328	45,362	51,028	57,408	64,592	72,682	81,794	12.5%

TABLE 5.2

CONSTRAINED OPTIMAL EXPENSION PATHS FOR HEALTH FACILITIES
ALL PROVINCES COMBINED (BASED ON HISTORICAL GROWTH RATES)

Variables		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Growth
		URBAN HEALTH FACILITIES (UHFs)												
Doctors	Numbers	*22,044*	22,776	24,499	26,326	27,995	29,719	31,549	33,491	35,553	37,743	40,066	42,533	6.4%
	Wage Rate	*49,862*	51,646	56,858	62,503	67,630	72,984	78,763	84,999	91,728	98,991	106,828	115,286	8.4%
Nurses	Numbers	*15,634*	16,659	18,120	19,700	21,303	23,016	24,867	26,867	29,027	31,362	33,884	36,609	8.2%
	Wage Rate	*30,801*	30,934	33,678	36,593	38,936	41,286	43,778	46,419	49,221	52,191	55,341	58,680	6.6%
Paramedics	Numbers	*33,458*	34,588	37,016	39,581	41,946	44,385	46,966	49,697	52,587	55,645	58,881	62,305	6.1%
	Wage Rate	*16,155*	16,724	18,505	20,443	22,196	24,031	26,017	28,168	30,497	33,017	35,747	38,702	8.8%
Beds	Numbers	*43,196*	50,138	50,138	50,138	52,207	54,753	57,429	60,242	63,201	66,314	69,590	73,038	3.8%
	URC ('000)	*49*	54	58	63	69	75	81	88	96	104	113	122	
	UDC ('000)	*19*	21	24	26	29	32	35	39	43	48	53	59	
Total Rec Exp.	Millions	*4,257*	4,964	5,615	6,356	7,251	8,283	9,462	10,808	12,346	14,102	16,107	18,396	14.0%
Total Dev. Exp	Millions	*827*	1,064	1,179	1,306	1,506	1,749	2,031	2,358	2,738	3,178	3,690	4,283	
Total Exp.(GH)	Millions	*5,084*	6,027	6,794	7,661	8,757	10,032	11,493	13,166	15,083	17,280	19,796	22,679	16.1%
Health Output (GH)		*14,288*	17,210	19,572	22,229	25,660	29,710	34,402	39,838	46,138	53,439	61,902	71,713	15.3%
		RURAL HEALTH FACILITIES (RHFs)												
Doctors	Numbers	*9,605*	10,209	11,516	12,971	14,387	15,916	17,608	19,480	21,551	23,841	26,376	29,179	11.1%
	Wage Rate	*51,389*	51,739	54,316	56,963	59,095	61,195	63,371	65,623	67,956	70,371	72,873	75,463	3.8%
Paramedics	Numbers	*22,726*	24,031	26,782	29,810	32,731	35,857	39,282	43,034	47,145	51,648	56,582	61,988	9.9%
	Wage Rate	*23,049*	23,327	24,786	26,305	27,566	28,827	30,146	31,524	32,966	34,474	36,050	37,698	4.9%
RHFs	Numbers	*1,465*	1,455	1,599	1,753	1,873	1,992	2,120	2,255	2,400	2,555	2,720	2,897	7.1%
	URC ('000)	*640*	687	737	791	848	910	976	1,046	1,122	1,202	1,288	1,380	
	UDC ('000)	*508*	550	596	645	699	756	819	886	958	1,036	1,121	1,211	
Total Rec. Exp	Millions	*1,955*	2,088	2,468	2,910	3,341	3,821	4,368	4,995	5,711	6,529	7,465	8,535	15.1%
Total Dev. Exp	Millions	*745*	801	953	1,132	1,309	1,507	1,735	1,998	2,300	2,648	3,048	3,509	15.9%
Total Exp.(RHFs)	Millions	*2,700*	2,889	3,421	4,042	4,650	5,328	6,103	6,992	8,010	9,177	10,513	12,044	15.3%
Health Output (RHFs)		*38,055*	39,157	43,703	48,683	53,104	57,728	62,760	68,237	74,198	80,688	87,755	95,450	9.6%
Total Exp.	Millions	*7,783*	8,917	10,215	11,703	13,407	15,359	17,596	20,158	23,094	26,457	30,309	34,723	14.6%
Total Health Output		*22,422*	25,120	28,322	31,881	35,856	40,328	45,362	51,028	57,408	64,592	72,682	81,794	12.5%

