# A MULTIVARIATE ANALYSIS OF SOME CHARACTERISTICS OF PSYCHIATRIC HOSPITALS

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ABSTRACT

The psychiatric hospitals in England and Wales differ widely in the ways in which they are run and on a range of other criteria such as staff-patient ratios and discharge rates. Many of these differences have come about for historical reasons. Some patients are treated in the former 'county asylums' set up over a century ago while other patients are treated in psychiatric units in the new district general hospitals. Other differences may be due to the location of the hospital and the make-up of its catchment population.

This wide spread variation was observable on a large selection of data, much of which is collected and published regularly by the Department of Health and Social Security. It was decided that the problem of comparing hospitals with a view to accounting for their differences could be profitably tackled using various multivariate statistical techniques. Principal components analysis and canonical correlations analysis were used to select a small number of important variables from the large number available and a form of causal analysis was used to examine the relationships between this reduced set of variables.

The variables chosen dealt with a psychiatric hospital's four main functions which were seen to be custodial, protective, therapeutic and socialization. A set of 'performance' variables, which covered the therapeutic function, was first chosen, since this

was considered to be the most important function. Then several 'explainer' variables, which were divided into sets dealing with environmental, professional, institutional and socio-medical aspects of a hospital's functioning, were chosen. These contained variables dealing with a hospital's remaining three functions and variables thought to explain differences between the variables which dealt with a hospital's functions.

The preliminary analysis identified several types of hospital characterized by their values on certain variables. In particular a kind of hospital which was called the 'revolving-door' type was observed. This had high discharge and turnover rates, few in-patients but many out and day patients. In addition it had high staffing and expenditure, good accessibility, fewer social workers. The wards were uncrowded with low bed-occupancy and some patients were able to work outside the hospital.

The causal analysis hypothesized that the variables were related in a certain order of causation and showed that several of them had only spurious correlations with one another which disappeared when the effect of other variables was removed by partial correlation. The most important feature of the 'revolving-door' hospitals which remained was that variations in the discharge rate were primarily due to variations in staffing ratios and expenditure on certain items.

It can thus be seen that variations in important aspects of a hospital's functions can be at least partially explained by the methods outlined above. The results depend to a large extent on the suppositions incorporated in the causal analysis. Despite this they can be of value to those who may wish to reduce variation between hospitals or to alter various aspects of their functions so that they carry them out in the way which is currently considered most suitable.

PREFACE

The major part for this thesis was undertaken between 1969 and 1973 while I was a Research Fellow in the University of Keele, working on a research project for the Department of Health and Social Security.

The aim of the project was to compare psychiatric hospitals on various criteria with a view to gaining an understanding of the reasons for the differences between them. The major source of data was returns made to the Department by the hospitals, a summary of which is published annually; supplementary data were obtained from Regional Hospital Boards. The results presented here are, in part, those which emerged while working on the project. The interpretation given to these results and aspects of the causal analysis were not included in the project.

My thanks are due to my former supervisor, Mr. R.E.A. Mapes, who was of great help both in the project and at all stages in formulating the thesis. Dr. W.R. Bytheway, my supervisor, assisted particulary in the final writing-up. Mr M. Clarke, who also worked on the project for the Department of Health, contributed valuably to the clarification of many of the ideas incorporated and my husband's help has been invaluable in expressing them. Finally, Mrs Brenda James, who typed the thesis, has been a continual source of encouragement.

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CONTENTS

## INTRODUCTION

The care of the mentally ill has been a matter of public concern, and embodied as such in English law, for over two hundred years. In the eighteenth century those suffering from mental illness were often simply locked up, the primary concern being to protect the public rather than treat the illness. Gradually, however, as public concern grew over the inhumane conditions in which patients were kept, it became accepted not only that treatment and even cure were possible, but that even incurable patients should be kept in reasonable conditions. The culmination of this concern was the Lunatics Act of 1845.

In the second half of the nineteenth century opinion shifted to disquiet over unjust detention. After extensive public debate the 1890 Lunacy Act was passed, making admission to an asylum depend upon the issue of an order signed by both doctors and a judge. As a result less serious cases were treated only in homes or clinics.

Public opinion changed again, however, and in 1930 voluntary admissions were once more made possible. Since that time the emphasis of treatment has shifted still further from simply containing the patient and protecting the public from him to a situation where the primary concern is to cure him, if that is considered possible. A cure is now considered more likely when the admission system is flexible and conditions are as pleasant as possible. Thus the present situation is much nearer to that prevailing in the middle of the last century than to the legalism of the intervening period.

Since there are many aspects of the treatment and cure of patients, different institutions have different ideas both about their aims and about ways of achieving them. Examination of the differences between psychiatric hospitals in variables such as discharge rates and staffing ratios reveals a large variation throughout the country. Some of these differences, in discharge rates for example, may be due to differing perceptions of a hospital's purpose and others in, say, the allocation of resources, may be due to different ideas about the most suitable way to achieve a hospital's goals. It appeared that the variation was so large that the collection of some data on aspects of the functioning of these hospitals would be useful, with a view to determining which variables changed independently of others and which appeared to be related. Clearly there are many variables connected with psychiatric hospitals. One of these is the composition of the catchment population, which is not amenable to change by the hospital. However, if a model can be established of the way in which this kind of variable affects, for example, the hospital's discharge rate then allowance can be made for it and the independent effect of other variables, which are subject to adjustment, can be assessed.

This study, therefore, is designed to collect and analyse some data on the main aspects of the functioning of psychiatric hospitals. A large number of variables was selected initially and was divided into groups of related variables. The number of variables was reduced using the results of principal components analysis and canonical correlations analysis. To examine relationships within this set of reduced variables a form of causal analysis was carried out using two stage least squares regression. The causal analysis began with a hypothesized causal ordering of the variables and established those variables which affected others directly, even when allowance was made for the effect of intervening variables.

The variables used measured aspects of four of a psychiatric hospital's functions: custody, protection, therapy and socialization. Also included were a number of variables which were thought to affect the ways in which these functions are achieved. The results of the analysis are described in detail in the text and from these results was obtained a clearer understanding of some aspects of psychiatric hospitals' functions. In addition the study demonstrated the use of multivariate analysis in clarifying a complex situation.

CHAPTER 1

## THE HISTORICAL BACKGROUND

Before beginning on the main study this first chapter gives a historical account of the way in which the psychiatric services have developed over the last two hundred years. Hospitals over the country vary in the ways they are run and many of the differences have arisen for historical reasons. For example many 'asylums' were built towards the end of the last century, when the most important consideration was the containment of the patient and the protection of the public from him. As a result the buildings are less amenable to an 'open-door' policy and provisions for facilities such as occupational therapy are likely to be inferior to those in a modern hospital. Consequently it was decided to give a brief description of the development of the psychiatric services to indicate how some of these differences may have arisen. Throughout the chapter reference has been made to Kathleen Jones' two historical studies of the psychiatric services. (Jones, 1954 and 1960).

Until the middle of the 18th century the insane were not recognized as a separate group needing particular forms of care and treatment. The upper classes tended to ignore the problem, confining the individual cases in their families either to their own houses, in secrecy, as single lunatics or paying for their keep in private madhouses. The Church and the medical profession condoned this practice because, to them, lunacy was an unalterable state which, although it could be repressed somewhat by physical treatment such as 'immersion' in cold water, bleeding or purging,    ultimately was incurable. Among the poorer classes the insane were either feared as being possessed by the devil, or if they were clearly harmless idiots were pitied and cared for, usually in work-houses and poor-houses which were supported by taxes from their parishes. Conditions in these houses were generally very bad, the inmates having to subsist on a very poor diet and live in rooms which were seldom cleaned. Many of the more violent were kept confined, this and the lack of food being the chief forms of discipline. Such treatment as there was took the form mentioned above.

At the beginning of the 18th century concern began to grow over the number of vagrants who were roaming about the country. The Vagrancy Laws of 1744 allowed for the insane, as one type of vagrant, to be apprehended and consigned to a secure place (such as a gaol, work-house or poor-house), on the authority of two J.P.'s. This was the first Act of Parliament which mentions lunatics as a separate class of person with peculiar needs. Another cause of public concern was unnecessary detention. Many people were confined on little or no evidence by their families, who could then exploit their estate. Once detained such people had no form of redress until the Act for Regulating Private Madhouses took some measures to overcome this wrong in 1774. Under the Act all institutions for the insane had to be licensed and had to give notice of the reception of an inmate. Houses were to be visited by specially appointed Commissioners, in the metropolitan area, and by two justices and a physician outside

London, and these visitations were to ensure both that no-one was wrongfully detained and that those who were detained rightfully were well treated. The Act established new principles for the care of the insane but the Commissioners and other visitors were given no powers to alter the conditions they found, or to take away licences, so it had little practical effect.

Public interest and concern continued to increase, however, strengthened by King George III's illness. The fact that the King's condition improved with treatment, despite its subsequent deterioration, made the public realize that insanity could be treated. Several institutions were founded with this end in view, including St. Luke's Hospital in London by public subscription. Here the inmates were 'diverted' rather than constrained. St. Luke's was also the first hospital to attempt to teach medical students how to care for the mentally ill. This shift in attention to care rather than simple confinement was also evident in Manchester Lunatic Asylum. The Asylum was connected with the Infirmary and its patients were seen as having needs similar to physically ill patients. In York Retreat, founded by the Quakers and run mainly by the Tukey family, the emphasis was again on care. The treatment stemmed from Christian recognition of the dignity of the individual and from common-sense. Accommodation and diet were good and the use of manacles rare.

With these hospitals as examples, interest in the possibility of humane treatment continued to increase. In 1807 a Select Parliamentary Committee was set up to survey conditions in asylums. The Committee's

Report revealed large variations between counties in the number of lunatics known to the authorities. These it considered due mainly to inefficiency and a desire to conceal malpractices, and partly to mere apathy; it recommended that an asylum should be set up in each county. The County Asylum Act of 1808 implemented this recommendation and provided means for the establishment of such asylums. They were to be initiated by J.P.s giving notice at the Quarter Sessions and financed from a county rate or by voluntary contributions. Inspection was to be by a committee of justices who also appointed staff. Patients were to be admitted by a warrant from two justices and discharged by the committee of visiting justices. Patients were supported by their parishes. The first asylum established under this Act was immediately found to be too small and this led to amendments providing that although all lunatics and idiots in a parish had to be declared to the justices and a medical certificate provided, a place in a County asylum did not have to be sought for all of them. Despite this Act public concern continued to increase over such abuses in asylums as poor care and crowded and dirty conditions; a Select Committee was duly set up in 1815. It inspected prevailing conditions, in particular in the York Asylum and in Bethlem in London, but its report merely stated the facts discovered and neither drew any conclusions nor made any recommendations. During the period 1816-1819 three Bills calling in particular for more regular and rigorous inspection of asylums were introduced and passed by the Commons. They were rejected by the House of Lords who wished to maintain the secrecy in which it was possible to keep lunatics. Notwithstanding these setbacks the public became increasingly aware of the abuses existing and of the great differences in the forms of care that obtained. Much of this awareness came into being through revelations in the press of individual cases of wrongful detention and of ill-treatment of those detained.

