Optimization of the configuration of public hospital infrastructure at the district level in South Asian countries

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ABSTRACT

South Asian countries face resource constraints in expanding public hospital infrastructure, which is a key requirement for achieving the health MDGs. Although increasing public expenditure efforts is partly a solution, it is unlikely to be sufficient. Recent studies of hospital efficiency in Bangladesh, Nepal, Sri Lanka and India show that large differences in system efficiency exist between the countries, with Sri Lanka generally achieving better efficiency levels. This study profiles the organisation of hospitals at the sub-regional or district level in the three countries, identifies differences in system efficiency, and explores possible explanations for the productivity differences found. Overall it is found that the Sri Lankan hospital system is much productive than those in Bangladesh and Nepal, producing much higher volumes of services than in those countries. Some of the higher output is due to higher levels of spending on hospital services in Sri Lanka. However, differences in spending levels are not sufficient to explain the differences observed in outputs. These appear to be also due to differences in productivity at the individual hospital level, with Sri Lankan hospitals being more technically efficient than Bangladeshi hospitals which are in turn more efficient than Nepalese hospitals. It is also found that lower relative wages and higher labour productivity in Sri Lankan hospitals also contributes to their lower cost. Other findings are that hospitals in Bangladesh and Nepal are not operating at scale economies, and that Sri Lanka achieves much of its higher output by operating a range of small and basic hospitals, which have no counterpart in the other two countries. These results suggest that there is considerable room for improvement in the system efficiency of hospital services in Nepal and Bangladesh. In particular, expanding the number of fixed delivery points and expanding the size of current hospitals, whilst at the same time reducing the capital, technology and labour intensity of facilities would be more optimal. Both countries might also need to consider introducing a simpler hospital design to provide even cheaper provision of services at the lowest community levels.

ACRONYMS

CSSD	Central sterile supplies division
ECG	Electro-cardiogram
GDP	Gross domestic product
ICU	Intensive care unit
MDG	Millennium Development Goals
NHA	National Health Accounts
OT	Operating theatre
PU	Peripheral unit (Sri Lanka)
THC	Thana Health Complex

1. INTRODUCTION

All South Asian countries, with the exception of Sri Lanka and Maldives and some states in India, face significant challenges in reaching the Millennium Development Goals (MDGs) in health, and in improving the overall health status of their populations. Although effective preventive services will reduce the burden of ill-health, the largest gains depend on expanding the use by the population of effective personal medical services (Devarajan, Miller, and Swanson, 2002; World Bank, 1993, 1997; World Health Organization, 2000). Although private medical services can and do provide a substantial part of the necessary provision, publicly-funded services remain critical to ensuring that the majority of the population, particularly the poor and rural people, have access (Filmer, Hammer, and Pritchett, 2002; Hammer and Berman, 1995; Institute of Policy Studies, 2003). A central policy objective in most of South Asia therefore is how to increase access to basic medical services, given the resource constraints that exist.

A critical constraint that countries face is that hospital infrastructure is expensive to establish and to maintain, and public budgets are limited. Although hospitals are not required to deliver all necessary medical services, they are essential to provide many types of needed care, such as emergency obstetric services required to reduce maternal mortality, and they form the central framework for any organised health delivery system. In addition, hospitals perform an important function in providing risk protection against the expensive costs of serious illness. However, hospitals are costly to build and then operate, and thus represent major opportunity costs for most governments. In all countries, hospitals accounts for a large share of overall public sector health budgets. In this context, knowing how to provide and expand hospital services in a cost-efficient matter becomes important, as it can be key to achieving overall health system efficiencies.

Countries face real dilemmas in knowing how to best deploy hospital infrastructure. For example, concentrating investments in a few large facilities may reduce average costs by exploiting economies of scale, but at the expense of reducing access, since demand studies suggest distance is a bigger barrier to the poor. At the same time, it is likely that if hospitals become too large, they no longer achieve economies of scale, and actually become more inefficient at greater scale. Similarly, an important question is should capital-intensive equipment be available at all levels or only at some?

It is important to note that even if financial resources could be increased, at current levels of technical efficiency in existing hospital systems, the level of spending that would be required just to meet the health MDG goals is for most countries is much greater than the likely level of financial resources (Commission on Macroeconomics and Health, 2001; Devarajan, Miller, and Swanson, 2002). Most accepted cost projections for achieving the MDGs imply that either international donors must fill the financing gap to achieve MDGs, which is unlikely for the larger South Asian economies, or that domestic resource mobilization must be increased to levels substantially greater than what most governments can afford.

This research makes use of a unique combination of data sets from Bangladesh, Nepal and Sri Lanka to explore whether current patterns of hospital infrastructure

deployment in most South Asian countries is optimal in maximizing cost-efficiency and equity of access to services. These data sets collected in three separate research studies have shown that there are remarkable differences in the average cost of public hospital service production in the three countries, and have pointed to striking differences in the pattern of hospital infrastructure in the three countries. In particular, Sri Lanka achieves a level of service provision five to ten times greater than in the other two countries, but does so whilst spending only 10-30% more in relative terms. The separate results suggest that this difference may be partly explained by critical differences in the composition of Sri Lankan hospital infrastructure and inputs (higher numbers of fixed facilities, lower capital and labour intensity, better economies of scale). The objective of this study is to explore whether such differences in infrastructural deployment are reasonable determinants of this differing performance, and whether this can provide lessons to the rest of South Asia.

2. LITERATURE REVIEW

Despite the intuitive expectation, most studies have failed to find close statistical relationships between the level of medical infrastructure and health expenditures and health outcomes (Kim and Moody, 1992), and this can be partly explained by the existence of large variations in productivity of providers and health systems (Filmer, Hammer, and Pritchett, 1997). In addition, most studies of large samples of public hospitals in both developed and developing countries generally find large differences in unit costs and productivity ratios between individual, similar facilities in the same country (Barnum and Kutzin, 1993; Linna, 1998; Rannan-Eliya and Somanathan, 2003). Common factors for such differences include differences in fixed operating budgets, differences in patient demand, input mixes and labour productivity differences. The few cross-national studies show that mean national unit costs increase with per capita GDP, but with an income elasticity of less than one (Adam, Evans, and Murray, 2003), and that there exists large variations between countries at the same income level. Input mixes and costs are know to vary considerably across countries (Barnum and Kutzin, 1993).

The best available data on cost levels and productivity in public hospitals in the three countries considered in the study are from three data sets to be used in this study (Nepal Health Economics Association, 2004; Rannan-Eliya and Somanathan, 2003; Somanathan *et al.*, 2000). These three studies are relatively unusual for their large nationally-representative samples of facilities (the Bangladeshi and Sri Lankan data account for a large percentage of all the observations in WHO's global hospital cost data for developing countries as compiled by Adam et al.), and all use standard step-down cost accounting methods. They all report large differences, often not immediately explicable, in costs and productivity levels between similar facilities. When the studies are compared, the most remarkable difference is the very low unit costs in Sri Lanka, which enable it to achieve levels of provision almost ten times as much as in Nepal and Bangladesh, despite only spending modestly more. Although Nepal's topography is more challenging, Sri Lanka does not have any advantage in terms of population density compared with Bangladesh (increased population density makes it easier to increase access for any given number of fixed facilities). Other differences that can be surmised from the studies are that Sri Lankan facilities are more likely to be achieving economies of scale (based on production function models), are less capital and labour intensive at the lowest levels (i.e., less well equipped), and are more differentiated in terms of scale and complexity.

We were unable to find any previous studies which have looked specifically at the questions of infrastructure configuration raised in this study, either in the South Asian context, or more generally. Certainly the most recent international review of the topic of the district hospital, by the Disease Control Priorities Project, does not consider this (Jamison *et al.*, 2006). There are clearly trade-offs in how one builds hospital infrastructure. In most parts of South Asia (Bangladesh, India), fixed facilities are deployed on the basis of administrative norms; for example in Bangladesh hospitals are generally only constructed according to five standard sizes. These norms may not be optimal in terms of expanding access, and it is hoped this study will inform the development of such norms or processes.

3. RESEARCH OBJECTIVES

The goals of this study are to profile and characterize the public hospital infrastructure deployment in Bangladesh, Nepal and Sri Lanka, and by doing this to identify potential factors or characteristics, which might make certain deployment choices more efficient than others. This is to be done by using nationally-representative facility survey data. The dimensions initially postulated as being of potential importance include the spatial density of facilities in relation to population, the extent to which facilities are differentiated according to class of complexity and by size, the distribution of infrastructure by level of complexity and size, the capital or technology intensity of different levels of facility, the use or non-use of referral systems, input mixes, and the distribution of patient demand by level of facility.

The objectives of the study can thus be described as follows:

1. To assess the relationship if any between the level and composition of infrastructural configuration and demand for services by the population.
2. To determine how much of the known differences in technical efficiency of the public hospital infrastructure in the three countries can be explained by the pattern of infrastructure deployment, and how much is due to differences in total spending and other factors.
3. To assess in a scenario analysis the potential gains or costs in changing the current infrastructure patterns in Bangladesh, Nepal and Sri Lanka.
4. To identify potential best practice lessons on how hospital infrastructure might be most efficiently deployed in the South Asian setting.

4. COUNTRY BACKGROUNDS

General social and economic conditions

All three countries, Bangladesh, Nepal and Sri Lanka, are located in South Asia, and share many historical and cultural attributes. However, there are some important differences between the situations in each country. Bangladesh and Nepal are amongst the poorest of the lower income countries, whilst Sri Lanka graduated to lower-middle income status in 2000. Nepal is a largely mountainous, land-locked country, Bangladesh's territory consists for the most part of a large delta, whilst Sri Lanka is an island. More importantly, Sri Lanka has health indicators, which are more akin to an upper-middle income economy than to a developing country, whilst Bangladesh and Nepal continue to experience health conditions typical of countries at their income level. All three countries are densely populated (Table 1).

Table 1: Demographic, health and social indicators, 2000

	Bangladesh	**Nepal**	**Sri Lanka**
Socio-economic			
Population (millions)	123	23	18
GDP per capita (US$)	403	264	899
Gini index	0.33	0.34	0.39
% of population living at less than $1-a-day	23	60	2.3
Female Literacy rate (%)	40	24	89
Health status			
Life expectancy at birth (male)	60.7	59.1	71.0
Life expectancy at birth (female)	61.7	58.6	75.0
Infant mortality rate	61	75	15
Population			
Total fertility rate	3.3	4.1	1.9
Crude birth rate	20	33	18
Crude death rate	4.8	10.1	6.0

Sources: World Development Indicators (World Bank, various years)

Health conditions are relatively poor in Bangladesh, with average life expectancy 61 years at birth in 2000, and the infant mortality rate was at 61 per 1000 live births. Health conditions in Nepal are similar, with life expectancy at 58.9 years in 2000, and the infant mortality rate 75 per 1000 live births in 2000. In both countries, major public health problems include disorders related to reproductive health and pregnancy, childhood diarrhoea, malaria, tuberculosis, and acute respiratory infections. Gender and regional differentials in disease prevalence and incidence are significant.

By contrast, Sri Lanka has achieved both low mortality and low fertility rates. By 2000, despite an income level of just less than US$1,000 per capita, Sri Lanka had reduced its infant mortality rate to 15, its child mortality rate to 18, its total fertility rate to below replacement level at 2.0, and raised its life expectancy to 75 and 71 years at birth for women and men respectively. Variations in health status between different subgroups of the population are not great, with minimal differences between urban and rural populations. This performance has notably been achieved without

expending a higher proportion of its national resources on its health care system than other countries in the region. In comparison with Nepal and Bangladesh where national health expenditures are variously estimated at 3.6-5.0% of GDP, Sri Lanka has traditionally been a low health spender, with spending being less than 3.5% of GDP.

Health systems

The national health systems and the public hospital infrastructure of the three countries are superficially quite similar. In all three countries, the principal government intervention in health car is the public financing and provision of medical services through an integrated hospital-dominated delivery system. Government services are tax financed in each case, with no significant involvement from social insurance and with a very limited role for public sector user fees. Meanwhile, private sector provision and financing of medical services is permitted, and the general government attitude is one of *laissez-faire* to its operations. In all three countries, the private sector accounts for a substantial share of overall ambulatory provision, plus a smaller share of inpatient provision. In general, Sri Lanka is characterised by a greater degree of government involvement in both provision and financing than in Bangladesh and Nepal (Table 2).

Table 2: Health system statistics

	Bangladesh	**Nepal**	**Sri Lanka**
Health spending in 2000			
Total health expenditures (US$ millions)	1,387	234*	509
Total expenditures on health (% of GDP)	3.4	4.9*	3.2
Total expenditures on health per capita (US$ millions)	11	11*	27
Public expenditures on health (% of GDP)	0.8	0.9	1.6
Composition of total expenditures on health in 2000			
Public (%)	23	25	50
Private (%)	77	75	50
Health sector facility provision and service use (1990s)			
Public sector beds per 1000 capita	0.24	0.15	3.08
Private sector beds per 1000 capita	0.06	0.07	0.13
Admissions per 100 capita in the public sector	<1	<1	18
Physician contacts per capita per year	2.0	<2.0	4.5

Notes: * Statistics as published by WHO in its World Health Report 2006. However, these numbers are not reliable and may be subject to significant errors.
Sources: Data International (2003), Institute for Health Policy (2006), Prasai, Bista, Sharma and Gnawali (2004) and Institute for Health Policy database (various years)

Organisation of health services

Hospital infrastructure in the three countries is characterised by a pyramidal structure. In each case, there are a small number of tertiary care centres located in the major

cities, a larger number of secondary care facilities and a very large number of lower-level inpatient care facilities.

Taking into account the officially-recognised differentiation and administrative classification of facilities, in all three countries, it is possible to categorise all facilities into distinct levels or tiers. As Figures 1-3 show, the types and number of facilities at each tier varies considerably across the three countries. In Bangladesh and Nepal there are essentially three major levels of hospitals. In Bangladesh the main levels of hospitals consist of (i) teaching hospitals, (ii) district and general hospitals, and (iii) thana health complexes. In Nepal, the main levels consist of (i) teaching hospitals, (ii) regional, sub-regional and zonal hospitals, and (iii) district hospitals. However, in Sri Lanka there are more levels in operation, consisting of (i) teaching hospitals, (ii) provincial hospitals, (iii) base hospitals, (iv) district hospitals, (v) peripheral units and rural hospitals, and (vi) maternity homes. The composition of facilities by level is not so pyramidal, and a substantial proportion of facilities exist at the middle levels.