TECHNICAL APPENDICES

TECHNICAL APPENDIX A

ALGEBRAIC SOLUTION FOR AN EXTENDED OPTIMIZATION HEALTH SYSTEM

The purpose of this technical appendix is to derive optimal solution for an extended health system based on maximization of the Health Welfare Function (HWF) for a given fixed total expenditure on health system.. The *HWF* is a composite weighted index of patients treated in Urban and in Rural Health Facilities. Patients treated in Urban Health Facility in turn is an index of inpatients and outpatients. Total cost on the other hand, consist of expenditures on recurring and development outlays for urban and rural health facilities. Since the producer [Public Health Department (*PHD*)] is assumed to act as *monopsonist*, input supply for health professionals (doctors, nurses and paramedics) are assumed to be a function of their respective, wages and the stock of registered personnel. It should be noted that the unit development cost in this framework is simply the average development expenditure on each bed or *RHFs* at a given point in time.[1] The basic optimization problem in this context simply involves the maximization of *HWF* with respect to the input prices of the personnel and infrastruture (beds and *RHFs*) subject to available budget. Once the optimal values of prices and physical infrastructure are determined, input supply of personnel are computed using their respectively supply funtions.

This optimization problem of the combined public health system thus can be written as:

$$Max: \qquad O_T = O_U^{\delta}\, O_R^{(1-\delta)} \tag{1}$$

$$Where \qquad O_U = O_{U_I}^{\gamma}\, O_{U_o}^{(1-\gamma)} = \phi_{10}\, D_1^{\phi_{11}}\, N_1^{\phi_{12}}\, P_1^{\phi_{13}}\, B^{\phi_{14}}$$

$$O_R = \phi_{20}\, D_2^{\phi_{21}}\, P_2^{\phi_{22}}\, R^{\phi_{23}}$$

$$Subject\ to \qquad \overline{C} = C_1 + C_2 \tag{2}$$

$$C_1 = W_{D_1} D_1 + W_{N_1} N_1 + W_{P_1} P_1 + m_1 B + c_1 B$$

$$C_2 = W_{D_2} D_2 + W_{P_2} P_2 + m_2 R + c_2 R$$

Input supply functions for Urban Health Facilities (UHFs) are

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1 We have considered unit average development cost (rather than unit development cost) per bed for the reason that no authentic cost data on new beds are available.

$$\left.\begin{aligned} D_1 &= \alpha_{10}\, W_{D_1}^{\alpha_{11}}\, Z_D^{\alpha_{12}} \\ N_1 &= \alpha_{20}\, W_{N_1}^{\alpha_{21}}\, Z_N^{\alpha_{22}} \\ P_1 &= \alpha_{30}\, W_{P_1}^{\alpha_{31}}\, Z_P^{\alpha_{32}} \end{aligned}\right\} \qquad (3.A)$$

and for Rural Health Facilitities (RHFs) the supply functions are as follows:

$$\left.\begin{aligned} D_2 &= \beta_{10}\, W_{D_2}^{\beta_{11}}\, Z_D^{\beta_{12}} \\ P_2 &= \beta_{20}\, W_{P_2}^{\beta_{21}}\, Z_{P'}^{\beta_{22}} \end{aligned}\right\} \qquad (3.B)$$

Thus the Lagrange equation for the above problem can be written as:

$$\mathcal{L}(W_{D_1}, W_{N_1}, W_{P_1}, W_{D_2}, W_{P_2}, B, R, \lambda) = O_T + \lambda(\overline{C} - C_1 - C_2)$$