Following the 1808 Act there were, by 1827, nine County Asylums whose object was mainly to keep the inmates clean, quiet and orderly, the latter often though not always, by mechanical means. A Select Committee was then set up to consider the provisions for pauper lunatics in London and was the first to draw up a list of standards against which to inspect asylums and workhouses. The emphasis of the list was on the humane treatment and occupation of patients as much as on their material well-being. The Committee found very bad conditions in several private madhouses and as a result of its report the Middlesex Asylum was built in London and two Acts were passed in 1828. The County Asylums Act provided for centralization of records by annual returns of admissions, discharges and deaths to the Secretary of State who was empowered to send visitors to inspect asylums. The Madhouses Act increased both the number of Metropolitan Commissioners and their pay, and gave them power to visit madhouses at irregular times. It also laid down more stringent conditions for care - for instance restraint was allowed only on medical authority. The Commissioners appointed made use of their powers straight away and to some purpose.

Despite the efforts of the Commissioners there were still many cases of illegal detention and other malpractices in private madhouses. But in some of the County asylums, particularly in Hanwell in Middlesex under John Connolly, a system of non-restraint began to be implemented. Connolly also advocated clinical instruction for doctors in mental illness and the training of keepers, rather than selection on the basis of mere physical strength, but his ideas were not implemented. In general, though, conditions and professional standards did improve gradually. The Poor Law Amendment Act of 1834 made specific mention of lunatics in only one clause - 'dangerous' cases were to be sent to County asylums while others were to be retained in workhouses where the cost of their maintenance was considerably cheaper. But even in the workhouses there was usually a doctor in attendance who would place idiots in a special ward despite there being no specific mention of such wards in any Act. These facts highlight the conflict which existed between the asylums which claimed that they could cure lunatics and the workhouses which only detained the insane but were cheaper. The Poor Law Commissioners chose to send non-dangerous incurables to the workhouses.

The Metropolitan Commissioners continued to make their reports until, in 1842, an Act was passed empowering them to visit all asylums and madhouses twice a year for the next three years. Their numbers were increased and they were to inspect the houses they visited completely, commenting particularly on the use of non-restraint and the classification, occupation and amusement of paupers. This arrangement was made with a view to an eventual permanent national inspectorate. One result of the tour of inspection was almost immediate reform in many houses which brought themselves up to the standards previously imposed but not enforced. The Commissioners reported in 1844 and found that in general County asylums had no major abuses though they were often poorly sited or in unsuitable buildings. Similarly most metropolitan madhouses were fairly good but many provincial ones were still very bad, often as a result of careless inspection by magistrates. Workhouses often still contained violent or curable lunatics. The Commissioners made a number of suggestions for amendments to the existing law and their report aroused much public attention and general enthusiasm. As a result Ashley proposed an Act and eventually in August 1845 the Lunatics Act was passed.

The Act appointed new Commissioners who were not only lay men but were also drawn from the legal and medical professions, these latter being given salaries. The Commissioners were to inspect, license and report regularly on all hospitals, gaols and workhouses. Certification was made fuller and gave the background and medical history of the patient, and all institutions were to keep records and to report to the Commissioners. Single lunatics kept for profit were also to be inspected. Thus a much more careful control was effected of the conditions under which lunatics were kept.

From the mid-nineteenth century onwards there was a gradual shift in emphasis from disquiet concerning conditions to disquiet over unjust detention; the Alleged Lunatic's Friends Society was formed.

The influence of doctors also became stronger and the Journal of Mental Science was founded. A Commission for the 'Lancet' investigated conditions and found them poor. On the legal side there was controversy over a proposal for an obligatory magistrate's order even in private cases of certification, which was opposed because it made early treatment more difficult. In 1874 a Grant in Aid for Pauper Lunatics ruled that all lunatics should be removed from poorhouses and should be aided from the Consolidated Fund, thereby increasing central control and the custodial element of care. A Select Committee in 1877 decided that public disquiet at excessive ease of admission was not justified, but opinion to the contrary gathered strength and eventually in 1890 the Lunacy Act was passed, despite Lord Shaftesbury's recommendations for early treatment and easier admissions. This Act might be considered as a triumph of legalism over a more humane view of treatment with a medical and social emphasis. Administration was to be by the Lord Chancellor through the Lunacy Commissioners, each asylum being run by the appropriate Local Authority. Admission was by a reception order on a petition by a relative, accompanied by two medical certificates and authorised by a judge. The order was to be reviewed regularly. In the case of paupers the petition was signed by a Poor Law Officer or the Police. Provisions were also made for short term detention without such petitions. In addition, the Act provided for regular visitations by the Commissioners.

The 1890 Act did not distinguish between 'idiots' and the insane but from 1845 onwards people began to realize that idiots could be at least partially educated and a few schools were set up. The Idiots Act of 1886 empowered Local Authorities to build institutions on the same conditions as lunatic asylums and distinguish between 'lunatics' and 'idiots'. Classes for the 'feeble-minded' were set up and in 1899 the Elementary Education (Defective and Epileptic Children) Act empowered Local Authorities to establish schools or classes. Fifteen years later in 1914 a further Act required Local Authorities to establish such schools. There was controversy as to whether idiocy was due to heredity or environment, with a tendency to favour the former. A Royal Commission on the Care of the Feeble Minded was set up and eventually, despite much opposition, the Mental Deficiency Act was passed in 1913. This distinguished several grades of mental defectives and said they could be brought into care if it was found to be necessary by a parent or guardian, and if the patient had been defective from birth or an early age. The criteria used to judge whether a patient should be certified were social in the case of adults and educational in the case of children, and there was far less emphasis on legalism than in the 1890 Act.

Concern for the welfare of mental defectives grew and the Central Association for the Care of the Mentally Defective was formed in 1914. Accommodation was still very limited and many defectives were still unascertained. Community care in, for example, occupational centres grew and became better thought of as an alternative to complete segregation. Children were dealt with by two authorities - Mental

Defective Committees and Education Committees. This led to anomalies. The Wood Committee of 1924 investigated the situation and recommended that the powers of the authorities for mental defectives should be widened to include all defectives except those in schools, and 'incorrigible criminals' who were to be under the Board of Control. The Committee also re-stated that the criteria of deficiency were social, that is deficiency depended on whether the patient could lead a sheltered, fairly normal life or not. In addition, more community care was recommended. All these suggestions were implemented. The definition of deficiency was extended to include not only those so born but also those who became deficient before 18 years of age. It was considered due either to 'primary amentia', i.e. was inherited, or to secondary, i.e. was caused by an accident or condition affecting the foetus or living child.

One result of the legalism implicit in the 1890 Act was that the patients had to be certified and so were usually admitted only when advanced in mental illness. Thus they had little hope of being cured and the emphasis was on custody. Milder cases were treated in homes or private clinics. In reaction to this the Board of Control suggested, shortly after the First World War, that treatment without certification should be available and also in general hospitals and out-patient clinics. After-care work was also to be encouraged by grants to voluntary societies and doctors should receive special training.

These suggestions were not, however, implemented and hospitals grew larger and became overcrowded with an accompanying shortage of staff.

In 1920 the newly-established Ministry of Health took over the control of lunacy and mental deficiency and anxiety gradually increased as to the condition of mental patients. The Maudsley Hospital, established in 1915, became used as a teaching hospital and admitted voluntary patients. A Royal Commission in 1924-6 investigated existing conditions and their short-comings and, after increasing public pressure, the Mental Treatment Act was passed in 1930 implementing most of the Commission's recommendations. New categories of voluntary patients were established and these could discharge themselves in 72 hours. There were also temporary patients who were admitted for a year only. Local Authorities were to provide out-patient clinics and after-care facilities and to foster research. The whole tone of the Act was more humane referring to mental hospitals and patients rather than asylums and lunatics. Public opinion welcomed the Act despite some fears that the voluntary patients would form an elite. Initially there was little specific accommodation for such patients although their numbers increased. Other facilities, such as libraries, also improved, and some wards were unlocked. Staff numbers also increased, mainly because of the depression. Additionally, training courses for psychiatrists, nurses and social workers became better established.

At this time there was a complete separation of mental illness and mental deficiency without any central co-ordinating authority and conditions varied greatly. Various surveys were carried out highlighting these facts but subsequent recommendations were not implemented because of the outbreak of war. During the war plans were made for the National Health Service, which was to embrace provision for mental illness and deficiency in the same way as physical illness. The patient was thus cared for under the tripartite national health system of Local Authority, G.P. and Regional Hospital Board. Local Authorities had to deal with the initial care of patients and their removal to hospitals, and also with the ascertainment and care of mental defectives in institutions and in the community. They could also provide facilities for prevention, care and after-care of patients but these were not mandatory. Only some areas provided these facilities so there was still much regional variation although there was generally greater freedom.

Most of the Local Authority Mental Health Departments began to do much, especially in community care, that had been previously done largely by voluntary organizations. Mental Hospitals were still usually large and inaccessibly located in the depths of the country. Concern increased because of the employment of ill-qualified nurses and social-workers, many of whom were qualified by experience rather than by academic training. The Younghusband Report in 1959 recommended that social workers should be professionally trained for specially difficult cases and assisted by officers with a general training given by the National Certificate in Social Work, but with a common basic training for all social workers emphasising the comparability of much of their work.