Figure 1: Numbers of facilities at different levels of hospital provision in Bangladesh, 2002

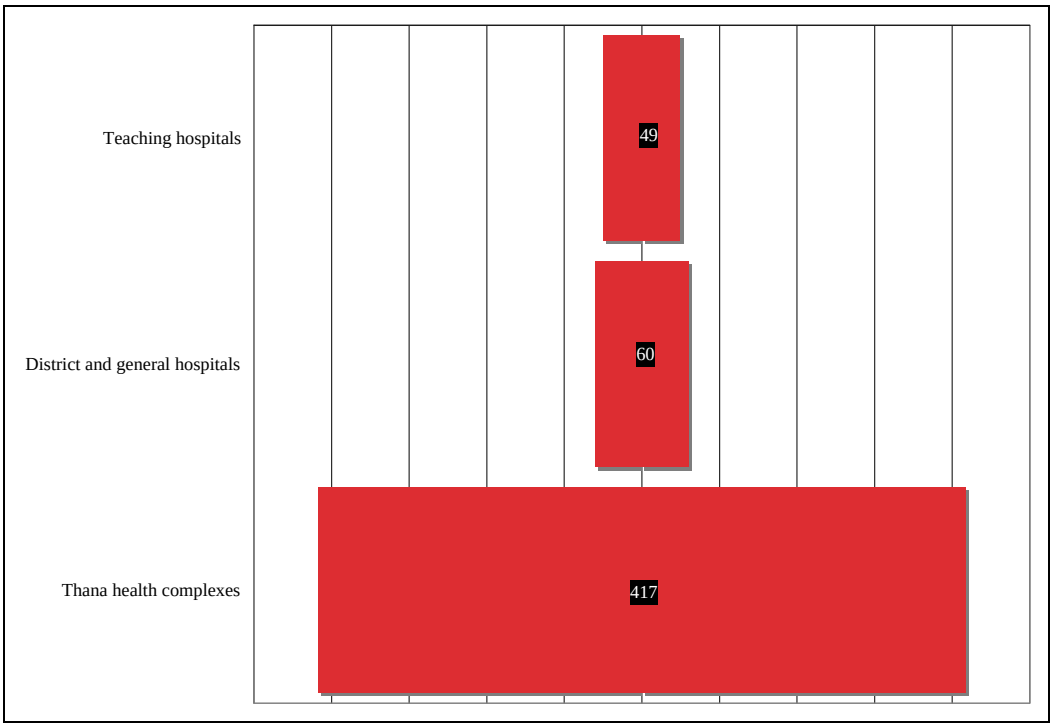


Figure 2: Numbers of facilities at different levels of hospital provision in Nepal, 2004

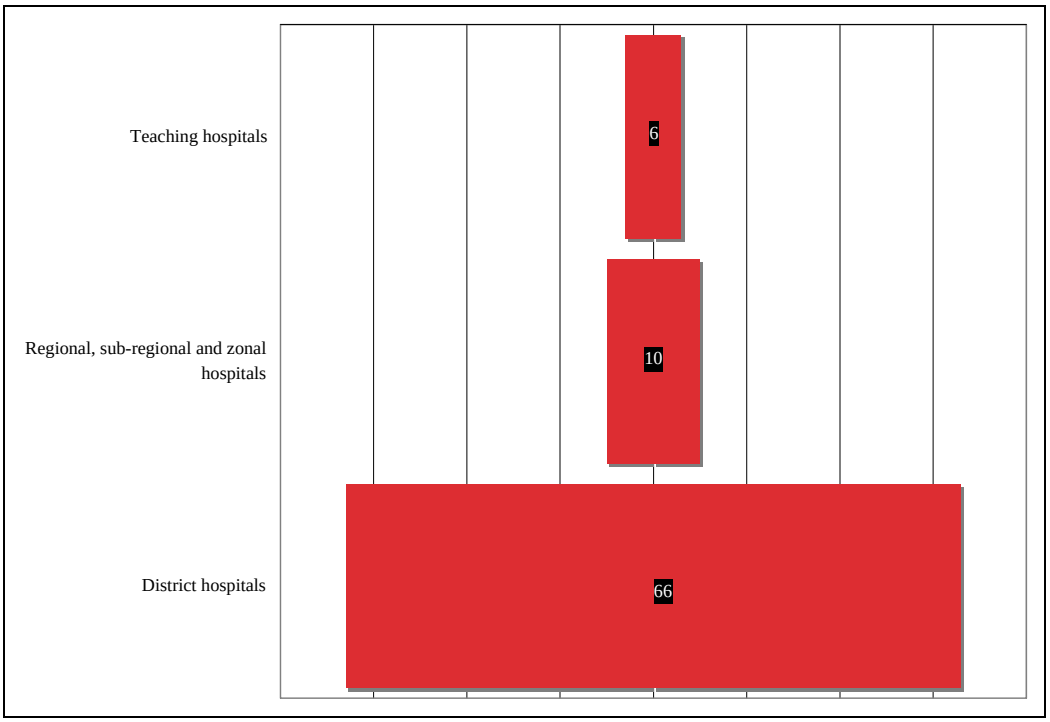
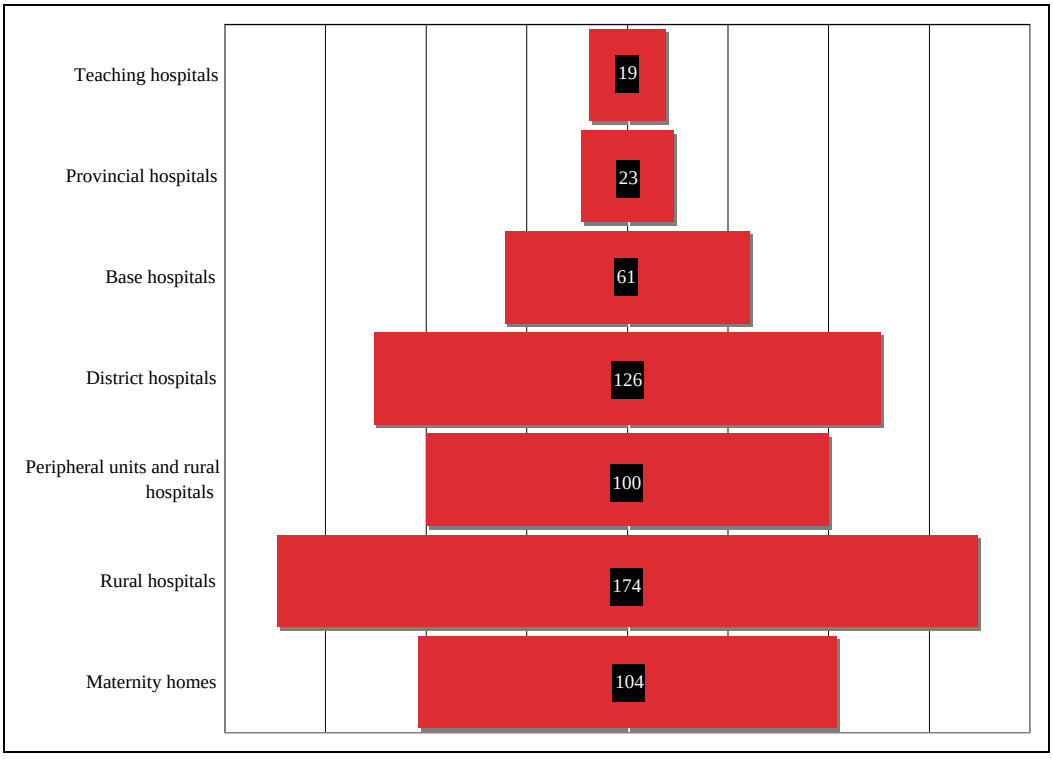


Figure 3: Numbers of facilities at different levels of hospital provision in Sri Lanka, 2003



5. ANALYTICAL FRAMEWORK

Units of analysis

Hospitals

This study is concerned with the optimal configuration of hospital infrastructure. We define hospitals to mean any fixed facility, which provides inpatient medical services, i.e., that routinely keeps patients overnight for treatment purposes. This excludes fixed healthcare facilities, which provide only outpatient services. However, it is noted that these latter facilities comprise only a small proportion of public sector facility expenditures in all three countries. It should also be noted that inpatient facilities, i.e., hospitals, provide the bulk of outpatient services delivered by the public sector in all three countries.

Standardised districts

In most developing countries, including those in South Asia, the public health sector delivery system is organised on the basis of defined and contiguous service areas outside the major urban centres. Within these areas, the population is typically served by a hierarchy of facilities, arranged in increasing order of technical sophistication and competency.

The *WHO Expert Committee on the Role of the Hospital at the First Referral Level,* which met in 1985, clarified the importance of the full involvement of hospitals in primary health care. It crystallized the concept of the district health system as a central strategy in this approach (WHO, 1987). In this traditional WHO approach to district hospital planning, a district hospital is a hospital, which acts as the primary referral level in a given area. Such hospitals can provide wide-ranging support for patient referral as well as support for various technical, administrative and educational/training activities in the area concerned, which is generally referred to a district.

Unfortunately, the term district as used by WHO is not so satisfactory for the purpose of this study for two reasons. First, the WHO ‘district’ by definition refers to a area served by one significant hospital, which is too small an area of analysis to consider the configuration of different levels of hospitals, at both primary and secondary referral levels, which is one of our concerns. Second, the term ‘district’ can itself be confusing, as it has different meanings in different national contexts. In the context in which WHO uses it, a district is essentially an area served by a district hospital, acting as the primary referral hospital, and these districts are generally considered to contain in most countries anywhere from 50,000 to 1,000,000 people. However, ‘district’ also often has a very specific meaning in the administrative and political terminology of a country, and this may not always correspond to the type of area that WHO intended.

In practice, ‘district’ is used in the three countries in different ways and does not refer to the same type of area. For instance, an administrative district in Bangladesh typically consists of nearly 1.8 million people. In smaller countries such as Nepal and Sri Lanka, the average population of what is termed a district ranges from 300,000 to 650,000.

Therefore, to aid comparative analysis, it is necessary for the purposes of this study to define a district as a common unit of spatial analysis, and one that is large enough to encompass both primary and secondary referral level facilities. This study proposes to base its analysis on what we define as a *standardised district.* This standardised district corresponds to an area, outside the major metropolitan centres of the three countries, which contains an average of 1.8 million people.

Within each of these areas, which we will henceforth term simply 'districts', all relevant primary and secondary health services are provided in a hierarchical referral structure. Tertiary referral facilities are typically not provided in these areas, unless they happen to be located around such a facility, but such tertiary services would generally be available by referral to relevant out-of-area centres. This paper is concerned with the level, pattern and structure of public hospital infrastructure in these defined service areas, and the extent to which it affects overall costs and system technical efficiency.

This standardised district concept corresponds approximately to existing administrative units, in the sense that it is roughly equivalent to a province in Sri Lanka, a zone in Nepal and, as already mentioned, a district in Bangladesh (Table 3). It is worth noting that at this level of aggregation, the population would not usually have access to tertiary care health services. The major urban centres of Dhaka and Chittagong in Bangladesh and Kathmandu in Nepal are excluded from the analysis. Also excluded is the Western Province of Sri Lanka, which contains Sri Lanka's largest city, Colombo. Excluding the major metropolitan centres allows us to focus the analysis on the pattern and structure of health services in areas where the density health facilities is less and where large tertiary centres of care are not present. Table 4 presents a summary of the overall features of the standardised districts defined in this way for each country.

Differences in the terrain between the three countries mean that on average, 1.8 million people in Nepal are likely to be spread out over a much larger, more mountainous area than the same number of people in Bangladesh and Sri Lanka. As Figure 4 shows, population density in the standardised districts chosen for this study is much lower in Nepal than in Sri Lanka and Bangladesh.

Table 3: Average population size of administrative units in the three countries

	Total population	**First sub-national level of government administration**		**Second sub-national level of government administration**	
		Type	*Population*	*Type*	*Population*
Bangladesh	146 million	Division	18.1 million	District	1.8 million
Nepal	25 million	Zone	1.7 million	District	323,000
Sri Lanka	19 million	Province	1.7 million	District	614,000

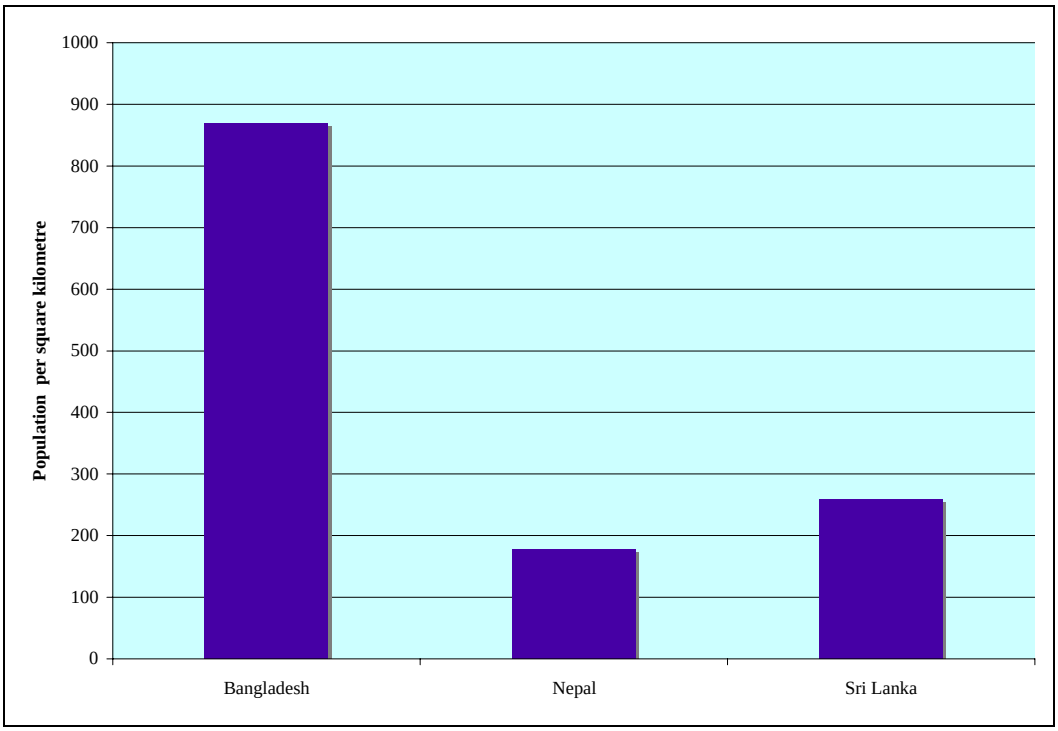
Notes: Average population numbers reported in this table exclude the following areas: Chittagong and Dhaka in Bangladesh, Kathmandu in Nepal and the Western province in Sri Lanka.

Table 4: Characteristics of the standardised districts in the three countries

	Bangladesh (2002)	Nepal (2004)	Sri Lanka (2003)
Population	1.8 million	1.8 million	1.8 million
Surface area (km^2)	2,271	10,485	7,345
Number of standardised districts	62	14	8
Number of public hospitals	8	6	64
Number of public hospital beds	380	225	5259
Number of government doctors		52	658

Note: The statistics given are mean characteristics of all defined districts considered in the analysis in the three countries.

Figure 4: Population density of standardised districts in Bangladesh, Nepal and Sri Lanka, 2005



Typology of facilities

Government health systems in South Asia, like elsewhere in the developing world, consist of a network of hospitals and facilities arranged in several tiers of increasing complexity. As described in the previous section, the top tier of hospitals in each country comprises the national tertiary care centres. Beyond the first tier, however, cross-country comparisons based on hospital labels such as district hospitals and provincial hospital become problematic. Health ministries use different labels to describe health facilities in each tier of the health care system, which do not necessarily translate to similarities in the case-mix, technical capacity and skills available at each level. For instance, district hospitals belong to the second tier in Bangladesh, the third tier in Nepal and fourth tier in Sri Lanka (Figures 1-3). Higher-

level facilities are generally larger. Bed size is not the definitive distinguishing feature between levels of facilities, however, and examples exist of facilities in which bed size runs counter to the expectation of size based on level. For the purposes of this study, it is necessary to re-classify hospitals in the three countries into comparable groups of facilities, more indicative of their function. This process of classification was done partly empirically by looking at the actual variation in facility characteristics in each country, and partly by reference to classifications that have been used the literature.

We thus develop a typology of hospitals based on the classification system used by Barnum and Kutzin (1993). This classification system corresponds to the pyramidal structure of the health services referral system, ranging from Group 1, the most technically complex to Group 4, the most basic. The groups in our classification system can be described as follows.

Group 1: Complex inpatient care facilities

Hospitals in this group have the most specialised staff and technical equipment. Clinical services provided at these hospitals are highly differentiated by function. Group 1 facilities are often, but not exclusively attached to a medical school and carry out teaching activities. Bed-size ranges from 250 to more than 2,000 beds. Hospitals referred to as central or tertiary-level hospitals generally fall into this group.

Group 2: Intermediate inpatient care facilities

With Group 1 hospitals located almost exclusively in the large cities, Group 2 hospitals represent the highest level referral facilities outside the major urban centres. Clinical services provided at Group 2 hospitals are also highly differentiated by function, but to a lesser extent that in Group 1 hospitals. Technical capacity and the availability of specialised staff are higher than in lower level hospitals, but lower compared to Group 1. Bed sizes range from 100 to 1,000. Provincial, zonal or regional hospitals may be categorised as Group 2.

Group 3: Basic inpatient care facilities

Group 3 comprises the first-level referral hospitals in most settings. The availability of skill levels within this category varies. Some entry-level hospitals may have specialists in internal medicine, obstetrics and gynaecology, paediatrics and surgery, while others may have only one or two general practitioners. Limited laboratory services are available for general but not specialised pathological services. Group 3 hospitals are often referred to as “district hospitals”.

Group 4: Very basic inpatient care facilities

This group represents the lowest level of inpatient care provision in any health system. Hospitals in this group consist largely of general medical wards, with one or more wards assigned to surgery, obstetrics and paediatrics. They are managed by one or two medical offices and have limited technical capacity. Located largely in rural areas, their primary function is to provide basic curative care services in relatively under-served areas. Group 4 hospitals have on average less than 100 beds. Hospitals

referred to as rural hospitals, peripheral units and health centres that provide some inpatient care generally fall into this category.