Substituting all supply functions, production functions in the above expression will yield:

$$\mathcal{L}(W_{D_1}, W_{N_1}, W_{P_1}, W_{D_2}, W_{P_2}, B, R, \lambda) = \left[\phi_{10}\, B^{\phi_{14}} \left(\alpha_{10}\, W_{D_1}^{\alpha_{11}}\, Z_D^{\alpha_{12}}\right)^{\phi_{11}} \left(\alpha_{20}\, W_{N_1}^{\alpha_{21}}\, Z_N^{\alpha_{22}}\right)^{\phi_{12}} \left(\alpha_{30}\, W_{P_1}^{\alpha_{31}}\, Z_{P_1}^{\alpha_{32}}\right)^{\phi_{31}}\right]^{\delta} \left[\phi_{20}\, R^{\phi_{23}} \left(\beta_{10}\, W_{D_2}^{\beta_{11}}\, Z_D^{\beta_{12}}\right)^{\phi_{21}} \left(\beta_{20}\, W_{P_2}^{\beta_{21}}\, Z_{P_2}^{\beta_{22}}\right)^{\phi_{22}}\right]^{(1-\delta)} + \lambda\Big[\overline{C} - W_{D_1}\left(\alpha_{10}\, W_{D_1}^{\alpha_{11}}\, Z_D^{\alpha_{12}}\right) - W_{N_1}\left(\alpha_{20}\, W_{N_1}^{\alpha_{21}}\, Z_N^{\alpha_{22}}\right) - W_{P_1}\left(\alpha_{30}\, W_{P_1}^{\alpha_{31}}\, Z_{P_1}^{\alpha_{32}}\right) - m_1\, B - c_1\, B - W_{D_2}\left(\beta_{10}\, W_{D_2}^{\beta_{11}}\, Z_D^{\beta_{12}}\right) - W_{P_2}\left(\beta_{20}\, W_{P_2}^{\beta_{21}}\, Z_P^{\beta_{22}}\right) - m_2\, R - c_2\, R$$

The first order conditions for the above system can be written as:

$$\frac{\partial \mathcal{L}}{\partial W_{D_1}} = \alpha_{11}\, \phi_{11} \delta\, \frac{O_T}{W_{D_1}} - \lambda(\alpha_{11} D_1 + D_1) = 0$$

$$\frac{\partial \mathcal{L}}{\partial W_{N_1}} = \alpha_{21}\, \phi_{12} \delta\, \frac{O_T}{W_{N_1}} - \lambda(\alpha_{21} N_1 + N_1) = 0$$

$$\frac{\partial \mathcal{L}}{\partial W_{P_1}} = \alpha_{31}\Phi_{13}\ \delta\ \frac{O_T}{W_{P_1}} - \lambda(\alpha_{13}P_1 + P_1) = 0$$

$$\frac{\partial \mathcal{L}}{\partial B} = \Phi_{14}\delta\frac{O_T}{B} - \lambda(m_1 + c_1) = 0$$

$$\frac{\partial \mathcal{L}}{\partial W_{D_2}} = \beta_{11}\Phi_{21}(1 - \delta)\frac{O_T}{W_{D_2}} - \lambda(\beta_{21}D_2 + D_2) = 0$$

$$\frac{\partial \mathcal{L}}{\partial W_{P_2}} = \beta_{21}\Phi_{22}(1 - \delta)\frac{O_T}{W_{P_2}} - \lambda(\beta_{22}P_2 + P_2) = 0$$

$$\frac{\partial \mathcal{L}}{\partial R} = \Phi_{23}\ (1-\delta)\frac{O_T}{R} - \lambda(m_2 + c_2) = 0$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = \overline{C} - W_{D_1}D_1 - W_{N_1}N_1 - W_{P1}P_1 - m_1B - c_1\ B - W_{D_2}D_2 - W_{P_2}P_2 - m_2R - c_2\ R$$

Solving simultaneously the above eight equations and also supply functions for professionals, we can get the optimal solution for wages, beds, and *RHFs:* :

$$W^*_{D_1} = \left[\frac{\alpha_{11}\Phi_{11}\delta\Delta}{(1 + \alpha_{11})\alpha_{10}Z_D^{\alpha_{12}}}\right]^{\frac{1}{(1 + \alpha_{11})}}$$

$$W^*_{P_1} = \left[\frac{\alpha_{31}\Phi_{13}\delta\Delta}{(1 + \alpha_{31})\alpha_{30}Z_P^{\alpha_{32}}}\right]^{\frac{1}{(1 + \alpha_{31})}}$$