Once again public concern gradually increased, particularly at large, overcrowded hospitals with out-of-date, unsuitable buildings and low staff-patient ratios. A Royal Commission was set up from 1954-7 and its findings were largely implemented in the Mental Health Bill of 1959 which repealed all other Acts. Mental disorder was defined as 'mental illness, arrested or incomplete development of mind, psychopathic disorder or any other disorder or disability of mind'. The Board of Control was abolished and a Mental Health Review Tribunal was set up for each Regional Hospital Board while central administration became the responsibility of the Ministry of Health. Admissions were to be informal where possible, but provision was also made for compulsory admission under emergency, observation or treatment orders which all required doctor's certificates and an application from the Mental Welfare Officer or a relative. Detailed provisions were also laid down for care and treatment, guardianships, visitations etc. The spirit of the Bill was much nearer that prevalent in the middle of the last century, with the benefit of the patient being the primary consideration, than the strict legalism of the 1890 Act. Since 1959 the custodial concept has largely disappeared from the running of mental hospitals, with a policy of more rapid admission and discharge, largely voluntary, and very few remaining locked wards. The emphasis on care in the community and out-patient and day-patient clinics has also grown though it seems that there is still much to be done.

CHAPTER 2

## THE PSYCHIATRIC SERVICES TODAY

The psychiatric services in England and Wales took their present form on the basis of a tripartite system under the National Health Act of 1946 with G.P.s, Hospitals and Local Authorities each having separate functions to fulfil. Until reorganization in April 1974, i.e. throughout the period dealt with, any mental health service had to fit in with this scheme. Successful interaction between the three branches required good communication both at the formal and informal level.[1] One example of good communication is the almost total integration between hospital and local authority achieved in Nottingham.[2] Martin and Rehin (1969) outline some of the other ways in which good liaison can be achieved, either by integration of the services or by co-ordination. Some of the relevant factors have been quantified in the environmental indices chosen in this analysis.

Increasingly in recent years a greater emphasis has been placed on the importance of care of the mentally ill not only in hospital but in the community. This was recognized in the 1959 Mental Health Act which empowered local authorities to set up a large number of services such as training centres. Despite the fact that the

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1. See DHSS, 1971. This need for good communication still exists despite reorganization.
2. Macmillan, 1956.

Mental Health Act and more recent memoranda from the Department of Health (DHSS 1971) state that the patient should be cared for in the community if possible, relatively little quantitative work has been done to investigate this.[3] The use of psychiatric wards in general hospitals, usually linked with one of the larger traditional 'asylums' situated some distance away in the country, has increased because it enables a patient to remain closer to the community from which he comes.[4] Patients may be more willing to be admitted to psychiatric wards in the local general hospital and moreover, while there, they are able to keep in touch with their families and friends more easily, if only because visiting is made much less of a burden. (Hoenig and Hamilton, 1969; McKeown et al., 1971). This maintenance of social contacts facilitates return to the community. Follow-up by the hospital is also made easier, which in turn usually means that patients tend to be discharged earlier and re-admitted more often than in the old type of hospital. This partly accounts for the recent increase in admission rates. Psychiatric wards in general hospitals tend to be smaller than those in the traditional 'asylums', and have higher staff-patient ratios, which means more individual attention for patients, again facilitating recovery.

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3. Among the studies that have been carried out are those of Plymouth (Weeks, 1965) and Chichester (Rehin and Martin, 1968).
4. See, for example, Hoenig and Hamilton, 1969.

In most cases psychiatric wards have been set up initially for short-term patients and it has been expected that potential long-term patients would be transfered to the 'backing-up' mental hospital. This may lead to two types of patient emerging who receive two types of care and who are dealt with, generally, by different psychiatrists. Fears have been expressed (Hayward, 1961) that consultants in mental hospitals may come to be regarded as inferior to those in psychiatric wards, in the same sort of way that psychiatrists in general used to be regarded as inferior to the rest of the medical profession. Nurses also may be more difficult to recruit when they have to look after chronic patients only. From the patients' point of view the accumulation of chronic patients in one place may also lead to slower recovery rates. In fact this situation need not arise if consultant psychiatrists have patients and sessions in both. The fears outlined above have not been justified in the wards studied by Hoenig and Hamilton (1969) who found that patients entering the wards rarely became 'long-term' patients requiring transfer to the mental hospital. If these findings are borne out in other hospitals there would seem to be a strong case for the establishment of such wards in much larger numbers, and the gradual specialization of mental hospitals in research into particular problems such as alcoholism or drug-addiction (Oldham, 1969), or in the care of those patients such as psychopaths who will always need a more custodial institution. This is, in fact, the prospect envisaged in 'Hospital Services for the Mentally Ill' (DHSS, 1971).

The fact that a psychiatric ward is situated in a general hospital carries with it certain advantages and disadvantages. Many cases of mental illness are accompanied by physical illness and in a general hospital these may be diagnosed and treated more easily and efficiently. Conversely some physical illnesses are accompanied by psychiatric symptoms and if a consultant psychiatrist is readily available he is more likely to be asked for advice. However, the needs of patients with mental and physical illnesses are very different (Clark, 1956). To begin with, few mental patients are bed-ridden and so they need such facilities as day-wards and occupational therapy centres. It follows from this that they will need fewer nurses to do routine things such as bed-making which many patients will be able to do themselves, but instead they will need occupational therapists and teachers of various skills. Taking these points into consideration, a more viable alternative to a psychiatric ward may be a psychiatric hospital with an admission unit to which all patients go initially and in which many of the short-term patients will stay for their entire hospitalization period. Such an admission unit is being used in Lancaster Moor Hospital (Smith, 1965). Ideally the site of such a hospital would be near a general hospital to facilitate co-ordination of treatment of the sort mentioned above, and there would probably be some facilities for treatment of physical illness such as an X-ray unit. One possible system would have a fairly large number of flexible units reasonably small and dealing with different types of patient. These patients would be able to meet in central units for activities such as occupational therapy and industrial training. In this way patients who needed intensive care could be well looked after, while those who were in need of more hostel-like facilities could also be catered for. This sort of hospital is described by Barton (1963) and Maddison (1963).

Hostels, night-hospitals and out- and day-patient facilities could also be included in this sort of hospital complex. Freeman (1963) distinguishes three types of hostel. The first is short-term either for patients who are soon to be discharged but are not yet completely ready to return to the community, or as a preventative measure for those patients who would otherwise get worse and be in need of complete hospitalization, and who for some reason cannot use day-patient or out-patient facilities. The second type is long-stay, for psychiatric patients who are unable to return to the community completely but who are not in need of complete hospitalization (see also Kramer, 1963). The third type of hostel is for the elderly, again in particular for those who do not need full hospitalization.

The first hostels established by local authorities have been mainly of the first type, that is short-term rehabilitative hostels. Usually the patients have been expected to return to the community within a year. This policy has not always been successful however, as many patients who need short-term rehabilitation are cared for entirely in the hospital, and for the period of time which they could have spent in the hostel they have worked in the community by day and returned to the hospital by night. Many of the patients who had previously been seen as long-term and who would benefit from this sort of rehabilitation have received it since the 1959 Act has been implemented, consequently there remains in hospitals a higher percentage of permanent chronic patients who would not be receptive to such treatment. This sort of patient is described by Wing and Brown (1961) and by Goffman (1968). Thus some hostels have been established for a fairly scarce type of patient and it might be better if the emphasis were to shift to more permanent forms of care, that is to hostels of the second and third type. (Apte, 1967).

The functions of a hostel for night-patient care are similar to those of one for day-patient care but may be seen as complementary. The complementary nature of their roles has been made use of in Montreal where day-patients and night-patients use the same beds but at different times. (Moll, 1957). Night-hospital patients work in the community and return to the hospital at night, whereas day-patients come to the hospital by day and return to their families in the evening. Hostels perform similar functions to night-hospitals but patients do not usually receive clinical treatment - for this they go to out-patient departments. The functions of day-hospitals correspond to those of hostels; some day-patients attend day hospital as the first phase of their discharge into the community. Others attend to avoid total hospitalization. Without any support, their families would be unable to cope but when relieved of their burden for a good deal of the time they find that it is possible to manage. Yet another type of patient is not able to return to the community completely, but does not need intensive care continuously. Most of the time he does not manifest seriously disturbed behaviour and so may be treated in a day-hospital. When and if the need for more intensive care arises he can be transferred to the appropriate in-patient department.[5] In yet other cases there is a deliberate policy of repeated admission, discharge and re-admission, with a period of several weeks in and then several weeks out of hospital. This is described by Boag (1960).

Day hospitals can also be useful in geriatric services. If the hospital has good social and occupational therapy facilities which interest the patients and provide them with things which they want to do, then the rate of incidence of mental and physical deterioration is often decreased. (Fine, 1963).

The care of the aged is another aspect of the psychiatric services which needs a good deal of co-ordination between the different branches of the health services. Probably more than any other patients, geriatrics need both physical and mental treatment as the two types of illnesses are very often found together. Many elderly people who are not seriously ill need hostels or welfare homes, as suggested above, where they can live, and have access to treatment when necessary, but most of the time will be fairly self-sufficient. Often this type of patient would be able to live in the community if he or she had some sort of support from, for instance, a spouse or child, but without this support is unable to manage. Other elderly patients have a mental illness but are physically fit and at present these patients usually, but by no means always, go to psychiatric hospitals and receive the

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5. This is the type of service provided in, for example, Chichester (Grad and Sainsbury, 1968).

same sort of treatment as younger patients.[6]

On the other hand some elderly patients have just a physical illness and the usual place for their treatment is a geriatric ward. But in a very large number of cases there is a concomitant mental illness which at present is not adequately treated because of the lack of a psychiatrist. Clearly it would be better if such patients had the care of both a geriatrician and a psychiatrist. There might perhaps be an admission unit, or a pre-admission visit, for elderly patients where a full physical and mental diagnosis would be obtained. On the basis of this diagnosis the patient would be assigned to the type of unit most suitable. Here again the need for a hospital in which the patients have easy access to the community becomes important. If admission to a geriatric ward or to a mental hospital means that a patient is cut off from the few people with whom he has contact then re-entry into the community is made more difficult.[7]

Some of the different ways in which a psychiatric patient might be treated have now been outlined but with no discussion of the relative effectiveness of different forms of treatment. The two chief aims of any institution caring for a psychiatric patient are restoration to the community, as far as possible permanently, and care of the patient

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6. See Kay, Beamish and Roth, 1962.
7. Anderson (1965) and the subsequent discussion examines these and other aspects of the care of the aged. See also Macmillan, 1967.

while undergoing treatment (Clark, 1956). Clearly these two aims are not necessarily compatible as evidenced by the phenomenon of 'institutionalization' explained by Goffman (1968), where a patient conforms to the hospital staff's concept of an ideal patient but thereby renders himself unfit to return to the community.