This typology was then empirically applied it to the available data to categorise hospitals types in Bangladesh, Nepal and Sri Lanka using this classification system. To do this we exploited the three national facility surveys already mentioned, and described in further detail in the next section.

We examined bed numbers, the availability of an operating theatre, CSSD, ICU, ECG, blood-bank, radiology unit and specialists at each hospital-level of hospital. In all three countries, there was a clear distinction between national tertiary care facilities with teaching functions and all other facilities. These were categorised as Group 1.

Hospitals with specialists on their staff and equipped with four or more of the equipments listed above were classified as Group 2. Typically, provincial hospitals in Sri Lanka, regional and zonal hospitals in Nepal and district hospitals in Bangladesh were categorised as Group 2.

Hospitals that were staffed predominantly by medical officers with a few specialists, and which reported owning less than four of the types of equipment listed above were classified as Group 3. District hospitals in Nepal and Sri Lanka and thana health complexes in Bangladesh fell into this category.

Very small hospitals with less than 100 beds, that were managed by one medical officer or by less qualified registered medical practitioners and did not have any of the above equipment were classified as Group 4. No hospitals in Bangladesh and Nepal fell into this category.

Table 5 presents the typology of hospitals and lists the types of hospitals that belong in each group in each country.

Table 5: Typology of hospitals used in study and mapping to hospital types in the three countries

Group	Description	Types of hospitals in each group		
		Bangladesh	*Nepal*	*Sri Lanka*
Group 1: Complex inpatient care facilities	National tertiary care centres, with highly specialised staff and equipment providing services highly differentiated by function. Average bed-size 250-2000.	Teaching and specialist hospitals	Teaching, specialist and national hospitals	Teaching and specialist hospitals
Group 2: Intermediate inpatient care facilities	Highest level of referral care outside the major urban centres. Less specialised than Group 1, but do have specialised and some high-tech equipment. Average bed-size 100-1000.	District and general hospitals	Regional, sub-regional and zonal hospitals	Provincial and base hospitals
Group 3: Basic inpatient care facilities	First level referral care facility. Some entry-level facilities may have specialised staff, others only general practitioners. Limited laboratory services. Bed-sizes largely variable.	Thana health complexes	District hospitals	District hospitals
Group 4: Very basic inpatient care facilities	Lowest level inpatient care facilities, containing general medical wards and staffed by general medical practitioners and nurses. Very limited technical capacity. Average bed-size less than 100.	-	-	Peripheral units, rural hospitals, maternity homes with central dispensaries

6. DATA AND METHODS

Data sources

Three data sources were used for this analysis:
(i) Facility cost surveys
(ii) Government budgetary data and health accounts
(iii) Administrative records.

Data from nationally-representative facility cost surveys were used to estimate cost ratios, patterns of capital and technology intensity at each level and for the econometric analysis of provider efficiency. In Sri Lanka and Bangladesh, data were obtained from public facility surveys carried out in 1998, which collected data on a national sample of government medical facilities (Rannan-Eliya and Somanathan, 2003; Somanathan *et al.*, 2000). Both surveys used a similar survey instrument and collected almost identical information for calendar year 1997. The Sri Lankan survey covered a sample of 210 health facilities and the Bangladesh survey, a sample of 121 facilities. For Nepal, data for the year 2000 were obtained from a public facility survey carried out in 2003 on a sample of about 20 hospitals (Nepal Health Economics Association, 2004). The instrument for this survey was also based on the earlier Bangladesh and Sri Lankan survey instruments, allowing for a high degree of comparability between the three surveys.

National health accounts were available for Bangladesh and Sri Lanka and used to extract data on national expenditures on hospital inpatient and outpatient care (Data International Ltd., 2003; Institute for Health Policy, 2006). Both countries have adopted the System of Health Accounts (SHA) framework published by the OECD (2000), which ensured the estimates were comparable and consistent. Nepal is in the process of establishing a system of health accounts, which are also compatible with SHA, but these were not yet available. In their absence, we used public expenditure reviews, which had been carried out in preparation for the Nepal NHA, and these included functional breakdowns of public sector health expenditures (Prasai *et al.*, 2004).

In each country, data were also obtained from annual health reports and other health ministry data sources on the number of hospitals and bed-sizes by type of hospital for each district and province/zone. We also collected detailed data on levels of remuneration for hospital staff by type of hospital.

Methods

The analysis undertaken in this study is essentially novel, as no similar analysis has been published in the literature to our knowledge. Therefore, it uses a mix of techniques to address the issue of efficiency, which have not been used in combination before. Briefly, these are previewed in this section.

Profiling the hospital infrastructure in a standardised district

To our knowledge, there has not been any prior analysis of this nature reported in the literature, so the dimensions of the profiling had to be determined during the course of

the study. The list of critical aspects needed to profile the hospital infrastructure in each country includes the relative distribution and activity of facilities by level and the pattern of capital, technology and human resource intensity at each level and the scale of facilities.

In order to create the profiles of a standardised district, the facility survey data were combined with administrative data to characterise the facility features and parameters in a standardized district. This was done by using the administrative data to first estimate the number of facilities of each type that exist in the average standardized district outside the identified metropolitan urban centres. So for example, if there 20 type X hospitals outside the major metropolitan areas in a country, where the non-metropolitan population was equal to 18 million, then the mean number of type X facilities per standardised district is computed as 2.0. The facility survey data were then examined to estimate the mean characteristics of each of these facilities, and the overall numbers of particular inputs, for example doctors, was obtained by multiplying the mean number per facility in a given facility category by the number of facilities in that category estimated to exist in the standardised district.

Measuring productivity

Although some previous studies have been done of productivity using the datasets from Bangladesh and Sri Lanka, these were not strictly comparable owing to differences in methods. Therefore, for the purpose of this study, these analyses were reworked to ensure strict comparability in key productivity and cost ratio indicators. In addition, we used an identically-specified modelling approach (production functions), and marginal products were estimated for all three countries and used to analyse whether facilities were operating at economies of scale.

Explaining differences in system costs and productivity

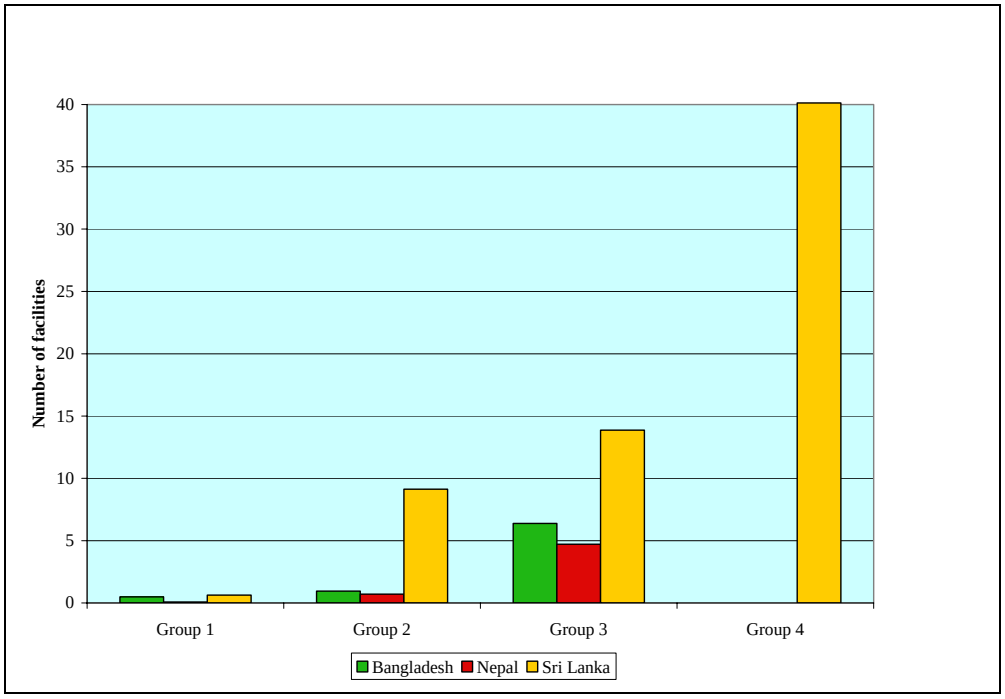
By combining the information on infrastructure patterns, costs and productivity, the study explores to what extent the known differences in system efficiency in the three countries can be explained by different choices made in the deployment of public hospital infrastructure.

7. CONFIGURATION OF THE PUBLIC HOSPITAL INFRASTRUCTURE

Distribution of fixed points

We begin by examining the number of hospitals available at each level of care in a standardised district, defined as an area of 1.8 million people living outside the major urban centres in each country. For each of the groups of facilities, we estimated the share of total hospitals in the country that can be attributed to a district using administrative data for 2005, and then computed the mean number of such facilities in these standardized areas. The representative distribution of fixed points in each country is presented in Figure 5.

Figure 5: Number of fixed healthcare delivery points available to the population in a standardised district, 2005



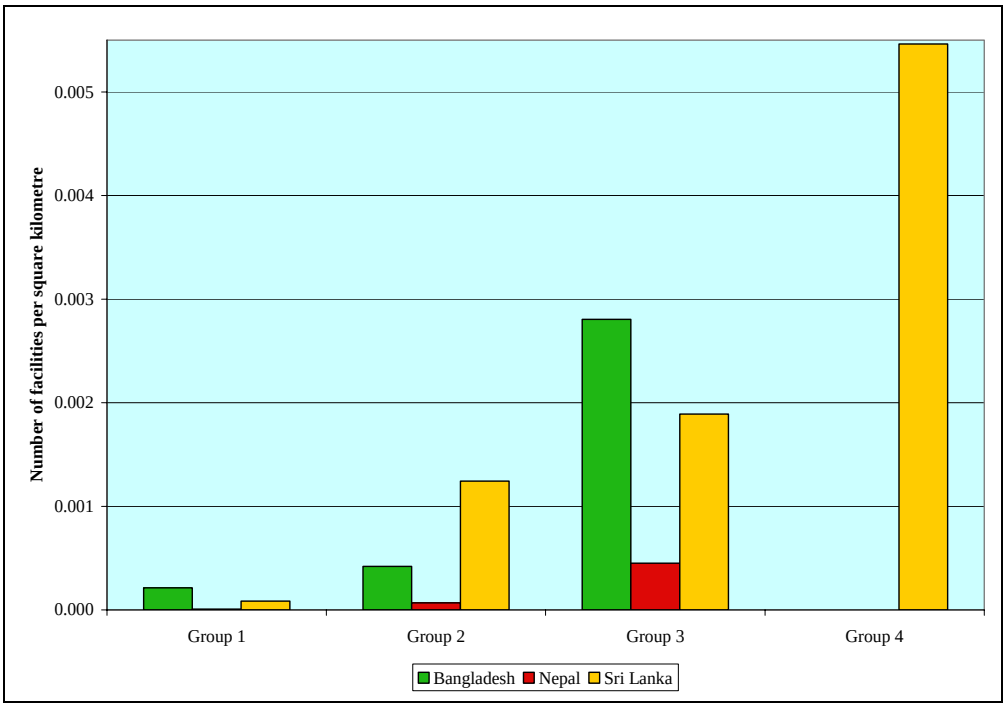
The availability of Group 1 hospitals at the district level is relatively low (less than one hospital per district) in all three countries. This is not surprising, given the exclusion of the major cities from the analysis, and since we defined a standardized district as being an area up to, but not necessarily including, tertiary level facilities.

The distribution of fixed points in Groups 2 and 3 is significantly greater in Sri Lanka compared to Bangladesh and Nepal. In Sri Lanka, an area of population that we have defined as a standardised district would have available nine Group 2 facilities, usually consisting of one provincial hospital, two or three large base hospitals and five or six smaller base hospitals. By contrast, an equivalent district in Bangladesh or Nepal has less than one Group 2 facility available. In Bangladesh, this would be a district or general hospital and in Nepal, a zonal or regional hospital. As noted earlier, Group 2 hospitals are the highest level of inpatient care available to populations living outside the big cities, typically providing five or more clinical specialties and access to

specialists. The existence of a large number of such facilities at the district level in Sri Lanka is therefore quite significant. A Bangladeshi district has six basic inpatient care (Group 3) hospitals on average, less than half the number available to a comparable area of population in Sri Lanka. Comparable population groups in Nepal have even fewer Group 3 facilities available in their area. In Bangladesh and Nepal, Group 3 represents the first level of referral in most areas, unlike in Sri Lanka where a fourth tier of basic inpatient care facilities (Group 4) exists. These results imply that a typical district in Sri Lanka has a larger number of both low-level and complex inpatient care facilities available than an equivalent area of population in Bangladesh or Nepal.

A somewhat different picture emerges once the physical size of districts is taken into account. Figure 6 shows the average number of facilities per square kilometre in a standardised district in each country. A district in Nepal has the least number of facilities per square kilometre, at each level of care. Bangladesh has a relatively higher number of Group 1 and Group 3 facilities per square kilometre of a typical district than Sri Lanka or Nepal. Sri Lanka has the highest number of Group 2 facilities per square area. In addition, Sri Lanka has a high density of very low level (Group 4) facilities. The main explanation for the reversal in rankings of Bangladesh and Sri Lanka compared with before is that rural areas in Bangladesh are much more densely populated than in Sri Lanka. Thus although the ratio of fixed Group 2 and 3 facilities to population is lower in Bangladesh than Sri Lanka, the higher population density means that more people are closely located to such facilities in Bangladesh than Sri Lanka. However, the much lower population density in Nepal than either country confers no compensating advantage.

Figure 6: Average number of facilities per square kilometre in a standardised district, 2005

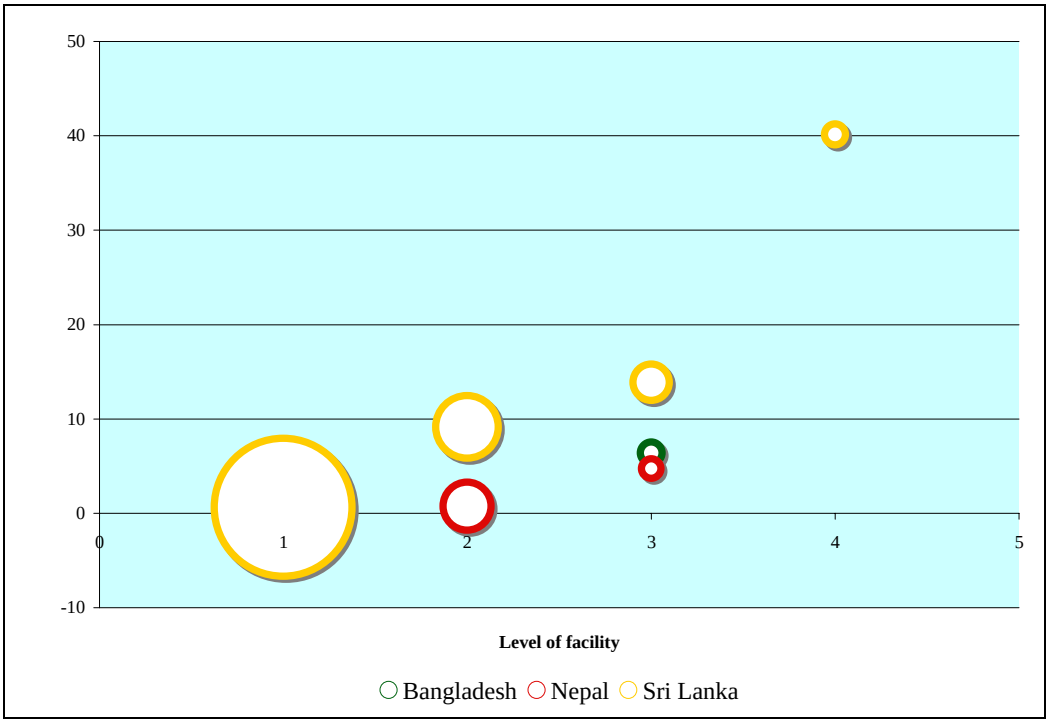


These findings imply that the density of facilities at the lowest levels of care are considerably higher in Sri Lanka, but that those of mid-level facilities is similar in Bangladesh and Sri Lanka. High facility density may be associated with greater access to care because it reduces the physical distance between people and facilities. In Nepal, where access to health care is already curtailed by the mountainous terrain, low facility density further impedes access.