$$W^*_{N_1} = \left[\frac{\alpha_{21}\Phi_{12}\delta\Delta}{(1 + \alpha_{21})\alpha_{20}Z_N^{\alpha_{22}}}\right]^{\frac{1}{(1 + \alpha_{21})}}$$

$$W^*_{D_2} = \left[\frac{\beta_{11}\Phi_{21}(1 - \delta)\Delta}{(1 + \beta_{11})\beta_{10}Z_D^{\beta_{11}}}\right]^{\frac{1}{(1 + \beta_{11})}}$$

$$W_{P_2}^{*} = \left[\frac{\beta_{21} \Phi_{22} (1 - \delta) \Delta}{(1 + \beta_{21}) \beta_{20} Z_P^{\beta_{21}}} \right]^{\frac{1}{(1 + \beta_{21})}}$$

$$B^{*} = \frac{\phi_{14} \delta \ \Delta}{(m_1 + c_1)}$$

$$R^{*} = \frac{\phi_{23} (1 - \delta) \ \Delta}{(m_2 + c_2)}$$

Substituting these optimal wages into the supply functions, will yield the following optimal values for doctors, nurses, paramedics and beds in *UHFs* and *RHFs*:

$$D_1^{*} = \frac{\alpha_{11} \phi_{11} \delta \ \Delta}{W_{D_1}^{*} (1 + \alpha 11)}$$

$$N_1^{*} = \frac{\alpha_{21} \phi_{12} \delta \ \Delta}{W_{N_1}^{*} (1 + \alpha_{21})}$$

$$P_1^{*} = \frac{\alpha_{31} \phi_{13} \delta \ \Delta}{W_{P_1}^{*} (1 + \alpha_{31})}$$

$$D_2^{*} = \frac{\beta_{11} \phi_{21} (1 - \delta) \ \Delta}{W_{D_2}^{*} (1 + \beta_{11})}$$

$$P_2^{*} = \frac{\beta_{22} \phi_{22} (1 - \delta) \ \Delta}{W_{P_2}^{*} (1 + \beta_{22})}$$

where Δ is defined as:

$$\Delta = \frac{\overline{C}}{\delta \left(\frac{\alpha_{11} \phi_{11}}{1 + \alpha_{11}} + \frac{\alpha_{21} \phi_{12}}{1 + \alpha_{21}} + \frac{\alpha_{31} \phi_{13}}{1 + \alpha_{31}} + \phi_{14} \right) + (1 - \delta) \left(\frac{B_{11} \phi_{21}}{1 + \beta_{11}} + \frac{\beta_{21} \phi_{22}}{1 + \beta_{21}} + \phi_{23} \right)}$$

CONSTRAINED OPTIMIZATION:

The constrained optimization problem of the health system assumes that the urban health facility has sufficient infrastructure and it is more than that of the Standard optimal. Thus additional infrasturucture is not needed in the urban health facility and therefore the development expenditure in this case will be zero for *UHFs*. In order to derive optimal solution for the constrained strategy, the budget constraint for *UHFs* (C_2) should be modified as follows:

$$\overline{C} = C_1 + C_2 \qquad ------(2.I)$$

$$C_1 = W_{D_1} D_1 + W_{N_1} N_1 + W_{P_1} P_1 + m_1 \overline{B}$$

$$C_2 = W_{D_2} D_2 + W_{P_2} P_2 + m_2 R + c_2 R$$

The input supply function for UHFs and RHFs are still the same, but the lagrangian of the new optimization process can be written as:

$$\mathfrak{L}(W_{D_1}, W_{N_1}, W_{P_1}, W_{D_2}, W_{P_2}, R, \lambda) = \left[\phi_{10}\, \overline{B}^{\phi_{14}} \left(\alpha_{10}\, W_{D_1}^{\alpha_{11}}\, Z_D^{\alpha_{12}} \right)^{\phi_{11}} \left(\alpha_{20}\, W_{N_1}^{\alpha_{21}}\, Z_N^{\alpha_{22}} \right)^{\phi_{12}} \left(\alpha_{30}\, W_{P_1}^{\alpha_{31}}\, Z_{P_1}^{\alpha_{32}} \right)^{\phi_{31}} \right]^{\delta} \left[\phi_{20}\, R^{\phi_{23}} \left(\beta_{10}\, W_{D_2}^{\beta_{11}}\, Z_D^{\beta_{12}} \right)^{\phi_{21}} \left(\beta_{20}\, W_{P_2}^{\beta_{21}}\, Z_{P_2}^{\beta_{22}} \right)^{\phi_{22}} \right]^{(1-\delta)} + \lambda \left[\overline{C} - W_{D_1} \left(\alpha_{10}\, W_{D_1}^{\alpha_{11}}\, Z_D^{\alpha_{12}} \right) - W_{N_1} \left(\alpha_{20}\, W_{N_1}^{\alpha_{21}}\, Z_N^{\alpha_{22}} \right) - W_{P_1} \left(\alpha_{30}\, W_{P_1}^{\alpha_{31}}\, Z_{P_1}^{\alpha_{32}} \right) - m_1 \overline{B} - W_{D_2} \left(\beta_{10}\, W_{D_2}^{\beta_{11}}\, Z_D^{\beta_{12}} \right) - W_{P_2} \left(\beta_{20}\, W_{P_2}^{\beta_{21}}\, Z_P^{\beta_{22}} \right) - m_2 R - c_2 R \right.$$

First order conditions for the above system can written as

$$\frac{\partial \mathfrak{L}}{\partial W_{D_1}} = \alpha_{11}\, \phi_{11} \delta\, \frac{O_T}{W_{D_1}} - \lambda(\alpha_{11} D_1 + D_1) = 0$$

$$\frac{\partial \mathcal{L}}{\partial W_{N_1}} = \alpha_{21}\ \Phi_{12}\delta \frac{O_T}{W_{N_1}} - \lambda(\alpha_{21}N_1 + N_1) = 0$$

$$\frac{\partial \mathcal{L}}{\partial W_{P_1}} = \alpha_{31}\Phi_{13}\ \delta\ \frac{O_T}{W_{P_1}} - \lambda(\alpha_{13}P_1 + P_1) = 0$$

$$\frac{\partial \mathcal{L}}{\partial W_{D_2}} = \beta_{11}\Phi_{21}(1 - \delta)\frac{O_T}{W_{D_2}} - \lambda(\beta_{21}D_2 + D_2) = 0$$

$$\frac{\partial \mathcal{L}}{\partial W_{P_2}} = \beta_{21}\Phi_{22}(1 - \delta)\frac{O_T}{W_{P_2}} - \lambda(\beta_{22}P_2 + P_2) = 0$$

$$\frac{\partial \mathcal{L}}{\partial R} = \Phi_{23}(1-\delta)\frac{O_T}{R} - \lambda(m_2 + c_2) = 0$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = \overline{C} - W_{D_1}D_1 - W_{N_1}N_1 - W_{PI}P_1 - m_1\overline{B} - W_{D_2}D_2 - W_{P_2}P_2 - m_2R - c_2\ R$$

Simultaneously solving the above equations we can get the optimal values of Wages :

$$W_{D_1}^{**} = \left[\frac{\alpha_{11}\Phi_{11}\delta\Delta'}{(1 + \alpha_{11})\alpha_{10}Z_D^{\alpha_{12}}}\right]^{\frac{1}{(1 + \alpha_{11})}}$$

$$W_{P_1}^{**} = \left[\frac{\alpha_{31}\Phi_{13}\delta\Delta'}{(1 + \alpha_{31})\alpha_{30}Z_P^{\alpha_{32}}}\right]^{\frac{1}{(1 + \alpha_{31})}}$$

$$W_{N_1}^{**} = \left[\frac{\alpha_{21}\Phi_{12}\delta\Delta'}{(1 + \alpha_{21})\alpha_{20}Z_N^{\alpha_{22}}}\right]^{\frac{1}{(1 + \alpha_{21})}}$$

$$W_{D_2}^{**} = \left[\frac{\beta_{11}\Phi_{21}(1 - \delta)\Delta'}{(1 + \beta_{11})\beta_{10}Z_D^{\beta_{11}}}\right]^{\frac{1}{(1 + \beta_{11})}}$$