Various simple measures have been used to examine the effectiveness of a hospital in caring for its patients. Barton (1965), for instance, has derived a scale which gives an overall subjective picture of a hospital but all the questions are given equal weight, their sum being the hospital's score. Wing and Brown (1962) selected a number of factors influencing the likely outcome of hospitalization, such as the type of wards and the activities undertaken by patients. Here again, though, there was no attempt to connect the factors or examine their mutual influence.

Rather more sophisticated measures of the efficency of a hospital in restoring its patients to the community quickly but permanently, have been used by Ullmann (1967) and by Jones and Sidebotham (1962). The latter considered several simple measures of efficiency, rejected them all, and finally decided on average cost per case, which was the product of the average length of stay and the daily cost per patient. This necessarily involved only short-stay patients and the sole measure they considered feasible for long-stay patients was the amount of resources devoted to them. Jones and Sidebotham concluded that high cost hospitals were more efficient than low cost if the money was used on staff, equipment and patient facilities rather than on maintenance and upkeep of the hospital. Large hospitals had advantages such as the ability to make economies of scale but greater disadvantages such as less individual attention to patients.

This and other research led Ullmann to hypothesize that as the size of a hospital increases its effectiveness decreases. The criteria he used were:

1. % of admissions who achieved their First Significant Release (i.e. left within 274 days of admission and remained in the community for at least 90 consecutive days).
2. % of patients who had been resident for over 2 years.

His hypothesis was proved correct even allowing for variations in staffing and expenditure, high levels of which were significantly and favourably associated with the two criteria.

Even in these two studies, though, there was little attempt to examine the reasons why these criteria were connected with the aims of a hospital. This study, therefore, explores the factors which could be seen as possibly connected with variations in these and other criteria of effectiveness.

CHAPTER 3

## THE CHOICE OF VARIABLES

A large number of simple indices of various aspects of the activity of a hospital, such as turnover rates and staff-patient ratios, are readily available from data published by the Department of Health and Social Security. Examination of these kinds of data immediately reveals that there are very large differences between Regional Hospital Boards. For example, in 1967, the average number of resident patients per thousand catchment population ranges from 1.95 to 3.38 and the number of consultant medical staff per hundred patients ranges from 0.27 to 0.84 i.e. the highest ratio is over three times as large as the lowest (DHSS,1969). Similarly total expenditure per in-patient week varies from £12.50 to £18.30. Some of these differences are even more marked when individual hospitals are considered.

It is obvious that simple indices of this kind 'can hardly be expected to describe or measure the work of such a complex organisation as a hospital .... but the ranges are so wide that very considerable differences calling for investigation do exist.' (DHSS, 1969). With this in mind, and also considering both the large number of different theories about the best way to treat patients, and the many different ways in which they are put into practice, it seemed a good idea to gather some basic data on psychiatric hospital activities, with a view to making detailed comparisons between them.

Jones (1963) suggests that a psychiatric hospital has four functions: custody, protection, therapy and socialization. These functions obviously cannot all be fulfilled simultaneously since custody and socialization, for example, are mutually incompatible, but indices can be chosen to examine a hospital's effectiveness in each of the four areas.

As described at the end of Chapter 1, a hospital's custodial function has become very much less important with the recent trend towards unlocked wards and informal admissions. The only measure for which information is readily available is the percentage of admissions which were informal admissions, and this measure was therefore used. The second function of a hospital is protection of the patient while in hospital, in particular of those patients who are unable to be discharged, either because their illness is not susceptible of treatment, or for family or other reasons. For these patients the extent and nature of the facilities devoted to them is the most suitable measure (c.f. Jones and Sidebotham, 1962) and some of the institutional and costing variables were chosen for this purpose.

The therapeutic function of a hospital is perhaps the most important and is considered so by the Department of Health (DHSS, 1971). Some idea of a hospital's effectiveness is given by turnover and discharge rates, but discharge need not necessarily imply cure, certainly not permanent cure. A better criterion of effectiveness would take account of re-admission rates or use an index like Ullmann's First Significant Release (see p.26 of ch.2 and Ullmann, 1967).

However re-admission rates by themselves give an incomplete picture unless there is also information on the length of time spent by the patient in the community before re-admission and on previous hospitalizations. This can only be obtained from individual patient records, to which access is restricted, so no details of re-admissions were included. The type of treatment given to patients may be an indicator of the way in which a hospital carries out its therapeutic function, so variables of expenditure on drugs and on physical methods of treatment were used to measure this. (c.f. Kessel and Hassall, 1971).

The therapeutic function of a hospital may also be carried out while the patient is living at home and using out or day-patient facilities. Kessel and Hassall (1971) thought that an increase in use of out-patient facilities with a corresponding decrease in in-patient numbers would indicate the success of community care, as opposed to traditional psychiatric hospital facilities. In-patient numbers, out and day-patient numbers and attendance rates give an indication of this.

Finally, the socialization function of a hospital can be measured by some of the facilities provided for the patients and by the extent of their contact with the community. The facilities examined were those for therapy and training, and the provision of places in workshops. Direct contact with the community was indicated by the number of patients working outside the hospital and by the involvement of voluntary organizations in hospital affairs. Possible sources of contact of patients with their families were indicated by visiting hours and by the involvement of social workers in hospital work.

The indices which measured the effectiveness of the therapeutic function of a hospital were considered to be the ones whose variation it was most important to examine; they were therefore grouped together as 'performance' indices. It was decided to explore the way in which these indices were related to what might be termed 'explainer' variables. These included the variables which were used to examine the way in which a hospital carried out its three other functions. They also included some of the resources available to the hospital and the way in which they were utilised; the hospital's contact with, and location in, the community it served and the community's attitude to the hospital; the make-up of the catchment population and the legal status of admissions.

Many of these indices were obtained from SBH 112, a form completed by each psychiatric hospital and returned to the DHSS annually. The data extracted from this form were for 1967, as was most of the rest of the data. Some indices were available from the DHSS from surveys it had carried out, others were obtained on application to the Regional Hospital Boards. However, there is great regional variation in what data are readily available at Board level, and some data were only available on application to individual hospitals. Here again there was much variation as to what was available and some hospitals were unable to provide the information requested. The socio-demographic data were taken from the Registrar General's Census Tables for 1961, suitably re-organized for the catchment population of each hospital.

The unit studied was a hospital, or group of hospitals, which had a total of over 500 beds, these being the hospitals for which the information taken from SBH 112 was available for 1967 (DHSS 1969). Thus the unit was either a hospital, or a group of hospitals, or a psychiatric hospital and psychiatric wards in near-by general hospitals, under the same management and with a common catchment area. Teaching hospitals were excluded. It was felt that they were so different from other psychiatric hospitals in such things as staff-patient ratios that their inclusion would give a distorted picture.

Each Regional Hospital Board contained an average of about 7 psychiatric hospitals so it was decided to study England and Wales as a whole, that is 99 hospitals in all, when exploring the connection between performance and explainer variables. Differences between the fifteen Boards were also studied for individual variables. Each hospital had a catchment population consisting of one or more local authorities and in general these catchment populations were discrete, although in a few cases a local authority area was divided between two hospitals. When it was impossible to divide an area geographically, its facilities were taken to be divided between hospitals in the ratio in which its population used the hospitals.

The indices collected for each hospital are listed below with explanations where necessary. A summary list is given in Appendix 4. The first group, of performance indices, is all taken from SBH 112 except the last two, which are each ratios of two previous indices, and the two adjusted discharge rates.

<u>Performance Indices:</u>

| | |
|---|---|
| Pe 1 | No. of In-patients per 1000 catchment population (UCP) |
| Pe 2 | No. of Annual Admissions per UCP |
| Pe 3 | Patient Turnover Rate |
| Pe 4 | Patient Death Rate |
| Pe 5a | Overall Discharge Rate |
| Pe 5b | Young Patients Discharge Rate |
| Pe 5c | Short Term Patients Discharge Rate |
| Pe 6 | No. of new Out-Patients per annum per UCP |
| Pe 7 | " " " Day-Patients per annum per UCP |
| Pe 8 | Total No. of Out-Patient Attendances per annum per UCP |
| Pe 9 | " " " Day-Patient " per annum per UCP |
| Pe10 | No. of Out-Patient Attendances per 100 In-Patient Days |
| Pe11 | " " Day-Patient " " " " " " |

Indices Pe1, Pe2 and Pe6-9 give information as to the basic patient load the hospital has to deal with; Pe10 and Pe11 give some idea about the relative importance given to in-patient and out-patient care; Pe3-5 deal with the 'results' a hospital has with its patients and, together with Pe2, indicate how the hospital fulfils its therapeutic function. The two adjusted discharge rates Pe5b and Pe5c are concerned with the patients which might be expected to be discharged i.e. patients under 65 who will not have concomitant physical illnesses leading to additional complications (the Young Patients discharge rate), and patients who have been in hospital for less than two years and so will not have to overcome the effects of institutionalization (the Short Term Patients discharge rate). The data for these two discharge rates were available only for some Hospital Boards so the rates are given for 32 hospitals only and analysed using only those hospitals. No index concerned with re-admission rates has been included for the reasons outlined above (p.29). Some hospitals did not have out or day-patient facilities situated at the hospital but in a nearby general hospital. Data for these were not separable so indices Pe6, 8 and 10 or Pe7, 9 and 11 were given zero values.

The 'explainer' variables were divided into four groups: Environmental, Professional, Institutional and Socio-Medical.

1. The environmental indices deal with facilities outside the hospital and with its relationship with its catchment population, geographically and with the institutions which have complementary functions.
2. The professional indices are simply the staff-patient ratios in the various staff categories concerned directly with the patients.

3. The institutional indices are concerned with the hospital itself and with how it allocates its resources, both financial and other kinds. They also attempt to quantify some of a hospital's attitudes to, for example, patients' working.

4. The socio-medical indices describe the hospital's catchment population, that is the 'raw material' with which it deals.