Distribution of the size of fixed points

The average size of facilities at each level of care varies across the three countries . Figure 7 plots the average number of facilities available in a standardised district at each level and their bed-sizes, with the size of each circle representing the mean bed capacity of those hospitals. The chart confirms the findings of the previous section that a standardised Sri Lankan district has more facilities at levels 2 and 3 than equivalent districts in Bangladesh or Nepal, so the points for Sri Lanka all lie above those for the other countries. However, it also shows that at each level of care, Sri Lankan hospitals have more beds on average than hospitals in Bangladesh or Nepal. The average bed-size of a Group 4 (very basic inpatient care) hospital in Sri Lanka is comparable to that of a Group 3 hospital in the other two countries.

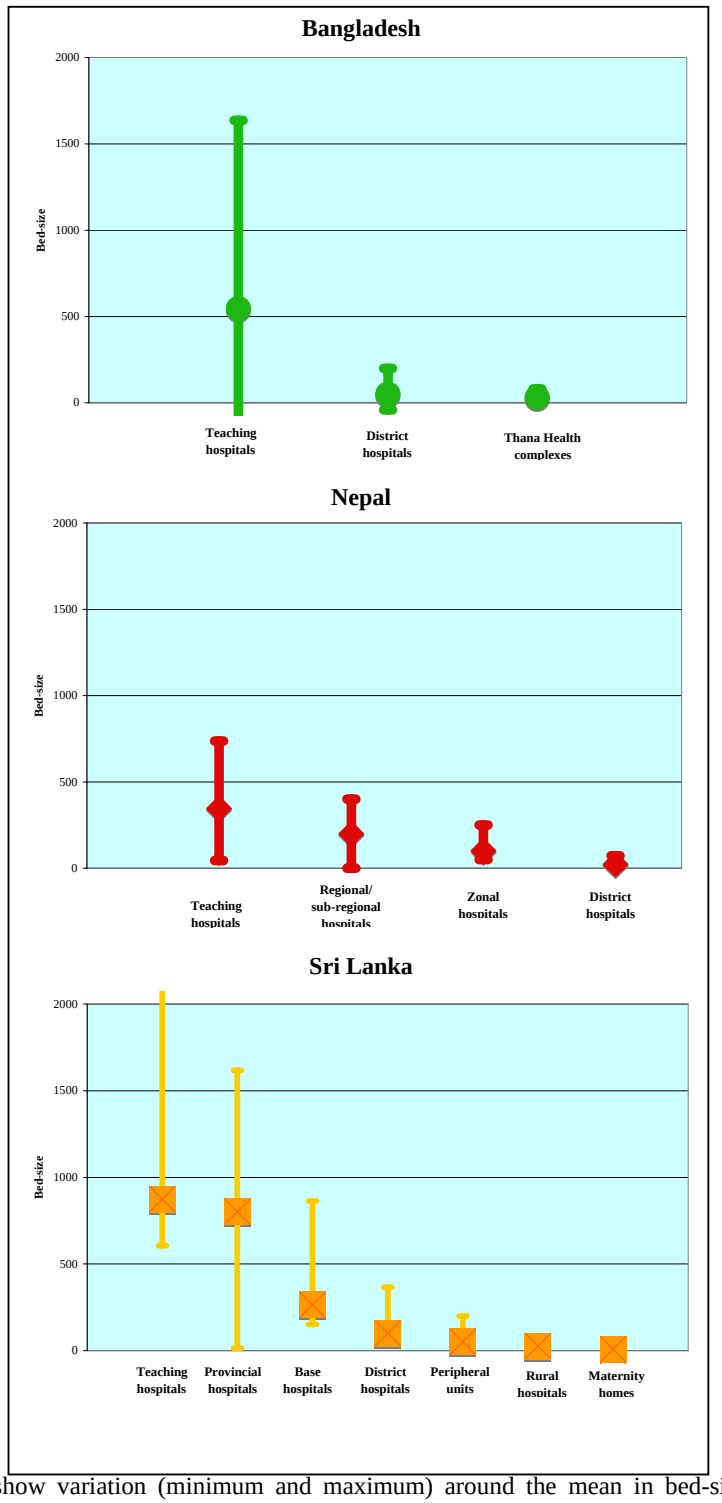
Figure 7: Distribution of facilities by bed-size of facility in a standardised district, 2005



An important distinguishing feature of the hospital infrastructure in Sri Lanka is the large range in bed-sizes between the lowest and highest levels of care. Figure 8 shows the variation around the mean in bed-sizes for different levels of facilities in the three countries. The largest hospital in Sri Lanka, the National Hospital has over 5,000 beds, while the smallest maternity homes have less than ten beds. In between these two levels are several tiers of hospitals with large variation in bed-capacity at each

level of care. This is in part a reflection of the fact that the Sri Lanka health system evolved in response to the populations demand for health services. In Bangladesh and Nepal by contrast, facilities were often built according to administrative norms regarding the level of facility and its bed size. The result was a system where the distribution of both beds and facilities is relatively “lumpy” compared to Sri Lanka.

Figure 8: Variation in bed-sizes in Bangladesh, Nepal and Sri Lanka



Notes: Charts show variation (minimum and maximum) around the mean in bed-sizes by type of facility in a standardised district in each country

Comparison of facility resources

Equipment

Next, we examine the availability and distribution of inputs across the four levels of facilities using data from the public facility surveys carried out in 1997 in Bangladesh and Sri Lanka and in 2003 in Nepal. Figures 9-12 show the percentage of facilities at each level that have available a functioning X-ray unit, operating theatre (OT), central sterile supplies division (CSSD), intensive care unit (ICU), electro-cardiogram (ECG) or bloodbank.

A relatively high proportion of Group 1 facilities have almost all of the equipment and facilities we examined. In Nepal, the availability of these key facilities and equipment is universal across all Group 1 facilities. The same is true of Bangladesh, with the exception of ICU's, which are not available in all Group 1 facilities. In Sri Lanka however, 10-15% of Group 1 facilities do not have all of the equipment examined. A partial explanation for this is that most Group 1 facilities in Sri Lanka tend to be concentrated in the same area, allowing them to share certain facilities and equipment. For instance, the highest level maternity care hospital in the country shares a blood-bank with the national hospital located adjacent to it.

Below Group 1, the lower level of availability of these equipment in Sri Lankan facilities presents a sharp contrast to that in Bangladesh and Nepal. Intermediate inpatient care (Group 2) and basic inpatient care (Group 3) hospitals in Nepal and Bangladesh almost all have functioning X-ray machines and operating theatres. In Sri Lanka, only 50% of Group 2 facilities and 10% of Group 3 facilities have a radiology unit. This is not surprising, as equipment norms set by the Sri Lankan Ministry of Health in fact specify x-ray machines only for hospitals above the level of a district hospital. Similarly, operating theatres are only available in 80% of Group 2 facilities and 35% of Group 3 facilities in Sri Lanka. In addition, all Group 2 and nearly 60% of Group 3 facilities in Nepal have a CSSD, which is possessed by less than 50% of comparable hospitals in Bangladesh and Sri Lanka. An exception to this pattern of availability is the ECG, which is possessed by a fairly high proportion of Group 2 and 3 facilities in Sri Lanka, relative to Nepal and Bangladesh.

Figure 9: Percentage of Group 1 hospitals with key facilities and equipment

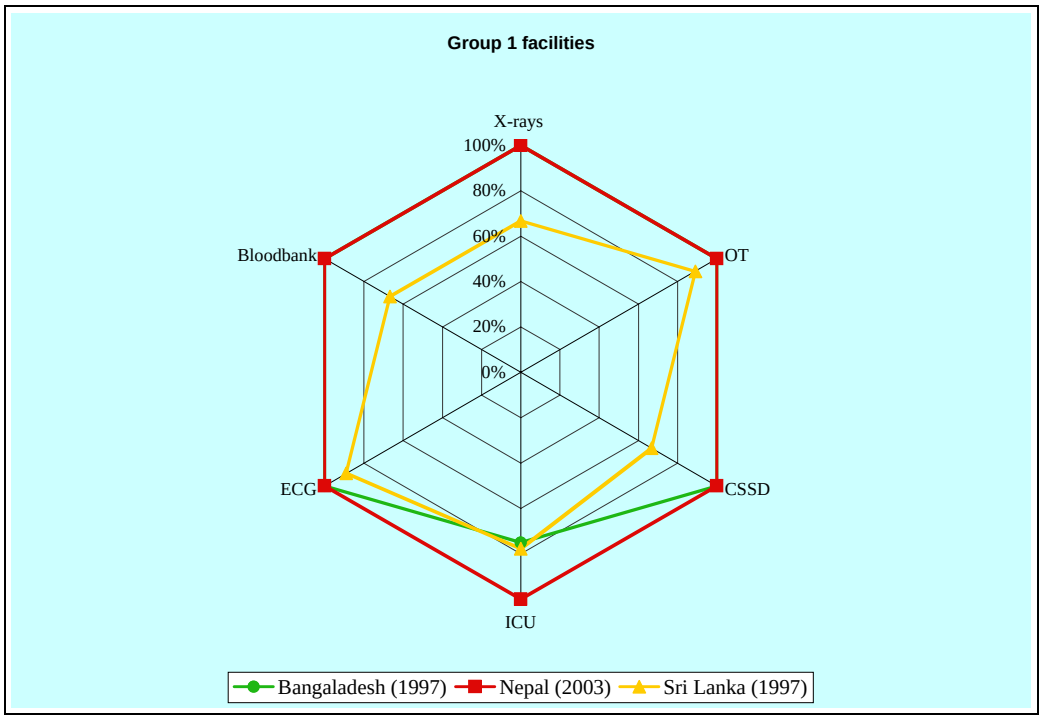


Figure 10: Percentage of Group 2 hospitals with key facilities and equipment

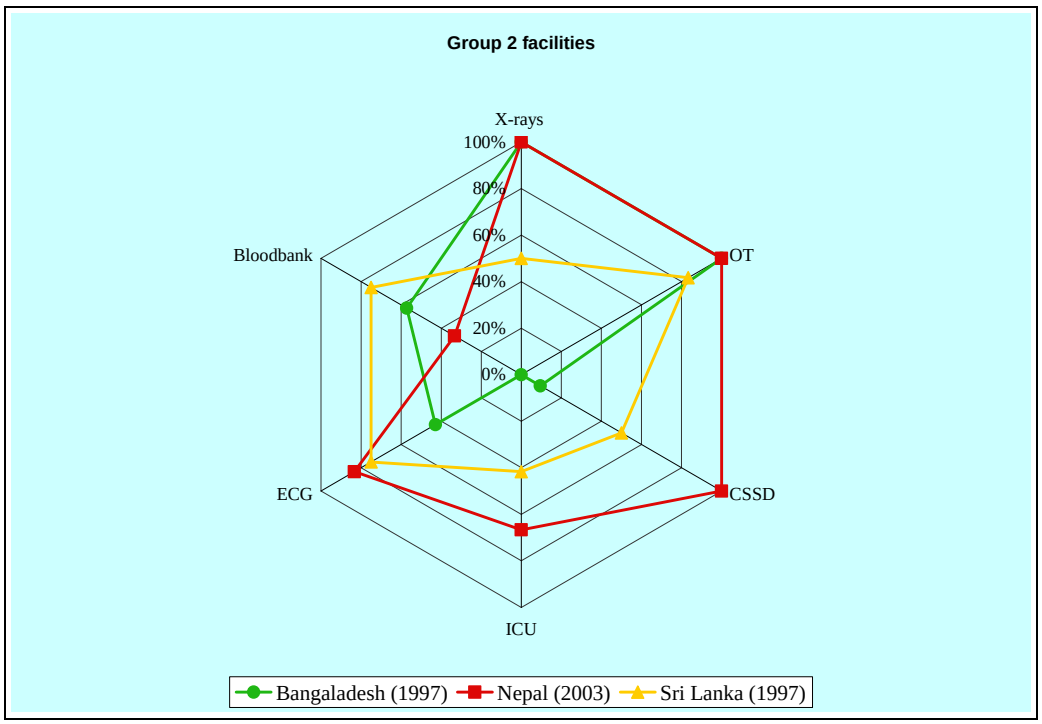


Figure 11: Percentage of Group 3 hospitals with key facilities and equipment

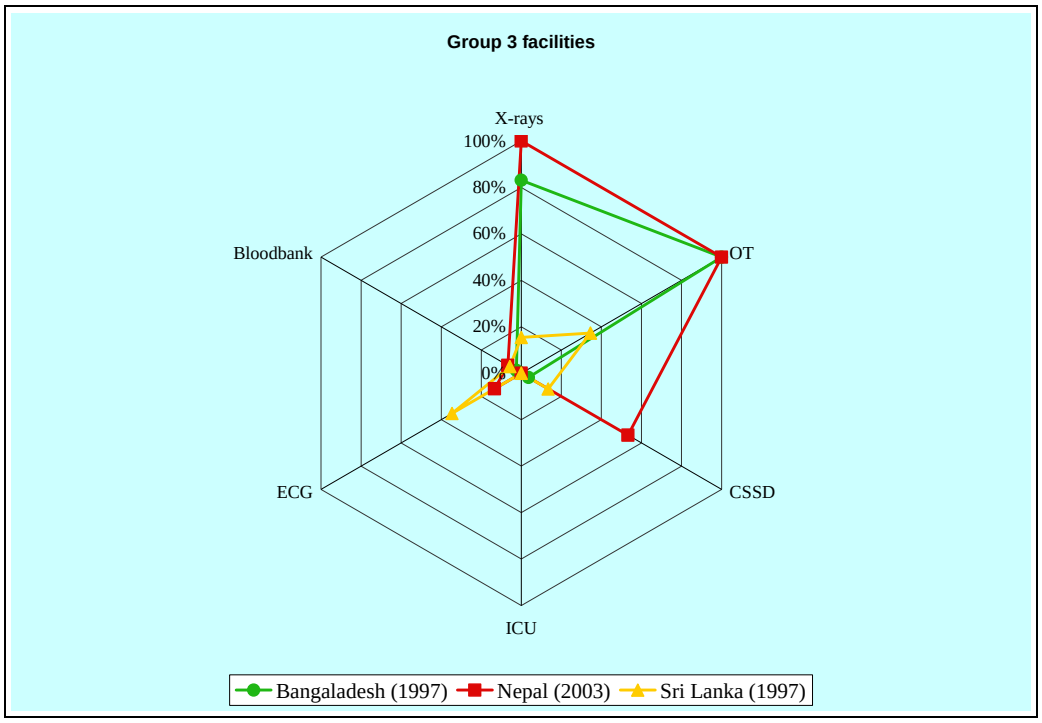
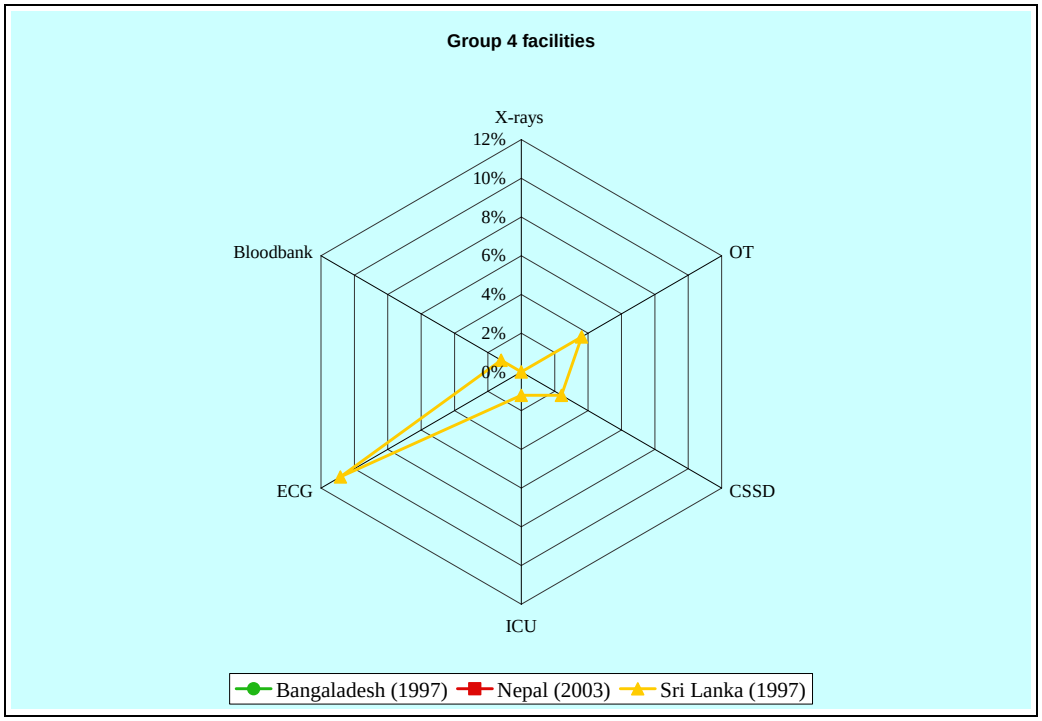


Figure 12: Percentage of Group 4 hospitals with key facilities and equipment



Human resources

To examine how labour intensive health facilities are in each country, we looked at the average numbers of doctors, nurses and other staff at each type of hospital, normalised with respect to the bed-size of the hospital (Figures 13-15). Public facility survey data from the three countries were used for this analysis.