$$W_{P_2}^{**} = \left[\frac{\beta_{21}\Phi_{22}(1 - \delta)\Delta'}{(1 + \beta_{21})\beta_{20}Z_P^{\beta_{21}}}\right]^{\frac{1}{(1 + \beta_{21})}}$$

$$R^{**} = \frac{\phi_{23}(1 - \delta)\ \Delta'}{(m_2 + c_2)}$$

Substituting theses optimal wages into the supply functions will yield the optimal values for Doctors, Nurses, Paramedics and Beds in UHFs and RHFs:

$$D_1^{**} = \frac{\alpha_{11}\phi_{11}\delta\ \Delta'}{W_{D_1}^{**}(1 + \alpha 11)}$$

$$N_1^{**} = \frac{\alpha_{21}\phi_{12}\delta\ \Delta'}{W_{N_1}^{**}(1 + \alpha_{21})}$$

$$P_1^{**} = \frac{\alpha_{31}\phi_{13}\delta\ \Delta'}{W_{P_1}^{**}(1 + \alpha_{31})}$$

$$D_2^{**} = \frac{\beta_{11}\phi_{21}(1 - \delta)\ \Delta'}{W_{D_2}^{**}(1 + \beta_{11})}$$

$$P_2^{**} = \frac{\beta_{22}\phi_{22}(1 - \delta)\ \Delta'}{W_{P_2}^{**}(1 + \beta_{22})}$$

In all the above Equations Δ' is defined as

$$\Delta' = \frac{\overline{C} - (m_1 + c_1)\ \overline{B}}{\delta\left(\frac{\alpha_{11}\phi_{11}}{1 + \alpha_{11}} + \frac{\alpha_{21}\phi_{12}}{1 + \alpha_{21}} + \frac{\alpha_{31}\phi_{13}}{1 + \alpha_{31}}\right) + (1 - \delta)\left(\frac{\beta_{11}\phi_{21}}{1 + \beta_{11}} + \frac{\beta_{21}\phi_{22}}{1 + \beta_{21}} + \phi_{23}\right)}$$

The variables used in the above model are defined as follows:

B	Beds (Infrastructure) in current period of Urban Health Facilities
c_1	Unit Development expenditure of Urban Health Facilities.
c_2	Unit Development expenditure of Rural Health Facilities.
$\overline{C}$	Total Health Expenditure.

C_1	Total Health Expenditure of Urban Health Facilities.
C_2	Total Health Expenditure of Rural Health Facilities.
D_1	Doctors in Urban Health Facilities
D_2	Doctors in Rural Health Facilities.
m_1	Unit Recurring expenditure of Urban Health Facilities.
m_2	Unit Recurring expenditure of Rural Health Facilities.
N_1	Nurses in Urban Health Facilities.
O_H	Index of Patients treated in Urban Health Facilities
O_{H_I}	In-Patient in General Hospitals.
O_{H_o}	Out-Patients treated in Urban Health Facilities.
O_T	Health Welfare Function (Index of Total Patient treated)
O_R	Patients treated in Rural Health Facilities
P_1	Paramedics in Urban Health Facilities
P_2	Paramedics (Sum of Nurses & Paramedics) in Rural Health Facilities
R	Infrastructure of Rural Health Facilities in current period
R_{-1}	Infrastructure of Rural Health Facilities in previous period
W_{D_1}	Wage rate of Doctors in Urban Health Facilities.
W_{D_2}	Wage rate of Doctors in Rural Health Facilities.
W_{N_1}	Wage rate of Nurses in Urban Health Facilities.
W_{P_1}	Wage rate of Paramedics in Urban Health Facilities.
W_{P_2}	Wage rate of Paramedics in Rural Health Facilities.

TECHNICAL APPENDIX B

PUBLIC HEALTH DATA SOURCES AND ITS LIMITATIONS

This section describes the variables used in the public health model, data sources, methodology and its limitations. The data was collected on health institutions primarily administered by the Provincial Health Departments. Excluded were institutions under the control of the Jails Department, Local Bodies, Pakistan Railways, Social Security, and private institutions.