Environmental Indices

| | |
|---|---|
| E1a | Index of hospital accessibility |
| E1b | Index of hospital inaccessibility |
| E1c | Distance from hospital to the nearest large town |
| E2a | No. of Welfare Service Social Workers per 1000 Catchment Population (UCP) |
| E2b | No. of Mental Health Social Workers per UCP |
| E2c | No. of places provided by the Local Authority for the mentally ill in workshops etc. per UCP |
| E3a | 'Official' contact between Local Authority and hospital |
| E3b | 'Actual' contact between Local Authority and hospital |
| E4 | Involvement of Voluntary Organizations |

The first three indices (E1a-c) are an attempt to measure the accessibility of a hospital to its catchment population. It was expected that this might affect staffing levels and some institutional variables as well as the other environmental variables and the performance indices (see e.g. Denham, 1965). The first two indices involve the breakdown of the catchment population into constituent parishes, each of which was taken to be concentrated at its population centre, which was estimated by eye.

The first index of accessibility, Ela, was the 'potential' of the hospital and was calculated as

$$\frac{1}{n} \sum_{a=1}^{n} \frac{P_a}{d_a}$$

where $P_a$ was the population size of unit a, distance $d_a$ from the hospital with a total of n units of population in its catchment area. This is analogous to the potential in a gravitational situation and indices of this kind, with different powers of $d_a$, have been used in socio-geographic work on, for example, shopping centres. (Wilson, 1970).

The centre of gravity of the catchment population was also calculated using parishes as the basic units of population and its distance from the hospital was taken to be a measure of inaccessibility, Elb. The third index of accessibility,Elc, was simply distance from the hospital to the nearest town over 10,000. This was assumed to be the distance to the nearest centre of communications; where the hospital was already in a large town the distance to the nearest main road was measured. All the distances used were 'as the crow flies' and were taken to be proportional to travelling time, which is obviously an important factor in any measure of accessibility. The second index and the general problem of choosing an index of accessibility are discussed in greater detail in Bytheway et al (1972).

Indices E2a-c deal with the facilities provided by the local authority or authorities in the hospital's catchment area and are taken from forms SBL 615 and 622, returned annually to the Department of Health. Indices E3 and E4 are from SBH 112. Index E3 quantifies the replies to question 13 which is as follows:

13. LIAISON WITH THE LOCAL AUTHORITY OR MINISTRY OF LABOUR AS AT 31ST DECEMBER 1967.

1. Is the Medical Officer of Health (or representative) a member of

   (a) the H.M.C?

   (b) the M.A.C?

2. Are social workers jointly employed by L.A. and hospital? If YES how many are jointly employed?

   If NO, do social workers of the L.H.A.

   (a) attend hospital regularly?

   (b) follow up patients when admitted to hospital?

   (c) " " " " discharged from hospital?

   (d) assist in out-patient clinics?

3. Are L.H.A. social workers designated members of the hospital/community team?

4. Do L.A. welfare department social workers visit patients in the hospital?

5. Are there regular arrangements with the Local Education Authority for assessment and re-assessment of children who may be suitable for education by them?

6. Does the Ministry of Labour Disablement Resettlement Officer

   (a) visit the hospital?

   (b) assist in placing patients in work?

7. Consultant psychiatrist working at the hospital

   (a) is a member of L.A. Health Committee?

   (b) attends L.A. Health Committee?

   If YES to (a) or (b); which L.A.'s are involved?

8. Is any consultant psychiatrist working at this hospital employed sessionally by any local authority?

Because of the widespread inapplicability of Question 5, it was excluded from the analysis.

Index E3a represents 'official contact' i.e. cross membership of Committees and Hospital Boards and joint employment between the Hospital and the Local Authority. It was quantified for each hospital by scoring 1 for each 'Yes' answer to Questions 1a, 1b, 2, 3, 7a, 7b and 8. The range of scores, therefore, on this index is from 0 to 7.

Index E3b represents 'actual contact' i.e. the regular, working co-ordination which actually takes place rather than the formal membership of Committees and the like. It was quantified for each hospital by scoring 1 for each 'Yes' answer to Questions 2a, 2b, 2c, 2d, 4, 6a and 6b. For Question 2 a 'Yes' answer was taken to imply 'Yes' for each of parts 2a to 2d and therefore scored 4. The range of scores, therefore, on this index is also from 0 to 7.

These indices were included because performance indices may be affected not only by the alternative community services available but also by the co-ordination with the Local Authority. The rationale behind the split between E3a and E3b is that official co-ordination does not necessarily imply actual working co-ordination. Either one could be a more potent explainer than the other.

Index E4 quantifies the replies to question 14 which is:

14. VOLUNTARY ORGANIZATIONS AS AT 31ST DECEMBER 1967.

Please describe the services provided by voluntary organizations including the League of Friends.

The returns for this question were examined and it was decided to divide the services of voluntary organizations into the following categories:

(i) Visiting of Patients.

(ii) Organization of trips and outings for Patients.

(iii) Provision of gifts or sending of birthday or Christmas cards to Patients.

(iv) Provision of general amenities or of funds for this purpose.

(v) The running of a canteen or shop for patients and/or visitors.

(vi) The provision of a patients' library.

(vii) Organization of a Darby and Joan or similar club and/or the organization of entertainments for patients.

Each hospital then scored 1 for the provision of services within one category by one voluntary organization. For example, the provision by the W.R.V.S. of services within three of the categories would score 3, as would three different voluntary organizations providing services within one category. There is clearly no theoretical upper limit to scores obtainable on this index, but it seems that only very exceptional hospitals would score more than 15.

This index was used in an attempt to find out how much work was done by voluntary organizations within the hospital. In some hospitals, facilities were provided by voluntary organizations which were part of the normal hospital provision in others, so in some cases the picture is misleading. All the facilities were given equal weight, which again may not reflect the true situation, but it was felt that even a poor index would give some idea of the importance of voluntary organizations in a hospital.

Professional Indices

Pr1a Consultant Psychiatrists.

Pr1b Other Psychiatric Medical Staff.

Pr2a Trained Nurses.

Pr2b Other Nurses.

Pr3a Psychologists.

Pr3b Psychiatric Social Workers.

Pr3c Therapists.

Pr3d Instructors/Teaching Staff.

Pr4 Domestic Assistants and Ward Orderlies.

All these are the number per 100 In-Patients and they are all taken from SBH 112. Their relevance is obvious.

Institutional Indices

These have been further sub-divided into those which deal with costing and those which do not.

In1a % Resident patients working in domestic and hospital service departments.

In1b % Resident patients working elsewhere i.e. handicrafts etc.

In2 % Patients in wards of 50 or more beds.

In3 Average % Bed occupancy.

In4 No. of years elapsed since qualification of Medical Superintendent.

In5a % of beds with space less than 50 sq.ft.

In5b % " " " " greater than 60 sq.ft.

In6 No. of visiting hours per week,

Indices In1-3 are taken from SBH 112 and deal with various aspects of hospital policy. It is possible that demand for beds from patients who wish to be admitted to hospital will increase discharge rates for non-clinical reasons. This will clearly be true only for hospitals which have high bed occupancy rates, i.e. when there is no 'slack' in the system, and will also be affected by the provision of out and day-patient facilities (Watt, 1956), so the analysis should determine the extent of this demand. Index In4 was obtained from the Medical Register for 1967 and was used in an attempt to find out how 'modern' a hospital was likely to be in its outlook, since it was thought that this would probably be related to the length of time for which the superintendent had been practising. Indices In5a and In5b were taken from a survey carried out by the Department of Health in 1969 on all hospitals except those in Wales and constituted a further attempt to find out the conditions in which patients lived. Index In6 was based on replies to question 15 in SBH 112 which asked whether hospitals had unrestricted, daily or less than daily visiting. Those hospitals with unrestricted visiting were taken to have 60 hours a week, on inspection of the usual hours during which visitors were likely to be present. The other hospitals were asked in writing for the exact visiting hours each week and almost all hospitals replied.

In-Patient Costing

IC1 Cost of drugs used on wards.

IC2 Total ward cost.

IC3a Cost of Pathology.

IC3b " " Pharmacy.

IC3c " " Ancillary Medicine.

IC4 Medical Service Departments cost.

IC5 Total cost.

All these costs were in £s per In-Patient per week and were obtained from the Regional Hospital Boards. IC5 is in fact the sum of IC2, IC4 and various other elements, such as catering and laundry, which were not included explicitly since they would be present in most institutions and were not specific to psychiatric hospitals. IC2 is the sum of IC1 and other elements of ward cost, including salaries of medical and nursing staff. IC4 is the sum of IC3a, IC3b, IC3c and other treatment facilities such as X-rays.

Out-Patient Costing

ICO1 Drug costs.

ICO2 Total Out-Patient Department costs.

ICO3 Cost for Treatment Departments only.

ICO4 Net total cost.

ICO5 Net total cost/Net total cost per In-Patient per week.

All these costs were in £s per 100 Out-Patient attendances. ICO1 is an element of ICO2, ICO2 and ICO3 are elements of ICO4. They were obtained from the Regional Hospital Boards but not all hospitals with in-patients had out-patient facilities and figures were obtained for only 62 hospitals.

The costs for different sorts of physical treatment in the medical service departments and for drugs, were included to see the relative weight a hospital gave to physical methods of treatment such as ECT, and to treatment using drugs.

Socio-Medical Indices

S1 % Catchment population who are male.

S2a % Male catchment population over 15 who are married.

S2b % Female catchment population over 15 who are married.

S3a % Male " " in Executive and Professional Classes.

S3b % Male " " in other Non-manual and Skilled Manual Classes.

S3c % Male " " in Semi-skilled and Unskilled Manual Classes.

S4 % Admitted patients who are informal admissions.

S5 % " " " " aged 65 or over.

S6 % " " " " male.

Indices S1-S3 were taken from the Registrar General's Census Tables for 1961 (Registrar General 1964 and 1966) and gave an indication of the make-up of the catchment population. The socio-economic group categories were summations of the 17 group categories as follows:

S3a Executive and Professional Classes : 1,2,3,4,13.

S3b Other Non-manual and Skilled Manual Classes : 5,6,8,9,12,14.

S3c Unskilled and Semi-skilled Manual Classes : 7,10,11,15.

Details of the 17 categories are given in Table 3.1.

These measures will give an idea of differences in morbidity of the catchment population, and in the possible outcome of treatment of patients. (Hollinshead and Redlich, 1958). No satisfactory measure of the extent of mental illness in a community which is unknown to doctors, social workers or hospitals has been derived. However, it is probably true that, as Wing and Hailey (1972) found in Camberwell, all severe cases of mental illness will eventually come into contact with the psychiatric services.