Figure 13 reveals two distinct patterns. In Nepal and Sri Lanka, the doctor-bed ratio increases with level of sophistication of hospitals, but in Bangladesh lower-level facilities have more doctors per bed than higher-level facilities. Figure 13 also shows that Group 1 and 2 hospitals in Nepal tend to have a higher number of doctors relative to beds than comparable hospitals in Bangladesh. Sri Lankan Group 1 and 2 hospitals are also more doctor-intensive than their Bangladeshi counterparts. By contrast, Group 3 hospitals in Bangladesh, the thana health complexes have a greater number of doctors relative to beds than comparable facilities in either Nepal and Sri Lanka.

Figure 13: Average number of doctors per bed at each facility level

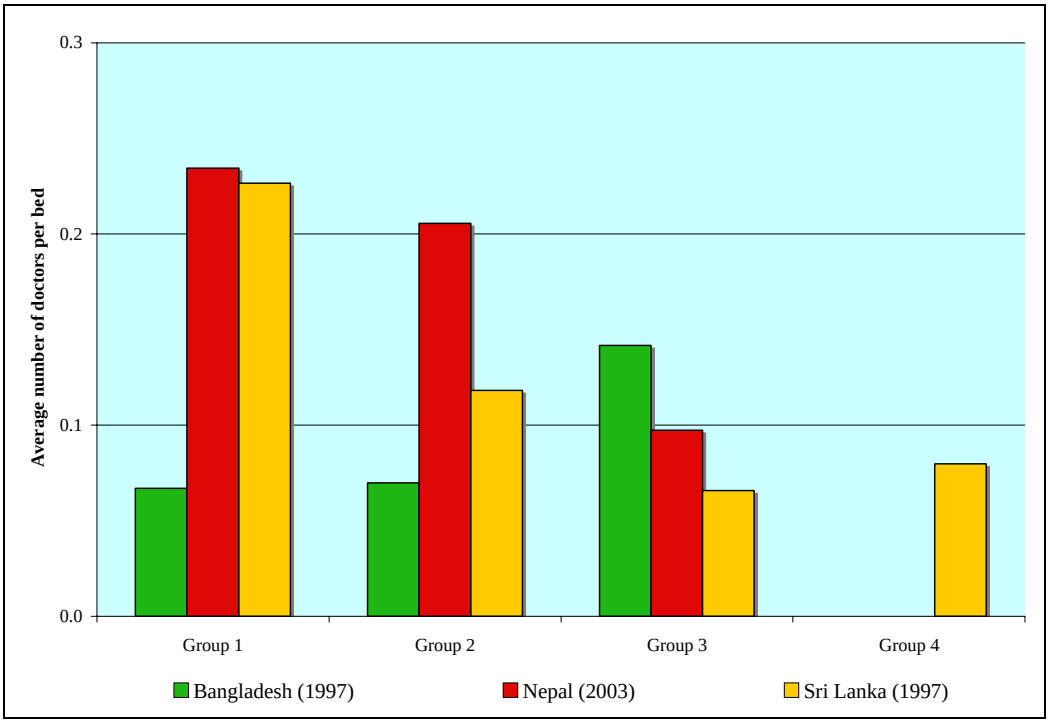


Figure 14 describes the nurse-intensity of hospitals in each of the three countries. Unlike with doctors, the average number of nurses relative to beds is comparable in all three countries at lower levels, although Nepal has fewer nurses at each level. With regard to other staff, including paramedical, administrative and non-professional staff, Sri Lankan facilities are less labour intensive than similar facilities in Bangladesh and Nepal (Figure 15).

Figure 14: Average number of nurses per bed at each facility level

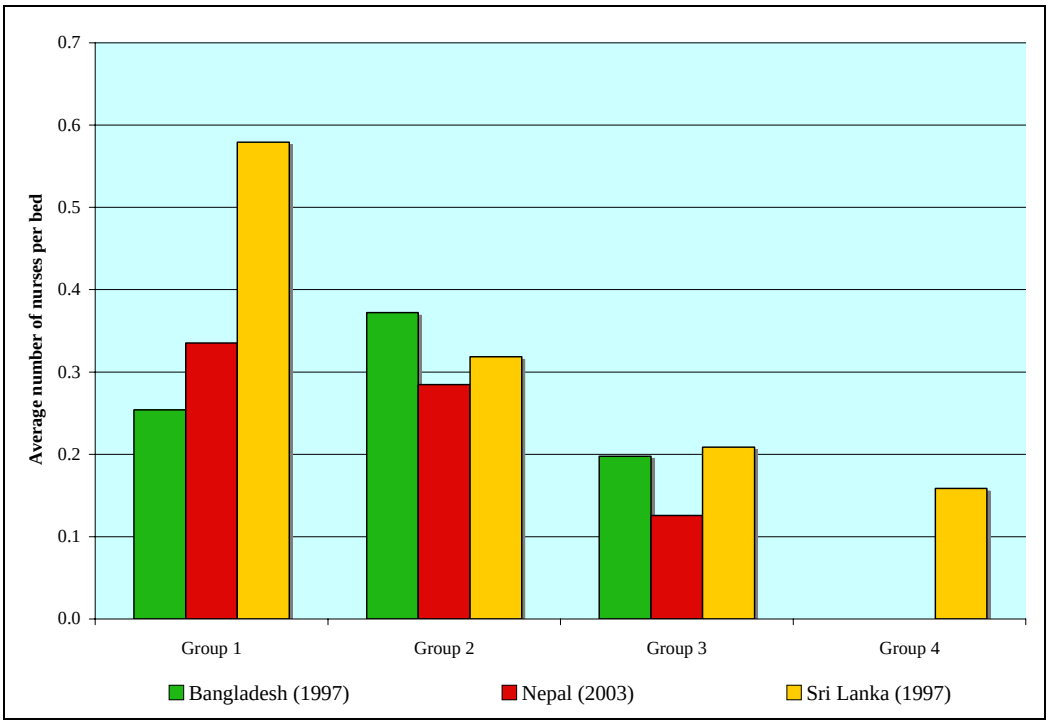
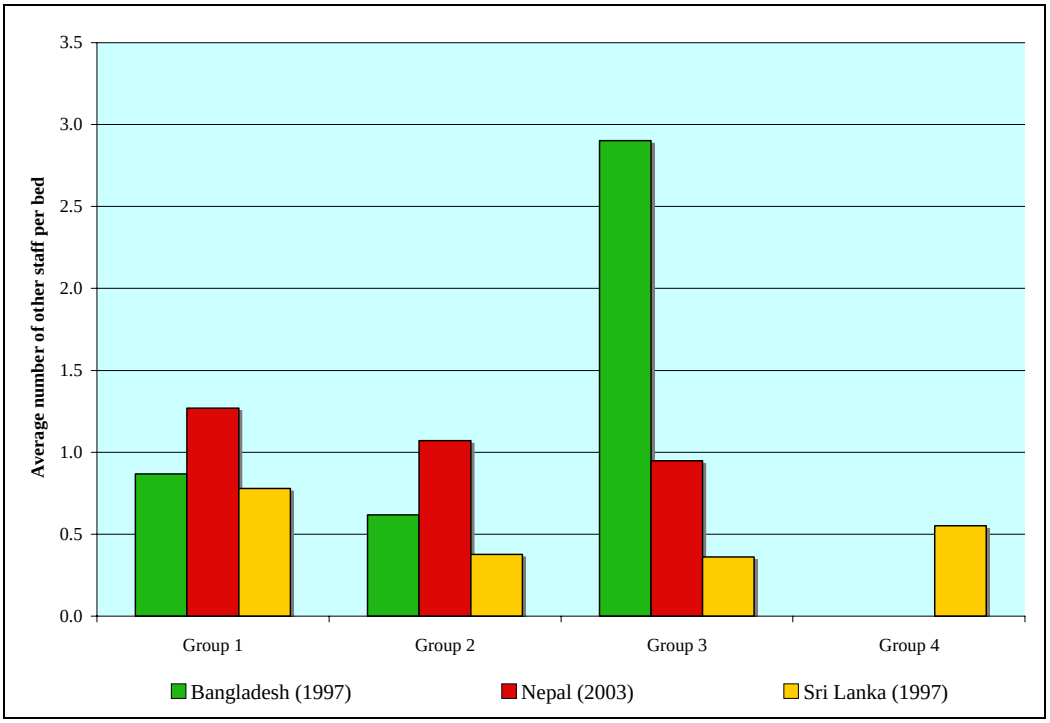


Figure 15: Average number of other staff per bed at each facility level



9. HOSPITAL EXPENDITURES AT THE DISTRICT LEVEL

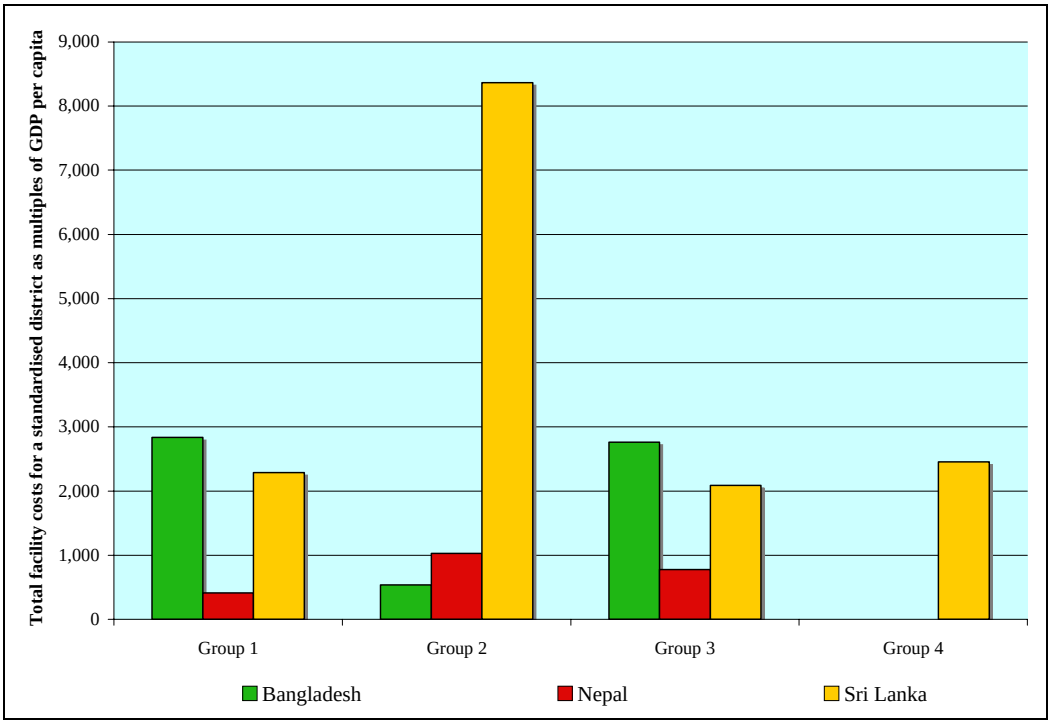
In this section, we examine the level and composition of hospital expenditures in a standardised district by type of hospital. The standardised district corresponds to an area containing 1.8 million people.

Overall hospital expenditures vary between the three countries. Government hospital expenditures as a share of GDP in a standardised district were equivalent to 0.35% in Bangladesh, 0.13% in Nepal and 0.90% in Sri Lanka in 2005.

Expenditures at each facility level

Analysis of the public facility survey data provided estimates of mean recurrent costs at each type of hospital in each of the three countries. This was multiplied by the number of facilities of each type that were available in a standardised district to estimate total facility costs for a district (Figure 16). Expenditures were normalised with respect to GDP per capita for comparison across countries.

Figure 16: Total public facility expenditures at each facility level (multiples of GDP per capita)

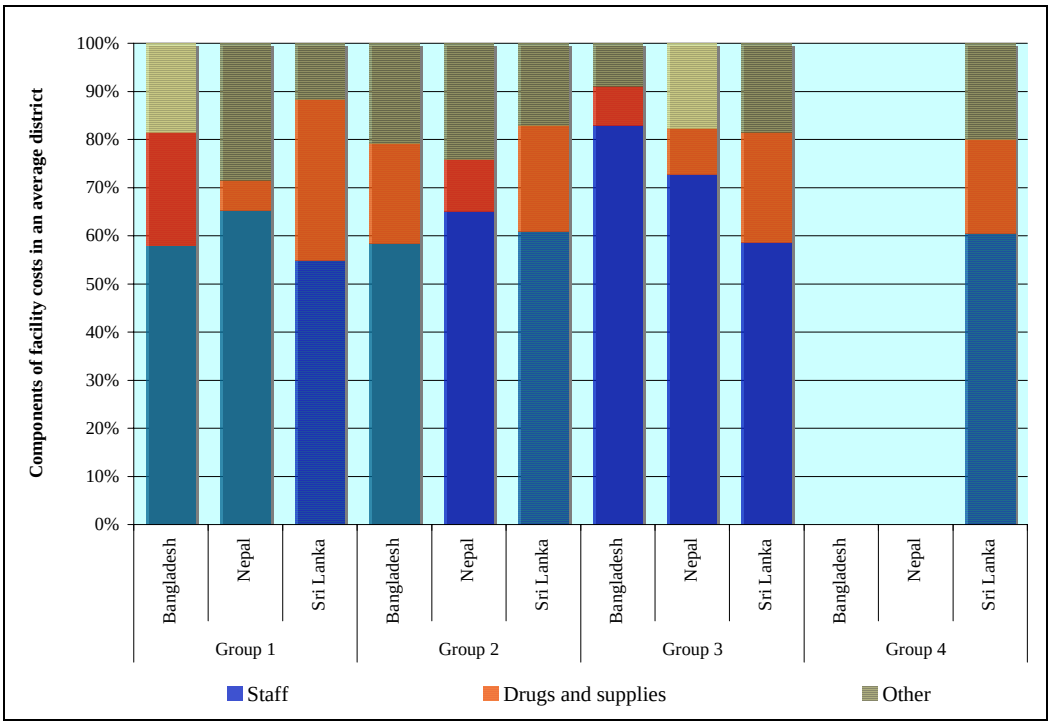


Total facility expenditures in a standardised district at the intermediate hospital level are considerably higher in Sri Lanka than in Bangladesh or Nepal. Expenditures on Group 3 hospitals are higher in Bangladesh than Sri Lanka. However, once Group 4, the lowest level of care, which exists only in Sri Lanka is taken into account, total spending on hospital beds in an average district is found to be substantially higher in Sri Lanka for lower levels as well as higher levels of care.

Components of hospital expenditures

Facility survey estimates of mean expenditures in each facility on personnel, drugs, supplies and other costs were multiplied by the number of beds in an average district in order to calculate expenditures by type of inputs at each facility level in each district. These were used to estimate the share of total district level spending attributable to staff, drugs and supplies and other inputs into hospital care (Figure 17). The category "other costs" include hotel costs such as food and laundry, as well as overhead costs.