Variables

Our Health Model has two separate production functions for two broad categories of health facilities. We have called these categories General Hospitals and Rural Health Facilities. This separation was done for two reasons. First, General Hospitals, as opposed to Rural health facilities, are large institutions providing comprehensive health care. They have a much greater population coverage and are located in urban areas and at district headquarters. Second, and related to the first, the outputs of our health production functions - patients treated - are subject to different inputs in these two categories.

General Hospitals include medical colleges, general hospitals, and dispensaries. The data contained two output variables, total outpatients treated and total inpatients treated. The inputs were the numbers and wages of doctors, nurses, and paramedics, and number of hospital beds. Evidently, an inpatient is not "equivalent" to an outpatient, both in terms of the type of inputs or in the intensity with which a particular input is used. For example, hospital beds are only used to treat an inpatient. The effort required to treat an inpatient, in terms of the work-hours of medical personnel, is considerably greater for inpatients. Unfortunately, it was not possible to separate the inputs for inpatients and outpatients. Therefore, the output used was total patient treated. However, to capture the greater effort needed to treat an inpatient, a geometric mean of inpatients and outpatients was used.

Rural Health Facilities include Rural Health Centres (RHCs), and Basic Health Units (BHUs). Theoretically, one BHU covers a population of 5000, while one RHC covers a population of 25,000. The output is total patient treated - separate data for inpatients and outpatients was not available. Inputs include numbers and wages of doctors, number and wages of other medical staff (other medical staffs are nurses and paramedics - separate data for these two categories was not available), and a weighted sum of the number of BHUs and the number of RHCs. The logic of using a weighted sum was as follows: there was no data on the number of hospital beds in BHUs. Therefore, one had to use the total number of RHCs and BHUs as inputs. Now, a RHC is not equivalent to a BHU in terms of the patients it treats. Therefore, a linear aggregation would have distorted the picture by overstating the effect of BHUs on patients treated. The weights assigned were based on the population coverage of BHUs and RHCs.

Data Source and Methodology

Four different sources were used to collect data most of the on public health system namely, Development Statistics (*DS*), Estimates of Charged Expenditures and Demands for Grants Current Expenditure (*ECEDGCE*), Annual Development Plans (*ADP*) and Pakistan Economic Surveys (*PES*). Various issues of *DEs* were used to get information on the number of inpatients and outpatients, and the number of hospital beds, *RHCs* and *BHUs,* while *ECEDGCEs* were used to get information on the number and wages of doctors, nurses, paramedic, other staff and current expenditure on medical supplies. Development expenditure data was collected from *ADP*. As for the registered health professionals, it was gathered from *PES*.

ECEDGCE provides very detailed data for each individual medical facility in the province. The number and type of posts and the budgeted salary expenditures for each of these posts are given. These posts vary from radiologists to sweepers. Using these documents, the number of personnel in three categories - doctors, nurses, and paramedics - were estimated. *ECEDGCE* documents also provide data on the two components of salary - basic pay, and allowances. Data for basic pay is given by type of post. Unfortunately, the data for allowances is not given by post. Instead, the total allowances for the entire medical institution are given. Therefore, the allowance component for each category (doctor, nurse, and paramedic) has to be imputed. This imputation was done as follows: the ratio of allowances to total basic pay was calculated for the entire province. Here the basic pay for all the personnel - medical as well as non-medical - is used. This ratio was then multiplied by the total basic pay for each category to determine the allowance component of each category. The wage rates were then calculated for each category by dividing the sum of the basic pay and allowances for the category by the number of personnel in that category.

There were some problems with data particularly with *ECEDGCE*. One was that of missing observation. For example, the number and type of posts would be given for a particular year in a particular medical facility, but the budgeted salary component would be missing. Or the salary would be given, but the number of posts would be missing. In such cases, we simply estimated the missing data based on other information. Another problem was that of data unreliability. On several occasions there were clear misprints in the figures for personnel and salary. In many medical facilities, there was a mismatch between the number of personnel in a particular post and the budgeted salary for that post, or vice versa. For example, the budgeted salary for a particular post was unrealistically high or unrealistically low. Again, we had to use our own judgement to adjust the data so as to make it more realistic.

In summary, data is always a major constraint particularly for earlier years. We tried to collect the secondary data with utmost care, however, wherever we found anomalies, we attempted to resolve it by cross checking it with the same document for other years.