Indices S4 and S6 were obtained from the Regional Hospital Boards and S5 from SBH 112. These three indices give some idea of the general type of patient who uses a hospital. Information on diagnoses of patients was not included since the primary aim was to study the hospitals as institutions and it was felt that the emphasis given to different hospital functions would depend mainly on the explainer variables detailed above rather than on the characteristics of individual patients. It was, however, assumed that differences in diagnosis between Regional Hospital Boards were not very large. This assumption was tested on data from a Census carried out by the DHSS in 1970 and the results are given in Appendix 2. No significant differences between the Regional Hospital Boards were found except for patients with alcoholic psychoses and mental handicap. For similar reasons the only indication of the kind of home conditions to which a discharged patient would return was given by S1 -S3 above and no attempt was made to obtain information on individual patients.

TABLE 3.1

Executive and Professional Classes (S3a):-

1. Employers and Managers in central and local government, industry, commerce, etc. - large establishments.

2. Employers and Managers in industry, commerce, etc. - small establishments.

3. Professional workers - self employed.

4. Professional workers - employees.

13. Farmers - employers and managers.

Other Non-manual and Skilled Manual Classes (S3b):-

5. Intermediate non-manual workers.

6. Junior non-manual workers.

8. Foremen and Supervisors - manual.

9. Skilled manual workers.

12. Own account workers (other than professional).

14. Farmers - own account.

Unskilled and Semi-skilled Classes (S3c):-

7. Personal service workers.

10. Semi-skilled manual workers.

11. Unskilled manual workers.

15. Agricultural workers.

The following categories were excluded from the analysis:-

16. Members of armed forces.

17. Indefinite.

CHAPTER 4

## METHODS OF ANALYSIS

A large number of variables had now been selected, some because it was thought that they would be suitable as indices of the different functions of a hospital, and others because it was expected that they would be useful in explaining variation in these indices. As so little work has been done to examine the different ways in which hospitals carry out their functions it was thought that the analysis would be most fruitful if it began with this number of variables, all of which had some theoretical connection with a hospital's functions, and several of which were eliminated using the multivariate techniques described below.

The two initial aims of the study were:

1. To see how the variables chosen varied between hospitals and between Regional Hospital Boards.
2. To examine the relationships between the variables both within the groups outlined above and between the performance variables and the groups of explainer variables, with a view to selecting the most important.

The differences between hospitals, and even between Regions, of certain variables were noted at the beginning of Chapter 3, p.27 . To examine these differences in greater detail some basic descriptive statistics were first obtained for each variable. These were the mean, standard deviation, skewness and kurtosis and the results obtained are presented and commented on in Chapter 5.

To examine differences between the mean values of the variables for the Regional Hospital Boards an analysis of variance was carried out for each variable (Rao, 1965). Since the number of hospitals in each Board varies, the analysis of variance scheme used was a simple, completely randomized design, yielding a table of the form:

| Source | Degrees of freedom | Sum of Squares | Mean Square |
|---|---|---|---|
| Between Boards variation | (15 - 1) | $S_B$ | $S_B/14 = M_B$ |
| Residual | (99 - 15) | $S_R$ | $S_R/84 = M_R$ |
| Total | (99 - 1) | $S_T$ | |

$S_B$ is the sum of squares within boards, $S_T$ the total sum of squares and $S_R = S_T - S_B$. The ratio $M_B/M_R$ was tested using an F-test with 14 and 84 degrees of freedom. Significant values meant that the variable under consideration differed significantly between the Regional Hospital Boards; these F values are given, together with the other basic data, in tables in the next chapter.

To examine relationships between the variables it was necessary to employ certain multivariate techniques. Those chosen depended upon the underlying assumption that the variables examined were normally distributed. To this end the distributions of the variables were examined and where the departure from normality was severe the variable was transformed to bring it nearer to normality. The variables for which this was done are specified at the appropriate point in Chapter 5.

To examine the relationships between the indices within each group a principal components analysis was carried out. This determined first, the dimension of the space spanned by the group of indices, that is the number of significant eigenvalues of the correlation matrix, and second, the factor loadings of the indices on each eigenvector, which gave the relative importance of that index in that eigenvector or component. (Kendall and Stuart, 1968). The eigenvectors were derived in order of magnitude of their eigenvalues and were orthogonal and so independent. The ratio of the eigenvalue to the sum of the eigenvalues gave the percentage of variance explained by that eigenvector. It was thus possible to see which indices were important in accounting for variation in each group of variables. Eigenvalues greater than one were taken to be significant (Kaiser, 1960) and the components were rotated with a varimax rotation to obtain a clearer picture of the underlying structure (Kaiser, 1958). In the tables of results the principal components are re-scaled so that the largest loading is 1.0; only those loadings greater than 0.7 are included, to make it easier to identify the most important variables for each component (Jeffers, 1967).

Finally, since the performance indices were those whose variation it was considered most important to examine (Ch.3, p. 28 ), their relationship with each set of explainer variables was explored in turn. For this, canonical correlations analysis was considered appropriate to give 'some idea of the structure of the multivariate complex under study'. (Kendall and Stuart, 1968, p.305). This analysis explores the relationships between and within two sets of variables simultaneously. A series of pairs of canonical factors are derived, one factor in each pair being a linear combination of the first set of variables under consideration, and the second factor being a combination of the second set of variables. Each pair of canonical factors is correlated and they are so derived that the first pair has the maximum possible correlation of any pair of linear combinations of the variables. The second and subsequent pairs of factors are then derived so that they have maximum correlation with each other but are orthogonal to, and therefore independent of, all preceding factors, both within their own set of variables and in the other set. The correlations between the pairs of factors are called canonical correlations. The derivation of the canonical factors and correlations, and the way in which they are tested for significance is described in Appendix I.

The chief interest, though in each pair of canonical factors lies in the amount of variation in one, which is redundant to the variance in the other. The redundancy is a measure of the amount of overlap in variance between the two sets of variables, since even variables which are highly correlated with one another need not be important within their respective variable sets. We can derive the proportion of variance extracted from one set of variables by each canonical factor; we can also find what proportion of variance in one of a pair of factors is predictable from the other in the pair. The product of these proportions is the proportion of variance in one factor which is redundant to the variance in the second factor; it is called the redundancy $Rd_x$ for that factor x, and its derivation is described in greater detail in Appendix I.

Because of the symmetry of the situation we can also derive the redundancy of the second factor in a pair, given the availability of the first. Since each pair of canonical factors is independent of preceding pairs, the redundancy of one canonical factor is zero with respect to all factors except the other one in the pair of which it forms half. They can thus be summed to obtain the total redundancy of one set of variables, given the other set.

Once the sets of variables which were most strongly connected had been established, they were examined more closely with a view to determining at least some of the causal relationships within the system. The techniques used for this are described more fully in Chapter 6. The results of the preliminary analyses described above have been presented and discussed in the next chapter. The programmes used for the analysis of variance and the principal components analysis were written by the author. The programme for the canonical correlations analysis was a modification of the one in Cooley and Lohnes (1971). Copies of these programmes are given in Appendix 3.

CHAPTER 5

## RESULTS OF THE INITIAL ANALYSIS

These results are presented for each group of variables in turn. First the basic data and the principal components analysis (with the rotated factor matrix) are given and then the canonical correlations analysis for each group of explainer variables with the performance indices. Correlations significant at the 5% level or above are the only ones considered throughout. Finally a few of the most important variables in each group are selected for further analysis. In each case the text is followed by tables of the relevant data.

### I PERFORMANCE VARIABLES

#### (i) Basic data and Principal Components Analysis

An examination of the correlations between the three discharge rates (Pe5a-c, Table 5.3) shows that they are all highly correlated. It seems that nothing new is contributed by the revised rates so they were removed from further analysis.

An examination of the moments of the distributions of the variables (Table 5.1) showed that the out and day-patient variables all had extremely high skewness and kurtosis; it was decided to apply a square root transformation which decreased these measures and brought the variables nearer to normality. Only one of the F tests in the analysis of variance was significant - that on Pel.

Correlations between the other performance variables was very strong, 4/5 of the correlations being significant. These correlations were all positive except those of Pel with Pe3, Pe4, Pe5 and Pell. The correlations indicate that hospitals with high discharge and turnover rates have large numbers of out and/or day-patients and fewer in-patients. These hospitals would appear to be pursuing a policy of rapid admission and discharge with an emphasis on out and day-patient care rather than long term in-patient care. Other hospitals have the opposite policy and larger numbers of in-patients per unit catchment population. The correlations between Pel, Pe2 and Pe5 highlight one aspect of this. The correlations between Pel and Pe2, and between Pe5 and Pe2, are both positive while that between Pel and Pe5 is negative. Each of the correlations becomes larger when the effect of the third variable is removed. It would appear likely that the admission rate is composed of two elements. When discharges increase re-admissions usually increase and so the admission rate goes up. But if a hospital has a large number of in-patients the admission rate will also be high.

Four factors were significant in the principal components analysis: (after rotation) the first with loadings on Pe3 and Pe5, the second with loadings on the variables dealing with day-patients, the third with loadings on the variables dealing with out-patients and the fourth with loadings on Pel and Pe2.

The partial correlations of the out and day-patient variables were also examined. The correlation between Pe6 and Pel0 disappears when the effect of Pe8 is eliminated and that between Pe7 and Pell becomes significant and negative when the effect of Pe9 is eliminated. No other correlations changed on partialling.

(ii) Selection of Variables for Further Analysis

Their high correlation and similar weighting in the principal components analysis led to the decision to retain only one of Pe3 and Pe5. Partial correlation indicated that Pe3 explained little additional variation in the performance variables after the effect of Pe5 had been removed, so Pe3 was discarded.

Similar reasoning led to elimination of Pe6 and Pe10 from the group of out-patient variables and Pe7 and Pe11 from the group of day-patient variables. This left:

1) Pe1 No. of In-patients per 1000 Catchment Population (U.C.P.).

2) Pe2 No. of Annual Admissions per U.C.P.

3) Pe4 Patient Death Rate.

4) Pe5 Patient Discharge Rate.

5) Pe8 Total No. of Out-patient attendances per annum per U.C.P.