Figure 17: Composition of hospital expenditures at each facility level, 2005



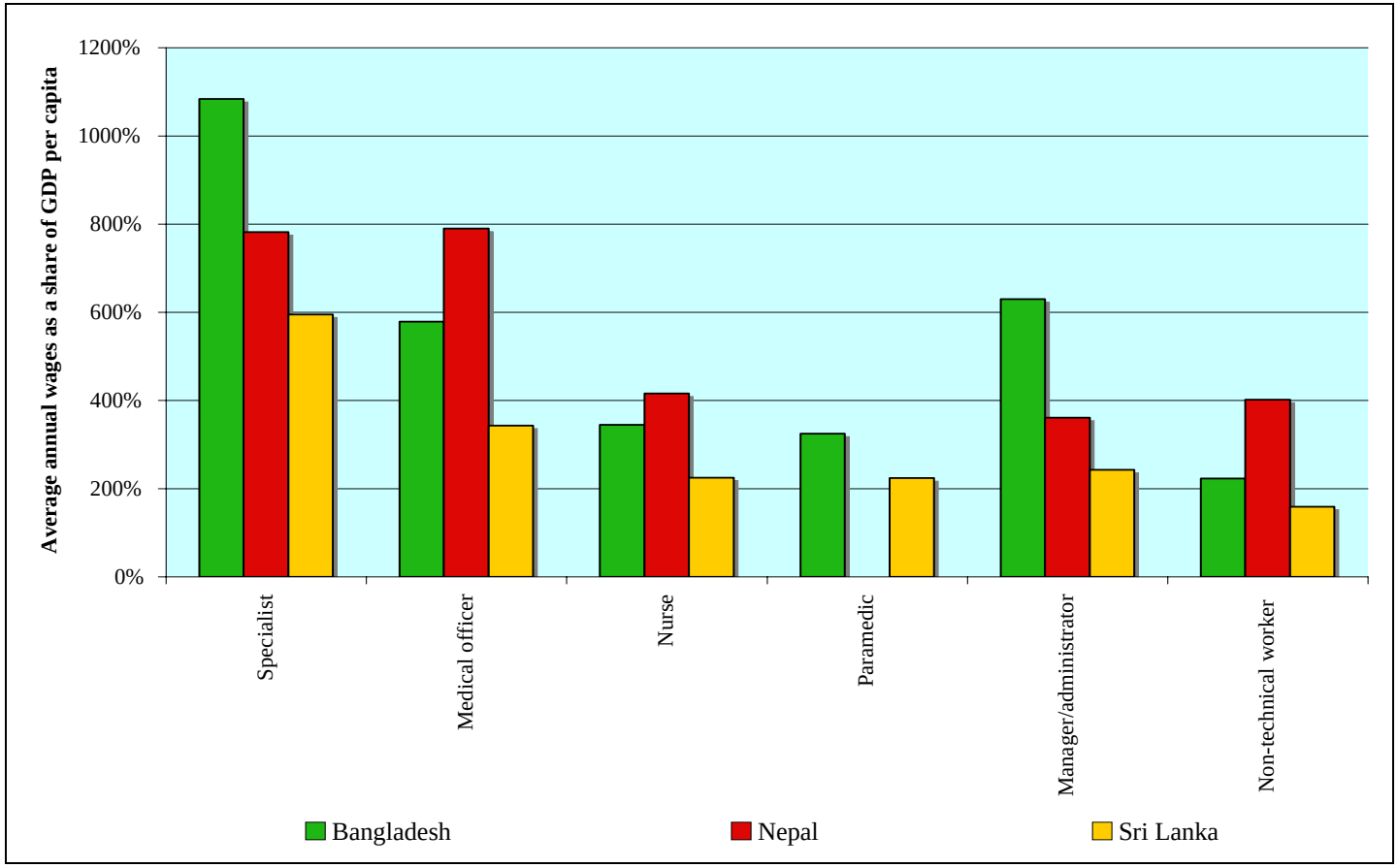
Several key points emerge from Figure 17. At all levels of care, Nepalese hospitals spend proportionately less than the other two countries on drugs and supplies than on personnel. A larger share of spending on staff is associated with higher labour intensity, in particular doctor intensity, shown earlier for Nepal. Intermediate and basic inpatient care hospitals (Groups 2 and 3) in Sri Lanka allocate a smaller share of their budget to personnel, spending considerably more on drugs and supplies than their counterparts in Bangladesh and Nepal. For instance, personnel and drugs account for 45% and 28% of total spending on Group 3 hospitals in an average Sri Lankan district, compared to 87% and 5% for similar hospitals in a Bangladeshi district. The previous section showed that Sri Lankan hospitals were less labour intensive than those in Bangladesh and Nepal. The expenditure shares presented in Figure 17 confirm that the input mix is indeed different in Sri Lanka relative to the other two countries, with Sri Lankan hospitals spending relatively more on drugs and supplies than on personnel.

Wage levels

Lower unit costs of inputs provide a further explanation why Sri Lanka is able to spend proportionately less on staff than Bangladesh or Nepal. Figure 18 presents average annual wages in the public sector in the three countries, expressed as a ratio in relation to per capita GDP. Annual wages include both salaries and allowances. The average annual earnings adjusted for per capita GDP differences of a specialist in Sri Lanka are 55% that of a specialist in Bangladesh and 76% that of a specialist in Nepal. A medical officer in Bangladesh or Nepal earns roughly twice as much as a Sri Lankan medical officer in a year. Nurses in Sri Lanka earn 55-65% of what their counterparts in Bangladesh and Nepal receive in a year. Even taking into account pension benefits, which are slightly more generous in Sri Lanka than in the other two countries, remuneration for doctors and nurses is considerably lower in Sri Lanka.

Other staff including administrators, managers and non-technical workers in Sri Lanka earn half as much as similar hospital employees in Nepal and Bangladesh. It was shown earlier that hospitals in Bangladesh and Nepal tend to be quite labour intensive with regard to administrative, managerial and non-technical staff. Relative wage differences of these other staff further explain the relatively low share of personnel spending in Sri Lanka.

Figure 18: Average annual wages of hospital staff as a multiple of GDP per capita



Explaining relative differences in spending levels

Hospital expenditures at the district level in Sri Lanka are significantly higher than in similar areas in Bangladesh or Nepal. Two potential explanations for this have already been examined. Figure 7 showed that health facilities in Sri Lanka have a larger number of beds than comparable facilities in Bangladesh or Nepal. It was also shown that an average district in Sri Lanka has over twice as many Group 1 and 3 hospitals and nearly ten times as many Group 2 facilities than a similar area of population in Bangladesh or Nepal (Figure 5). Sri Lanka also operates an additional level of facilities (Group 4), which is not found in the other two countries. In short, hospital spending at the district level is higher in Sri Lanka because an average Sri Lankan district has more hospitals, and these hospitals are larger relative to the provision of hospitals in Bangladeshi and Nepali districts. However, at the same time, expenditure levels in Sri Lanka are less than what might be expected, since wage levels of staff appear to be lower.

Differences in output levels

Higher expenditure levels in Sri Lanka relative to Bangladesh and Nepal correspond to higher levels of output. We estimate the number of admissions and outpatient visits per thousand population in a district by multiplying facility survey estimates of mean annual utilisation by the average number of hospitals available at the district level in 2005. This is then divided by the average population size of a district in each country. Figure 19 presents the admissions rate at the district level, by type of hospital. Admission rates for intermediate and basic inpatient care in Sri Lanka are 10-40 times greater than in Bangladesh or Nepal. Figure 20 shows similar differentials in outpatient utilisation rates at the district level. When the lowest level of care in Sri Lanka, Group 4, is also taken into account, it is clear that district level utilisation rates for both inpatient and outpatient care in Sri Lanka are far in excess of those in Bangladesh and Nepal. These findings are not inconsistent with more general evidence that shows that Sri Lankans make frequent and early use of medical services. Overall utilisation rates of modern medical treatment are high, with 4.5 physician contacts per capita annually, and an inpatient admission rate of 20 percent per annum.

Figure 19: Hospital admissions at each facility level

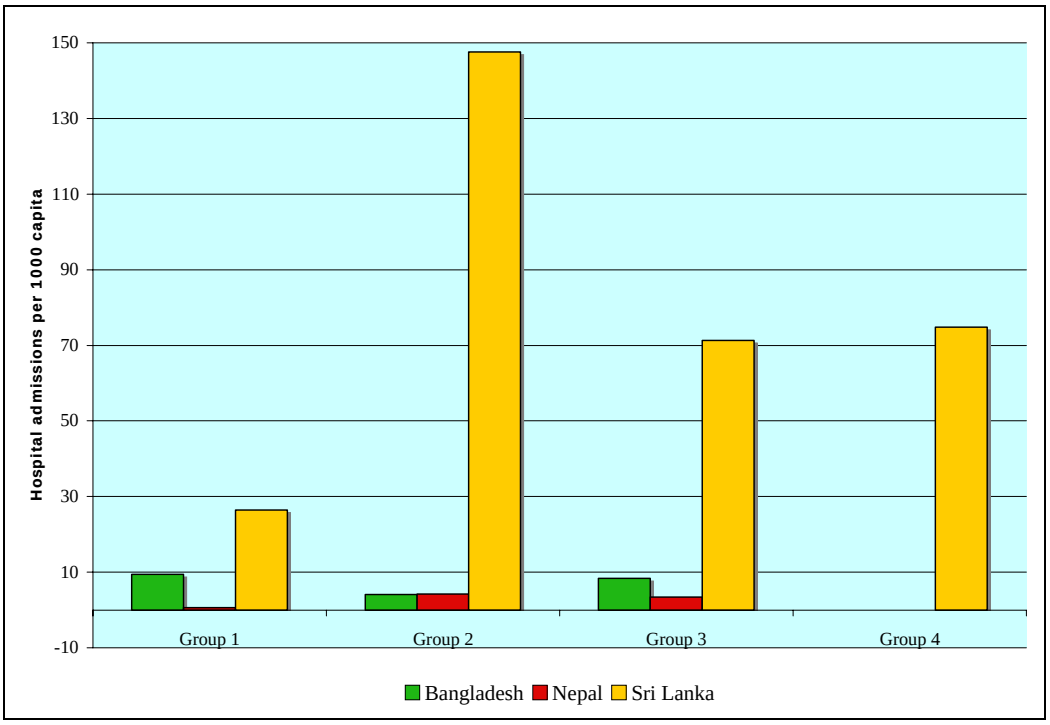
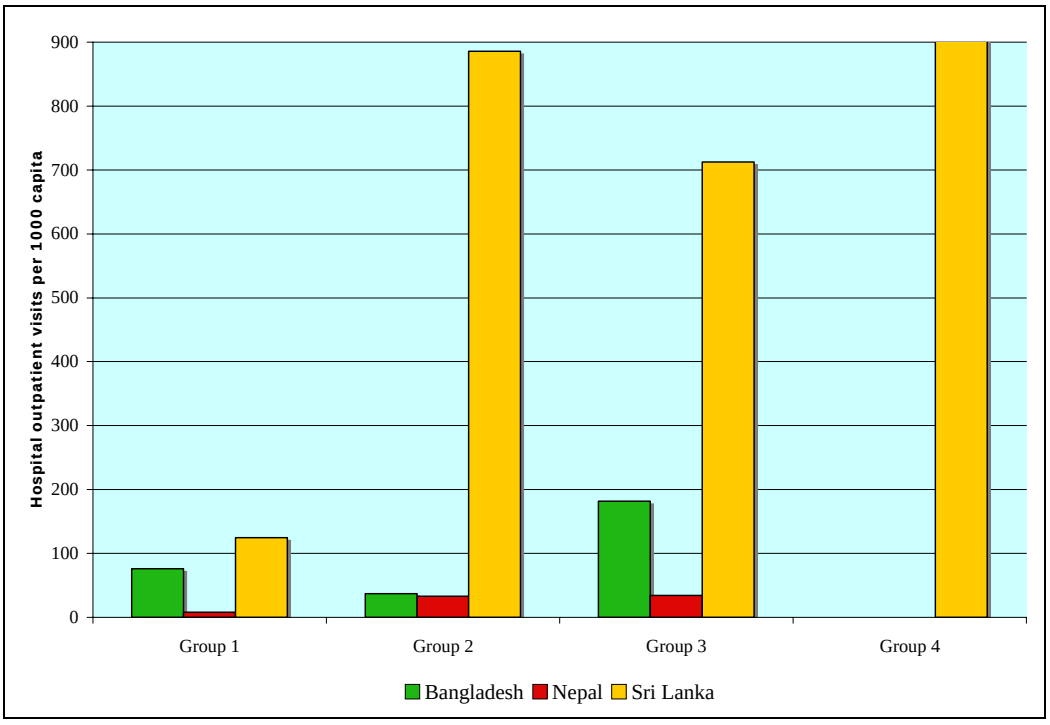


Figure 20: Hospital outpatient visits at each facility level

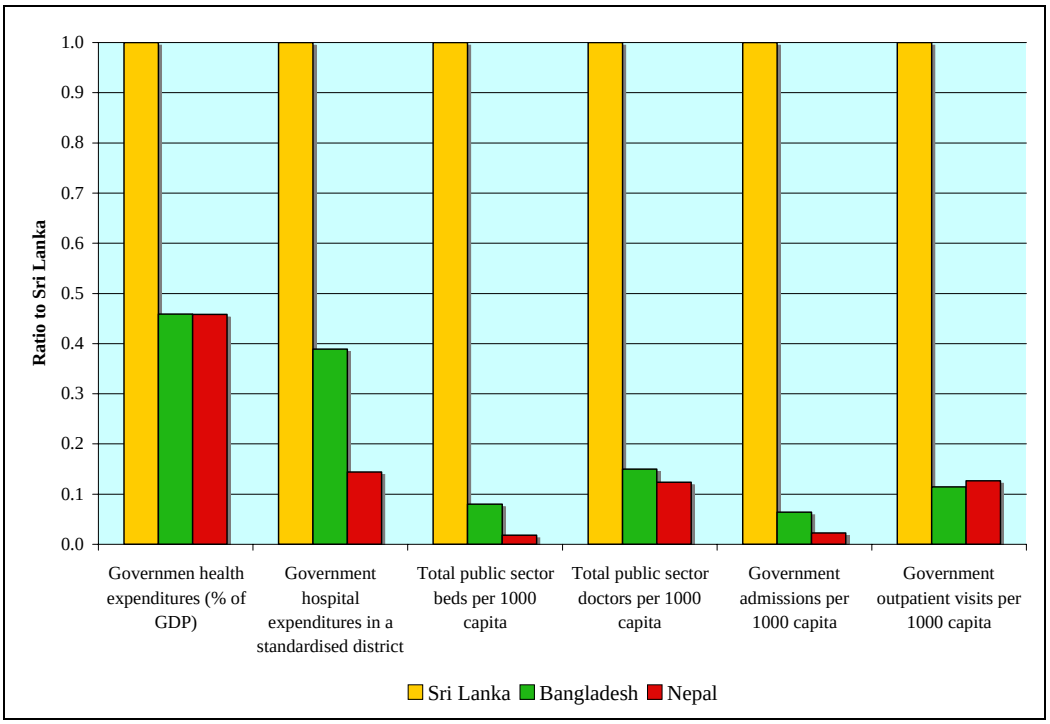


10. THE PRODUCTIVITY GAP

The results presented in the previous sections show that district-level public hospital infrastructure is much more extensive in Sri Lanka than in Bangladesh or Nepal. Levels of service provision and hospital spending are also significantly higher in Sri Lanka. The question arises as to whether the spending differentials between Sri Lanka and the other two countries are proportional to the differentials in service provision, or whether Sri Lanka achieves more output for each additional unit of spending.

Levels of service provision and curative care spending in Bangladesh and Nepal are presented as ratios to the levels in Sri Lanka in Figure 21. Statistics in this chart reflect the entire country, including health facilities in major urban centres. Sri Lanka achieves a level of services provision ten to fifty times greater than in the other two countries, while spending only twice as much as a share of GDP. Public sector beds per thousand population in Sri Lanka is fifteen times that of Bangladesh and nearly sixty times that of Nepal. Inpatient utilisation rates are 20-45 times higher in Sri Lanka than in the other two countries. The relative gap between spending differentials on the one hand and differentials in service provision on the other is particularly striking for Sri Lanka and Nepal. Government curative care spending in Nepal is approximately half of what the public sector in Sri Lanka spends. Yet, service provision in Nepal is only 5-10% of that in Sri Lanka.

Figure 21: A comparison of key expenditure, infrastructure and output indicators for Bangladesh, Nepal and Sri Lanka, 2000-2005



Sources: Data International {, 2003 #18}, Institute for Health Policy {, 2006 #19}, and Prasai *et al.* (2004); plus Ministry of Health data compiled by authors.

Underlying these results are large, productivity differentials between the three countries. In the next section of the report we measure technical efficiency at the hospital level in the three countries using a range of indicators. The objective is to determine how much of the measurable differences in technical efficiency of the public hospital infrastructure can be attributed to the pattern of infrastructure deployment (distribution and size of fixed points, input mix, better economies of scale) and how much is due to differences in total spending itself.

11. ANALYSIS OF TECHNICAL EFFICIENCY

Unit costs and service indicators

We begin by examining three simple measures of hospital efficiency and intensity of service use: unit costs, occupancy rates and lengths of stay.

The unit costs of admissions will be compared between the countries as a ratio of per capita GDP. This is because wages and labour-intensive costs comprise the largest costs of producing health services in these countries, so differences in the absolute unit costs of services will partly simply reflect differences in prevailing wage levels in each economy, and not any productivity differences which we are interested in. This is confirmed by cross-country analyses of hospital unit costs, such as by Adam *et al.* (2003), which find that unit costs vary across countries in relation to per capita GDP, with the income elasticity of unit costs in relation to per capita GDP being greater than 0.7. One other benefit of controlling unit costs using per capita GDP is that this study is principally concerned with the question of how countries can maximise their health investments in producing health services given the resources potentially available. Since GDP per capita is a measure of total resource availability, expressing unit costs as a ratio of the country's per capita GDP is appropriate.

Figure 22 presents the unit costs of admissions by type of hospital in the three countries. These are presented as a ratio of per capita GDP in order to allow account for income differences between the three countries. Nepal stands out as having the highest costs per admission at all levels of care. Hospital admissions are the least expensive in Sri Lanka, costing less than 5% of the per capita GDP. Admission costs are strongly correlated with utilisation rates and patient turnover. It was shown earlier that Sri Lankan hospitals have utilisation rates that are 20-50 times those of Bangladesh and Nepal. Lower admission costs in Sri Lanka are largely driven by relatively high utilisation rates. Admission costs are also correlated with the level of complexity of the case-mix at each level of care. For instance, tertiary care centres (Group 1 hospitals) have the highest admission costs in all three countries as they take in more severe cases requiring sophisticate, more expensive care. It is worth noting however that basic inpatient care (Group 3) hospitals in both Bangladesh and Nepal have high admission costs relative to intermediate inpatient care (Group 2) hospitals. This may be a consequence of low utilisation rates and inefficient mix of inputs, as we discuss below. When costs per bed-day occupied are examined in Figure 23 the same pattern emerges.

Figure 22: Cost per inpatient admission at each facility level

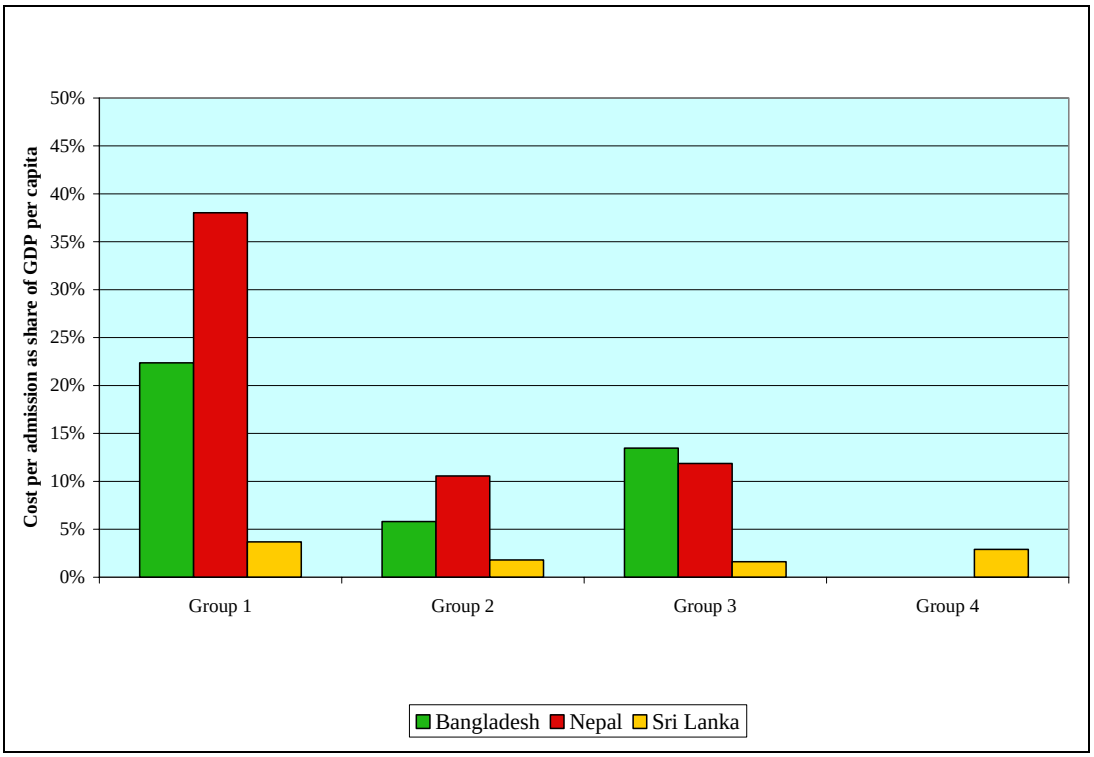
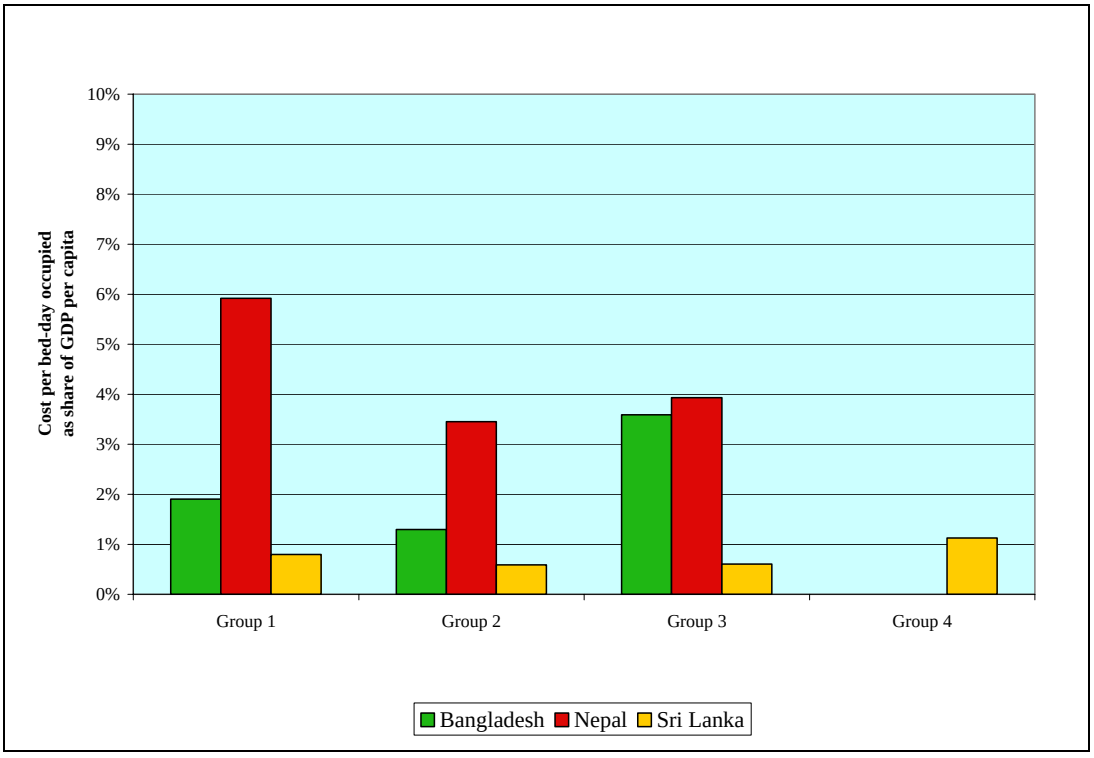


Figure 23: Cost per bed-day occupied at each facility level



Variations in bed-occupancy rates and average lengths of stay across the three countries partly explain these differences in inpatient unit costs (Figure 24 and Figure 25). Higher occupancy rates are generally associated with lower inpatient unit costs, due to the higher utilisation of fixed capacity, and the consequent spreading out of fixed costs over a larger number of units of outputs. Average length of stay is positively related to admission costs as the cumulative costs of care are higher for higher lengths of stay. Length of stay is also correlated with severity, which raises admission costs.

Bangladesh facilities have high occupancy rates in comparison with most other countries, with the tertiary care hospitals having amongst the highest observed occupancy rates for hospitals of their type (Rannan-Eliya and Somanathan, 2003). This is the product of relatively long lengths of stay and low bed turnover rates in Group 1 hospitals. In the case of Group 2 and 3 hospitals, the high occupancy rates are a consequence of very high turnover rates and short lengths of stay. Occupancy rates in Sri Lankan hospitals, although lower than in Bangladesh are still high by international standards (Somanathan *et al.*, 2000). High occupancy rates in Sri Lanka are due to relatively high turnover rates and medium lengths of stay. The high turnover rates are consistent with the high per capita admission rates, which are the norm for this country. High turnover and occupancy rates keep inpatient unit costs relatively low in Sri Lanka. By contrast, Nepalese hospitals are characterised by both low occupancy rates, typically less than 60%, and moderately long lengths of stay. High unit costs in Nepal may be a consequence of low demand for hospitalisation relative to the installed capacity resulting in under-utilisation of that capacity.

Figure 24: Bed-occupancy rates at each facility level

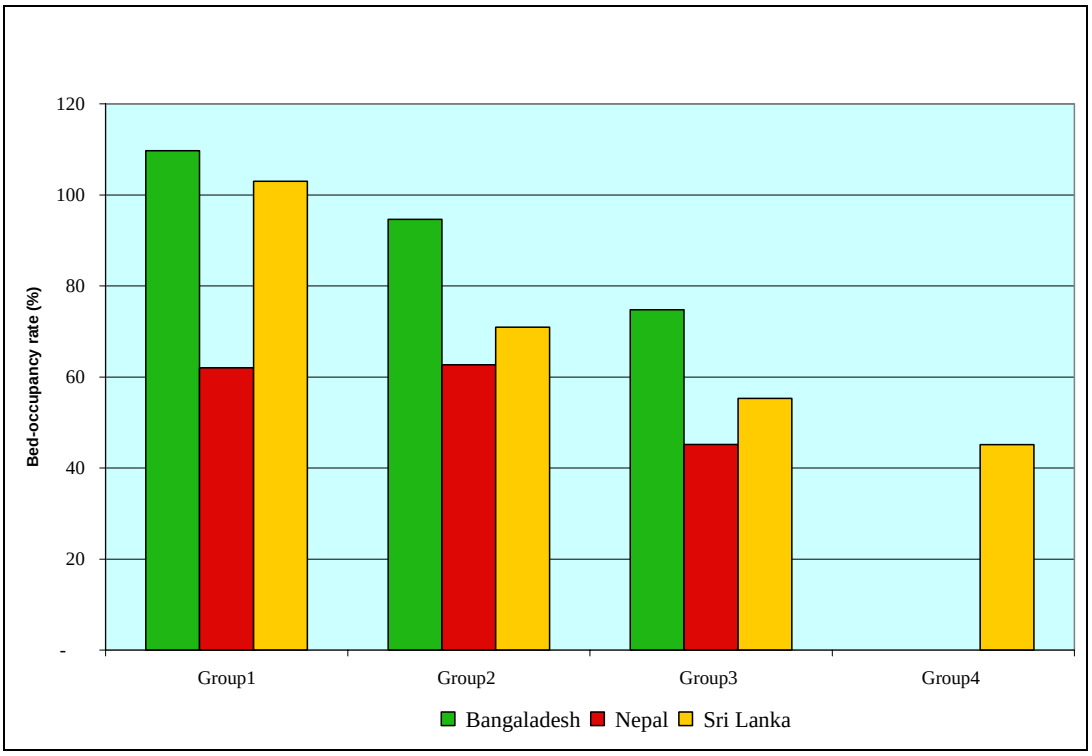
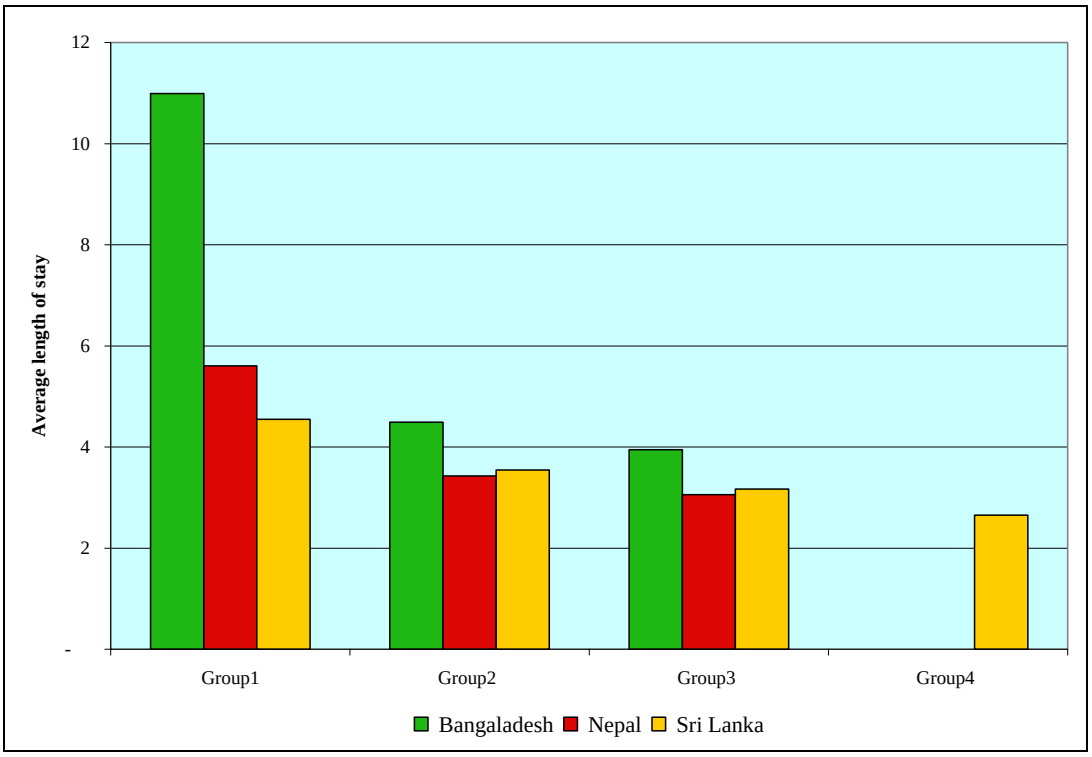
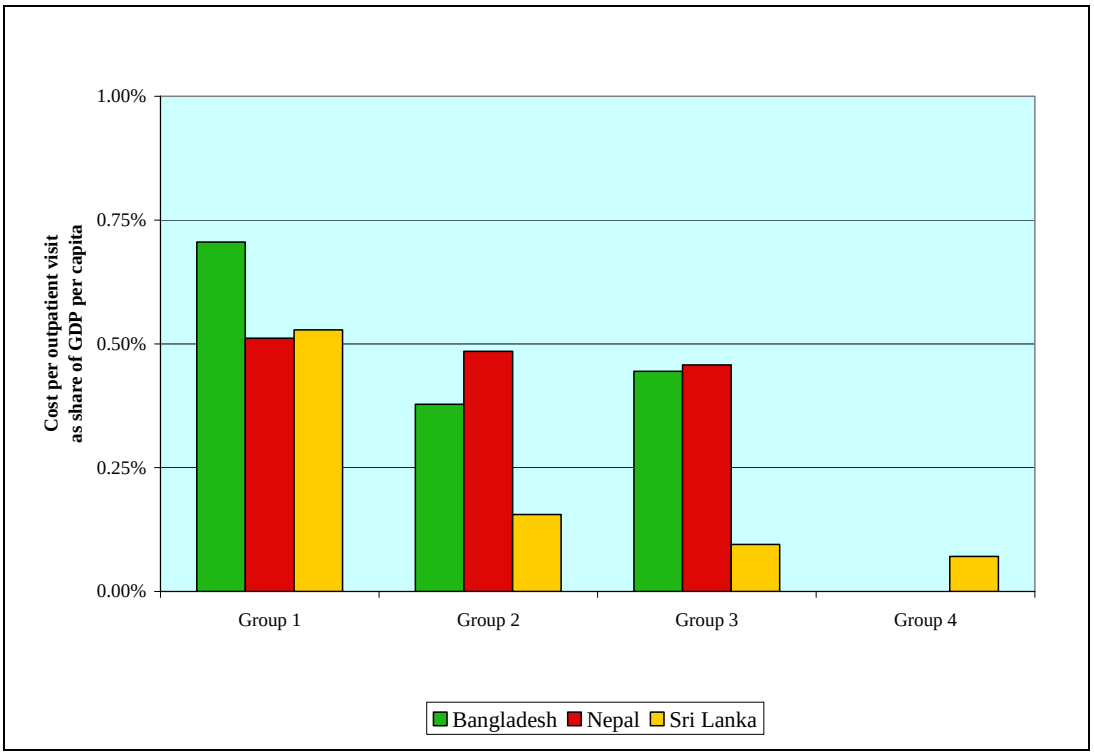


Figure 25: Average lengths of stay at each facility level



Unit costs of outpatient visits are generally lower in Sri Lanka than in Bangladesh and Nepal (Figure 26). As with inpatient care costs, low unit costs in Sri Lanka are driven by high outpatient utilisation rates at all levels of care. Quite surprisingly, basic inpatient care facilities are not the least costly for the provision of outpatient services in Bangladesh and Nepal.