6) Pe9 Total " " Day-patient " " " " "

TABLE 5.1

Performance Indices - Basic Statistics

| Variable | Mean | Standard Deviation | Skewness | Kurtosis | F[1] |
|---|---|---|---|---|---|
| Pe 1 | 2.62 | 0.66 | 0.53 | 3.47 | 2.96** |
| Pe 2 | 3.37 | 1.03 | 1.50** | 7.31** | 0.73 |
| Pe 3 | 1.20 | 0.34 | 0.55 | 3.15 | 0.89 |
| Pe 4 | 0.04 | 0.01 | 1.11** | 5.45** | 1.50 |
| Pe 5a | 0.33 | 0.11 | 1.07** | 4.45** | 0.70 |
| Pe 5b | 0.51 | 0.16 | 0.07 | 2.77 | - |
| Pe 5c | 0.88 | 0.28 | 0.09 | 2.63 | - |
| Pe 6 | 3.40 | 1.46 | 1.40** | 6.20** | 1.00 |
| Pe 7 | 0.43 | 0.84 | 6.73** | 57.79** | 1.04 |
| Pe 8 | 22.84 | 13.40 | 3.11** | 20.04** | 0.78 |
| Pe 9 | 28.63 | 43.92 | 3.59** | 18.45** | 0.44 |
| Pe10 | 2.87 | 3.11 | 5.79** | 45.21** | 0.55 |
| Pe11 | 3.42 | 6.00 | 4.77** | 32.02** | 0.61 |

N.B. Variables 5b and 5c are on 32 hospitals only

* Significant at 5% level

** " " 1% level

1. F Value in Analysis of Variance.

TABLE 5.2

Performance Indices - Correlation Matrix

| | Pe1 | Pe2 | Pe3 | Pe4 | Pe5a |
|---|---|---|---|---|---|
| Pe 1 | 1 | 0.35** | −0.43** | −0.23* | −0.48** |
| Pe 2 | + | 1 | 0.65** | 0.31** | 0.61** |
| Pe 3 | − | + | 1 | 0.42** | 0.95** |
| Pe 4 | (−) | + | + | 1 | 0.42** |
| Pe 5a | − | + | + | + | 1 |
| Pe 6 | | + | + | (+) | + |
| Pe 7 | | | | | (+) |
| Pe 8 | | + | + | (+) | + |
| Pe 9 | | + | + | + | + |
| Pe10 | | | | | (+) |
| Pe11 | − | + | + | + | + |

* Significant at 5% level (+) or (−)

** Significant at 1% level + or −

| Pe6 | Pe7 | Pe8 | Pe9 | Pe10 | Pe11 |
|---|---|---|---|---|---|
| −0.01 | −0.06 | −0.02 | −0.16 | −0.18 | −0.28** |
| 0.53** | 0.16 | 0.34** | 0.37** | 0.01 | 0.28** |
| 0.51** | 0.19 | 0.33** | 0.46** | 0.13 | 0.47** |
| 0.25* | 0.01 | 0.22* | 0.32** | 0.19 | 0.37** |
| 0.53** | 0.20* | 0.39** | 0.54** | 0.21* | 0.59** |
| 1 | 0.30** | 0.58** | 0.37** | 0.29** | 0.38** |
| + | 1 | 0.15 | 0.39** | 0.07 | 0.31** |
| + |  | 1 | 0.30** | 0.52** | 0.32** |
| + | + | + | 1 | 0.28** | 0.95** |
| + |  | + | + | 1 | 0.31** |
| + | + | + | + | + | 1 |

TABLE 5.3

Performance Indices - Correlation Matrix of Discharge Rates[1]

| | Pe5a | Pe5b | Pe5c |
|---|---|---|---|
| Pe 5a | 1.00 | 0.94** | 0.83** |
| Pe 5b | + | 1.00 | 0.85** |
| Pe 5c | + | + | 1.00 |

1. 32 Hospitals

** Significant at 1% level

TABLE 5.4

Performance Indices - Principal Components Analysis (excluding 5b and 5c)

No. of eigenvalues greater than 1 = 4, explaining 78% of the variance.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalue | 4.59 | 1.52 | 1.32 | 1.19 |
| % Variance explained | 41.75 | 13.77 | 11.98 | 10.81 |
| Components | | | | |
| Pe 1 | | 1.00 | | |
| Pe 2 | -0.71 | 0.75 | | |
| Pe 3 | -0.94 | | | |
| Pe 4 | | | | |
| Pe 5a | -1.00 | | | |
| Pe 6 | -0.79 | | | |
| Pe 7 | | | | -1.00 |
| Pe 8 | | | | |
| Pe 9 | -0.86 | | | -0.77 |
| Pe10 | | | 1.00 | |
| Pe11 | -0.88 | | | |

The components have been re-scaled so that the largest entry is one and only loadings greater than 0.7 have been retained so that the relative importance of the different variables can be seen in each component.

TABLE 5.5

Performance Indices - Rotated Factor Matrix

No. of eigenvalues greater than 1 = 4, explaining 78% of the variance

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalue | 3.16 | 2.13 | 1.80 | 1.52 |
| % Variance explained | 28.76 | 19.37 | 16.40 | 13.79 |
| Components | | | | |
| Pe 1 | | | | 1.00 |
| Pe 2 | | | | 0.83 |
| Pe 3 | -1.00 | | | |
| Pe 4 | | | | |
| Pe 5 | -0.97 | | | |
| Pe 6 | | | | |
| Pe 7 | | -0.87 | | |
| Pe 8 | | | 0.94 | |
| Pe 9 | | -1.00 | | |
| Pe10 | | | 1.00 | |
| Pe11 | | -0.93 | | |

Entries are re-scaled so that the largest entry is one and only loadings greater than 0.7 have been retained so that the relative importance of the different variables can be seen in each component.

## II ENVIRONMENTAL VARIABLES

### (i) Basic Data and Principal Components Analysis

Differences in the mean values of the variables for the Regional Hospital Boards were significant for Elc, E2a and E2b, all at the 5% level. The difference for Elc probably reflects the fact that some hospitals are nearer the centres of large towns than others, and is therefore to be expected.

Correlation between these variables was generally poor. Of the accessibility variables, Ela and Elb were negatively correlated. This would be expected from the fact that 'accessible' hospitals should have high values on Ela and low values on Elb and Elc. The other correlations were all between the variables dealing with the services provided by the local authority. They were of E2b with E2a and E2c. All were positive, so that an authority which provided one service was generally good at providing others as well. The partial correlations were also examined but none changed.

Principal components analysis also showed that the variables were not very strongly related. The first component had loadings on E2a, E2b and E2c. The second had loadings on Ela and Elb, of opposite signs. The third component had loadings on E3a, E3b and E4; hospitals with good local authority contacts had high voluntary organization involvement. Finally the fourth component had loadings of opposite sign on Elc and E4, which indicates that hospitals far from town have less voluntary organization involvement.

After rotation the first two components remained almost the same. The third component now had loadings on E3b and E4, and the fourth on Elc and E3a, of the same sign.

(ii) Canonical Correlations Analysis

Correlation between the two sets of variables was not very strong and only one canonical correlation was significant. This indicated that hospitals with many in-patients, a high admission rate and a tendency to out-patient rather than day-patient care were in local authorities with large numbers of social workers, many training centre places and good 'actual' liaison. The two accessibility indices, Elb and Elc, were of opposite sign and therefore contradictory.

The correlations between the accessibility indices and the performance indices indicated that hospitals with low day-patient numbers would be inaccessible. The positive correlations between E2a-c and the performance indices were explored further. When either Pel or Pe5 is held constant by partial correlation the correlations of E2a-c with the other variable increase, and those with Pe5 become significant. It would appear that the negative interaction of the two performance variables acts so as to decrease their correlations with E2a-c.

(iii) Selection of Variables for Further Analysis

Both Ela and Elb were retained as measures of accessibility, since they had differing relationships with the performance variables in the canonical correlations analysis. E1c was discarded, since it had no significant correlation with either the performance or the environmental variables. E2a and E2b had similar relationships with the other variables, so it was decided to sum them to form E2, the total number of social workers. E2c was discarded since it contributed nothing more than the other local authority variables already had done. Of the remaining variables it was decided to retain E3a and E4 because of the loadings on the last two principal components. Thus the variables retained were:

1) E1a Index of hospital accessibility.

2) E1b Index of hospital inaccessibility.

3) E2 Total no. of Social Workers per 1000 Catchment Population.

4) E3a 'Official' contact between Local Authority and hospital.

5) E4 Involvement of Voluntary Organizations.

TABLE 5.6

Environmental Variables - Basic Statistics

| Variable | Mean | Standard Deviation | Skewness | Kurtosis | F |
|---|---|---|---|---|---|
| E1a | 14.04 | 16.77 | 1.99** | 6.80** | 1.27 |
| E1b | 7.07 | 4.38 | 0.95** | 3.51 | 0.95 |
| E1c | 3.27 | 1.74 | 0.68** | 3.32 | 2.30* |
| E2a | 0.06 | 0.03 | 1.71** | 8.77** | 2.01* |
| E2b | 0.04 | 0.01 | 0.44 | 2.73 | 1.97* |
| E2c | 0.05 | 0.10 | 3.30** | 17.46** | 1.68 |
| E3a | 2.47 | 1.64 | 0.63** | 3.03 | 0.89 |
| E3b | 5.94 | 1.38 | -1.41** | 4.10 | 1.22 |
| E4 | 6.64 | 3.58 | 1.38** | 6.33** | 0.48 |

* Significant at 5% level

** Significant at 1% level

TABLE 5.7

Environmental Variables - Correlation Matrix

| | E1a | E1b | E1c | E2a |
|---|---|---|---|---|
| E1a | 1 | -0.42** | -0.17 | 0.06 |
| E1b | - | 1 | 0.13 | 0.17 |
| E1c | | | 1 | -0.05 |
| E2a | | | | 1 |
| E2b | | | | + |
| E2c | | | | |
| E3a | | | | |
| E3b | | | | |
| E4 | | | | |

| E2b | E2c | E3a | E3b | E4 |
|---|---|---|---|---|
| 0.14 | 0.16 | 0.17 | 0.13 | −0.12 |
| 0.11 | 0.10 | −0.13 | −0.03 | −0.00 |
| −0.10 | −0.07 | 0.11 | −0.09 | −0.05 |
| 0.54** | 0.17 | −0.04 | 0.10 | −0.03 |
| 1 | 0.49** | 0.07 | 0.18 | −0.04 |
| + | 1 | 0.17 | 0.12 | −0.03 |
| | | 1 | 0.17 | 0.05 |
| | | | 1 | 0.13 |
| | | | | 1 |