Figure 26: Cost per outpatient visit at each facility level



Analysis of marginal products

Analysis of unit costs and service indicators is a very limited method of analysing efficiency in hospitals. Government-funded hospitals, as in the three countries concerned are not profit-seeking entities. Their input mix is largely determined by external rules and budgetary allocations, and they cannot be assumed to operating at full technical efficiency. In this section we make a preliminary attempt to estimate production functions using the national facility survey data in order to further understand the determinants of technical efficiency in these hospitals.

Following Wouters (1993) and Somanathan, Hanson, Dorabawila *et al*. (2000), a bi-product production function is estimated for the non-specialised facilities in each of the three countries' samples. This type of function indicates the technical relationship between inputs and outputs for the production of two services: inpatient admissions and outpatient visits. The output of each service is estimated controlling for the output of the other by including the other output as an additional independent variable. Endogeneity of the second service is likely to be a problem, but few options exist to correct for this. The dataset available for this analysis is limited and does not include variables that could be used to instrument the potentially endogenous outpatient visit variable. Previous studies including Wouters (1993) have not been successful in controlling for endogeneity either, and so this must be recognised an inherent limitation of this type of analysis.

The double-logged form of the Cobb-Douglas production function is used for this analysis. The more flexible, full transcendental logarithmic (translog) form is preferred, but not used because of potential multicollinearity between the levels and

squares of the different inputs. Previous studies that estimated hospital production functions have shown that the Cobb-Douglas model performs almost as well as the translog model (Frank and Taube, 1987). Tests for heteroscedasticity in the model showed that the residuals did vary systematically with a subset of the independent variables. To address this problem, the final model was estimated using White's heteroscedasticity corrected errors.

The inputs included in the model are number of doctors, nurses, paramedical workers and other administrative and non-technical staff in the hospital. Other explanatory variables include the number of beds, average length of stay and dummy variables for facility type. This latter is expected to control for some of the variation due to differences in case-mix between the different levels of care. The inclusion of bed-size controls for the level of capital in the facility.

Differences in input mix between Sri Lanka on the one hand, and Bangladesh and Nepal on the other, were shown above to be quite significant. Output of health services depends not only on the absolute level of various inputs, but also on the proportions in which they are combined. Therefore, the proportion of non-staff input costs in total costs is included to control for the way in which inputs are combined.

Since all variables must be logged, any observations for which any of the variables have zero values would be dropped. To avoid this, all zero values for the relevant variables were replaced by a value of 0.10. Table 6 lists the variables included in the hospital production functions. The mean values for each variable are given in Table 7.

Table 6: Variables used for estimation of production functions

Variable	Definition
lnadm	Natural log of admissions
lnopt	Natural log of outpatient visits
lndoc	Natural log of total doctors
lnnurs	Natural log of total nurses
lnparam	Natural log of total paramedical staff
lnother	Natural log of other staff
lnbed	Natural log of total beds
alos	Average length of stay (days)
type2	Dummy variable, =1 if intermediate inpatient care hospitals
type3	Dummy variable, =2 if basic or very basic inpatient care hospitals
pernstfcost	Share of non-staff inputs in total costs

Table 7: Mean values for variables used in estimation

	Bangladesh	Nepal	Sri Lanka
Admissions	5,406	4,852	10,939
	(8,939)	(6,146)	(22,780)
Outpatient visits	66,421	45,788	80,506
	(84,885)	(62,900)	(111,284)
Doctors	7.7	15.3	20.8
	(15.2)	(27.9)	(78.3)
Nurses	29.0	21.5	49.5
	(54.4)	(36.2)	(148.5)
Paramedical staff	42.5	26.9	8.7
	(27.8)	(41.6)	(27.4)
Other staff	67.2	68.7	67.4
	(121.6)	(107.4)	(162.1)
Beds	108	79	139
	(210)	(103)	(288)
Average length of stay	6.9	3.4	3.0
	(14.9)	(1.6)	(1.5)
Share of non-staff inputs	0.25	0.24	0.41
in total costs	(0.2)	(0.18)	(0.1)

Notes: Standard deviations in parentheses

The model specified above was estimated separately for each of the three country samples. For the analysis to be consistent across the three countries, only the complex inpatient, intermediate inpatient and basic inpatient care (Groups 1-3) categorisations were used. Facilities classified as very basic inpatient care facilities in Sri Lanka were reclassified as Group 3 facilities. The results of the production function estimation are presented in Table 8.

Table 8: Production function estimates for Bangladesh, Nepal and Sri Lanka

	Bangladesh	Nepal	Sri Lanka
Dependent variable:	*lnadm*	*lnadm*	*lnadm*
lnopt	0.0907	1.1147	-0.0027
	(0.0604)	(0.5116)	(0.1030)
lndoc	0.0564	-0.0011	0.3249
	(0.0775)	(0.3650)	(0.2854)
lnnurs	0.1148	0.1438	0.5467
	(0.1738)	(0.2242)	(0.3033)
lnparam	0.1523	-0.5955	-0.1676
	(0.1209)	(0.5878)	(0.2031)
lnother	-0.068	0.3522	-0.1552
	(0.2730)	(0.3088)	(0.3165)
lnbed	1.0344	0.1673	0.6009**
	(0.2544)**	(0.3853)	(0.1229)
alos	-0.018	-0.1724	-0.072
	(0.0028)**	(0.0492)**	(0.0209)**
type2	1.2606	0.3806	0.5421
	(0.3159)**	(0.2618)	(0.2660)*
type3	0.8511	0.4871	0.7519
	(0.5526)	(0.5898)	(0.2960)*
pernstfcost	-0.4588	0.3241	0.7506
	(0.2961)	(1.8751)	(0.6464)
Constant	1.8223	-3.9502	3.7817
	(1.1076)	(3.3836)	(1.5281)*
Observations	89	21	75
R-squared	0.85	0.95	0.82

Notes: Robust standard errors in parentheses. * significant at 5%; ** significant at 1%.

The model appears to fit the data reasonably well, with a R-squared of over 0.80 for all three samples. The sample size for Nepal is, however, relatively small, undermining the reliability of the model estimates.

Most of the coefficients are of the expected sign, indicating positive marginal products of the different types of staff. The exceptions are doctors in Nepal, paramedical staff in Sri Lanka and other (non-technical and administrative) staff in both Bangladesh and Sri Lanka. None of these results are statistically significant however. Average length of stay has the expected negative relationship with output. The two type dummy variables are both positive and significantly different from zero, with the exception of Nepal. This is consistent with having a more complex case mix, requiring more intensive staff time, as we move from basic to intermediate and to complex inpatient facilities. The proportion of non-staff expenditures in total expenditures is positive in Nepal and Sri Lanka, but not statistically significant.

The sign for outpatient visits was positive in the models for Bangladesh and Nepal. This may reflect endogeneity, plus a direct relationship between outpatient visits and admissions. Group 3 and 4 facilities, which make the bulk of the sample act as primary care facilities, where most outpatient visits involve patients seeking first

contact care. Inpatient admissions are drawn directly from the pool of those outpatients presenting for examination, with a given probability of admission depending on severity of illness. In this context, increasing numbers of outpatient visits should result in increased admissions to the facility. In Sri Lanka however, the sign for outpatient visits was negative indicating complementarity between the two outputs. The coefficient for outpatient visits is not statistically significant in any of the models.

In this double-log functional form, the estimated coefficients on the different types of staff represent the elasticity of output with respect to the particular input. Marginal products for the main inputs for which the coefficients are positive are calculated by multiplying the output elasticity by the average product. Estimated marginal products and average products for each type of input are shown in Tables 8-10.

The coefficient for beds was highly significant in all the models, and positive. This is consistent with the picture of overcrowding observed, suggesting that expansion in bed numbers at all levels of facility would result in increased output of services. In both Bangladesh, the estimated marginal product for beds is higher than the average product at the intermediate and basic inpatient care levels. This provides strong evidence of the need to increase bed-capacity at secondary and primary care facilities in the two countries, which is equivalent to saying that these hospitals are operating at below their optimal size in order to maximise economies of scale. Since the capital cost of building new bed capacity was not available it is not possible to make a direct cost comparison between expanding facility size and employing new staff.

The marginal products for staff inputs are highest for Group 2 facilities in Bangladesh, which suggests the optimal allocation of staff would be to district and general hospitals. Group 3 facilities, or thana health complexes have the lowest marginal products for doctors, nurses and paramedical staff. In Bangladesh, it would be more cost-effective to expand bed-capacity in the thana health complexes than increasing staff numbers. In Sri Lanka, Group 3 and 4 hospitals (rural hospitals, peripheral units etc) have the highest marginal products for staffing inputs. The lowest level facilities in Sri Lanka would therefore benefit from an increase in staff inputs. It is difficult to draw any conclusions based on the results for Nepal. The low marginal products for staffing inputs in general may be associated with a lack of complementary inputs such as drugs and supplies.

Table 9: Estimated average and marginal products in output of inpatient admissions for Bangladesh

	Group 1		Group 2		Group 3	
	Average product	*Marginal product*	*Average product*	*Marginal product*	*Average product*	*Marginal product*
Doctors	2,105	94	1,523	86	556	31
Nurses	192	13	260	30	390	45
Paramedical staff	929	93	1,039	158	50	8
Other staff	89	-	214	-	83	-
Beds	47	31**	91	94**	74	76**

Notes: ** indicates marginal products estimated using statistically significant parameters. Marginal products not calculated where coefficients are negative

Table 10: Estimated average and marginal products in output of inpatient admissions for Nepal

	Group 1		Group 2		Group 3	
	Average product	*Marginal product*	*Average product*	*Marginal product*	*Average product*	*Marginal product*
Doctors	290	-	481	-	669	-
Nurses	147	21	342	49	480	69
Paramedical staff	206	-	253	-	153	-
Other staff	45	16	103	36	85	30
Beds	50	8	86	14	55	9

Notes: ** indicates marginal products estimated using statistically significant parameters. Marginal products not calculated where coefficients are negative

Table 11: Estimated average and marginal products in output of inpatient admissions for Sri Lanka

	Group 1		Group 2		Groups 3 & 4	
	Average product	*Marginal product*	*Average product*	*Marginal product*	*Average product*	*Marginal product*
Doctors	434	141	1,020	331	1,149	373
Nurses	151	82	420	229	512	280
Paramedical staff	1,171	-	2,067	-	2,248	-
Other staff	120	-	230	-	203	-
Beds	74	45**	78	47**	81	49**

Notes: ** indicates marginal products estimated using statistically significant parameters. Marginal products not calculated where coefficients are negative.

12. DISCUSSIONS AND CONCLUSIONS: INPUT MIX AND HOSPITAL PERFORMANCE

In Bangladesh, basic inpatient care (Group 3) facilities appear to be the most costly facilities for the delivery of inpatient services. The cost per admission and per bed-day occupied is lowest in the intermediate inpatient care (Group 2) hospitals, and highest in Group 3. There are several possible explanations for the higher unit costs at Group 3. First, Group 3 hospitals have higher staff-to-bed ratios compared with Group 1 and 2 hospitals. Second, the staff mix at Group 3 hospitals is more expensive than at Group 2, which use relatively more nurses per doctor, and fewer administrative and non-technical staff. Overall, the ratio of administrative and other support staff to doctors and nurses is highest for Group 3, which would add to the relative cost of delivering services. Finally, patient demand is higher for the level of services offered by Group 2 hospitals than for those in Group 3. This suggests that Group 3 facilities, all of which are Thana health complexes are too small to achieve economies of scale, a finding confirmed by the marginal product analysis above. The same is true of Group 3 facilities in Nepal.

By contrast, basic inpatient care facilities in Sri Lanka are relatively efficient providers of services on the basis of the measures used to evaluate efficiency in this study. Both intermediate and basic inpatient care hospitals (Groups 2 and 3) have the lowest inpatient and outpatient unit costs, high occupancy rate. Average lengths of stay at these facilities have also been falling over time (Somanathan *et al.*, 2000). The very basic inpatient care (Group 4) facilities tend to have high unit costs and low occupancy rates relative to Groups 2 and 3. However, they play an important role in ensuring access to health care services for people living in remote, rural areas.

Variations in unit costs across the three countries are driven largely by differences in relative utilisation. These differences in utilisation could be due to underlying differences in demand for facility services, differences in the quality of facilities, or a combination of both. In much of South Asia, particularly Bangladesh and Nepal, lack of information and knowledge about modern medical services prevent substantial expansion in the demand for hospital services. Lower propensities to seek care in Bangladesh and Nepal relative to Sri Lanka are therefore important factors underlying the vastly different rates of utilisation between Sri Lanka and the other two countries. A comprehensive analysis of these factors would require analysis of detailed household health survey data, which were beyond the scope of this paper. We are however able to point to several other factors which affect facility performance through their impact on utilisation rates.

Our assessment of the configuration of the hospital infrastructure in the three countries showed that an average district in Sri Lanka has a larger number of hospitals available than comparable areas in Bangladesh and Nepal. The population living outside the major centres in Sri Lanka have access to a relatively higher number of both intermediate inpatient care facilities and very basic inpatient care facilities per square kilometre than those in Bangladesh and Nepal. The implication of this is that physical barriers to access are substantially less in Sri Lanka, which has a positive impact on health care use. Empirical estimates of the impact of distance and access on

demand for health services confirms this. Developing country studies that estimate the demand for maternal and child health services have generally found that the impact on utilisation of travel costs and travel time is negative and significant(Ching, 1995; Gertler *et al.*, 1988; Hallman, 1999; Hodgkin, 1996; Hotchkiss, 1998; Hotchkiss *et al.*, 2003; Schwartz, Akin, and Popkin, 1988). Another study {Lindelow, 2003 #304} simulated the impact of extending physical access to basic care to all individuals on the demand for general curative care. Controlling for other determinants such as price, income and education, the study found that reducing distance to zero leads to a substantial reduction in the number of individuals who receive no treatment or self-treat.

We noted earlier that intermediate and basic inpatient care facilities in Sri Lanka allocated a larger share of their budgets to drugs and supplies relative to similar facilities in Bangladesh and Nepal. Shortages or absence of adequate medical supplies is known to be one of the main constraints to expanding use of lower level inpatient care facilities in low and middle income countries. Patients bypass the lower levels and travel longer to seek care at secondary or tertiary hospitals because they are more likely to obtain adequate care and medicines there. In Sri Lanka, the higher utilisation rates seen at lower levels of care may be correlated with greater spending on drugs and supplies compared to Bangladesh and Nepal. The facility survey data used for this study were not detailed enough to do a full, comparative analysis of the availability of medicines at the different levels of care in each country.

We also showed that intermediate and basic inpatient care facilities in Bangladesh and Nepal tend to be better equipped than Sri Lankan facilities. They are more likely to have radiology units, CSSD's etc regardless of the level or complexity of their casemix. The availability of high-tech services may be another factor driving up the costs of low level facilities in Bangladesh and Nepal relative to Sri Lanka.

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