TABLE 5.8

Environmental Variables - Principal Components Analysis

No. of eigenvalues greater than 1 = 4, explaining 65% of the variance

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalue | 2.01 | 1.58 | 1.18 | 1.11 |
| % Variance explained | 22.29 | 17.55 | 13.13 | 12.37 |
| Components | | | | |
| E1a | | -0.86 | | |
| E1b | | 1.00 | | |
| E1c | | | | -1.00 |
| E2a | 0.76 | | | |
| E2b | 1.00 | | | |
| E2c | 0.82 | | | |
| E3a | | | 0.94 | |
| E3b | | | 0.79 | |
| E4 | | | 1.00 | 0.87 |

TABLE 5.9

<u>Environmental Variables - Rotated Factor Matrix</u>

No. of eigenvalues greater than 1 = 4, explaining 65% of the variance

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalue | 1.96 | 1.59 | 1.17 | 1.16 |
| % Variance explained | 21.77 | 17.64 | 13.01 | 12.91 |
| Components | | | | |
| E1a | | 1.00 | | |
| E1b | | -0.97 | | |
| E1c | | | | 0.87 |
| E2a | 0.83 | | | |
| E2b | 1.00 | | | |
| E2c | 0.77 | | | |
| E3a | | | | 1.00 |
| E3b | | | 0.76 | |
| E4 | | | 1.00 | |

TABLE 5.10

Environmental Variables - Correlation Matrix with Performance Indices [1]

| | E1a | E1b | E1c | E2a | E2b | E2c | E3a | E3b | E4 |
|---|---|---|---|---|---|---|---|---|---|
| Pe 1 | | | | 0.28 | 0.34 | | | | |
| Pe 2 | | | | 0.26 | 0.29 | 0.24 | | | |
| Pe 3 | | | | | | | 0.24 | | |
| Pe 4 | | | | | | | 0.30 | | |
| Pe 5 | | | | | | | 0.24 | | |
| Pe 6 | | | | | | | | | |
| Pe 7 | | -0.25 | | | | | | | |
| Pe 8 | | | | | | | | | |
| Pe 9 | 0.36 | -0.38 | | | | | | | |
| Pe10 | | | | | | | | | |
| Pe11 | 0.36 | -0.36 | | | | | | | |

1. Only correlations significant at the 5% level or above are shown.

TABLE 5.11

Environmental Variables - Canonical Correlations with Performance Indices[1]

| | |
|---|---|
| $\lambda$ | 0.2079 |
| $\chi^2$ | 138.99** |
| df | 99 |
| $r^2$ | 0.3957 |
| cc | 0.6290 |

| | Pe | E |
|---|---|---|
| 1 | 0.495 | |
| 2 | 0.382 | 0.422 |
| 3 | | −0.422 |
| 4 | | 0.617 |
| 5 | | 0.722 |
| 6 | | 0.539 |
| 7 | −0.353 | |
| 8 | 0.220 | 0.315 |
| 9 | −0.224 | |
| 10 | 0.214 | |
| 11 | −0.299 | |
| Variance (V) | 0.072 | 0.187 |
| Redundancy (R) | 0.028 | 0.074 |

Total Pe V = 0.770     Total E V = 1.000

" Pe R = 0.128     " E R = 0.176



1. Only those loadings greater than 0.2 are shown. $r^2$ is the square of the cannonical correlation (c.c.) $\lambda$ is Wilk's $\lambda$ (see Appendix 2) Its significance is tested by the $\chi 2$ below it.

## III PROFESSIONAL VARIABLES

### (i) Basic Data and Principal Components Analysis

For the professional variables differences between Boards were only significant for Pr1a, the number of consultants and Pr2b the number of untrained nurses. All the variables were very strongly correlated with each other except for Pr3a. The correlations were all positive, indicating that hospitals with high levels of one sort of staff had high levels of others, and those correlations were generally still strong even when the effect of other professional variables was removed by partialling.

Only two factors were significant. The first had loadings on all the variables except Pr3c and Pr3d and the second, which was rather less important, had a loading only on Pr3d. From this, and the correlations, it would appear that the level of provision of instructors and teaching staff is unrelated to other staffing levels. The factors hardly changed when rotated.

### (ii) Canonical Correlations Analysis

The overall correlation between the groups of variables was strong except with Pr3d. All the correlations were positive except those with Pe1, which were negative. Hospitals with fewer in-patients, higher turnover and many out and day-patients also have high staff-patient ratios.

The canonical factors demonstrate this also. The first pair had positive loadings on all the variables, except Pel which had a negative loading and Pr3d which had no loading. The second pair of factors indicated that hospitals with an emphasis on out-patient as opposed to day-patient care are those with larger numbers of untrained nurses (Pr2b), psychiatric social workers and therapists (Pr3b and Pr3c) and ward orderlies (Pr4), as opposed to more consultant psychiatrists (Prla) and instructors and teaching staff (Pr3d). This set of relationships clearly needs further investigation.

It was decided to investigate in detail the reason for high staffing levels being associated with high turnover and few in-patients per unit catchment population. It appears that the more patients there are, the fewer staff there are to care for them and this is borne out by an examination of the correlations between Prla (for example), Pel, Pe5 and hospital size. Large hospitals are precisely those with many in-patients, fewer consultants and lower discharge rates. However it is apparent that there is no relationship between size and the number of in-patients if the effects of staff level or discharge rate, or both, are removed. Neither is size connected with discharge rate when the effect of the staff level is removed. Finally staff level is no longer correlated with the number of in-patients when the effect of the discharge rate is removed. It would appear that small hospitals have high staff-patient ratios, therefore a high discharge rate and therefore fewer in-patients.

(iii) <u>Selection of Variables for Further Analysis</u>

Since the variables were so strongly correlated, with the first principal component explaining 41.71% of the total variance, it was decided to use the factor scores on the two significant factors as the variables for further analysis. Thus P1 was a measure of overall staffing and P2 was a measure of the emphasis on staff for the training and instruction of patients. Because of their derivation, these two variables were independent and they were scaled to have a mean of zero and variance unity. Thus the variables chosen were:

1) P1 Overall staffing.

2) P2 Training and Instruction staff.

Analyses of variance were carried out on these two variables to see whether the difference found between Boards persisted. Neither result was significant.

TABLE 5.12

Professional Variables - Basic Statistics

| Variable | Mean | Standard Deviation | Skewness | Kurtosis | F |
|---|---|---|---|---|---|
| Pr1a | 0.50 | 0.21 | 1.36** | 5.26** | 2.98** |
| Pr1b | 0.89 | 0.41 | 2.39** | 13.58 | 1.26 |
| Pr2a | 11.57 | 2.76 | 0.68 | 2.94 | 0.82 |
| Pr2b | 17.80 | 3.81 | 0.48 | 3.48 | 2.26* |
| Pr3a | 0.15 | 0.20 | 3.09** | 16.19** | 0.81 |
| Pr3b | 0.32 | 0.24 | 0.94** | 3.45 | 1.32 |
| Pr3c | 0.77 | 0.64 | 1.37** | 4.64** | 1.23 |
| Pr3d | 0.14 | 0.20 | 3.22** | 16.83** | 0.56 |
| Pr4 | 5.11 | 1.96 | 0.53 | 3.56 | 1.20 |

* Significant at 5% level

** " " 1% "

TABLE 5.13

Professional Variables - Correlation Matrix

| | Pr1a | Pr1b | Pr2a | Pr2b | Pr3a |
|---|---|---|---|---|---|
| Pr1a | 1 | 0.58** | 0.56** | 0.44** | 0.33** |
| Pr1b | + | 1 | 0.60** | 0.51** | 0.50** |
| Pr2a | + | + | 1 | 0.46** | 0.28** |
| Pr2b | + | + | + | 1 | 0.42** |
| Pr3a | + | + | + | + | 1 |
| Pr3b | + | + | + | + | + |
| Pr3c | + | + | + | | (+) |
| Pr3d | | | | | |
| Pr4 | + | + | + | + | + |

| Pr3b | Pr3c | Pr3d | Pr4 |
|---|---|---|---|
| 0.50** | 0.32** | 0.07 | 0.29** |
| 0.50** | 0.26** | 0.07 | 0.36** |
| 0.52** | 0.26** | −0.12 | 0.39** |
| 0.49** | 0.11 | 0.10 | 0.41** |
| 0.37** | 0.24* | 0.19 | 0.37** |
| 1 | 0.33** | 0.08 | 0.30** |
| + | 1 | 0.05 | 0.20* |
| | | 1 | −0.05 |
| + | (+) | | 1 |

TABLE 5.14

Professional Variables - Principal Components Analysis

No. of eigenvalues greater than 1 = 2, explaining 55% of the variance.

| | 1 | 2 |
|---|---|---|
| Eigenvalue | 3.81 | 1.14 |
| % Variance explained | 42.32 | 12.64 |
| Components | | |
| Pr1a | 0.93 | |
| Pr1b | 1.00 | |
| Pr2a | 0.93 | |
| Pr2b | 0.89 | |
| Pr3a | 0.78 | |
| Pr3b | 0.91 | |
| Pr3c | | |
| Pr3d | | 1.00 |
| Pr4 | 0.72 | |

Table 5.15

Professional Variables - Rotated Factor Matrix

No. of eigenvalues greater than 1 = 2, explaining 55% of the variance.

| | 1 | 2 |
|---|---|---|
| Eigenvalue | 3.75 | 1.17 |
| % Variance explained | 41.71 | 13.10 |
| Components | | |
| Pr1a | 0.95 | |
| Pr1b | 1.00 | |
| Pr2a | 1.00 | |
| Pr2b | 0.87 | |
| Pr3a | 0.72 | |
| Pr3b | 0.91 | |
| Pr3c | | |
| Pr3d | | 1.00 |
| Pr4 | 0.72 | |

TABLE 5.16

Professional Variables - Correlation Matrix with Performance Variables

| | Pr1a | Pr1b | Pr2a | Pr2b | Pr3a | Pr3b | Pr3c | Pr3d | Pr4 |
|---|---|---|---|---|---|---|---|---|---|
| Pe1 | −0.41 | −0.30 | −0.26 | −0.25 | | −0.27 | | | −0.30 |
| Pe2 | 0.24 | 0.29 | 0.26 | 0.27 | 0.20 | 0.20 | | | |
| Pe3 | 0.58 | 0.47 | 0.44 | 0.42 | 0.34 | 0.42 | | | 0.39 |
| Pe4 | 0.30 | | | | | | | | 0.20 |
| Pe5 | 0.65 | 0.57 | 0.52 | 0.52 | 0.40 | 0.52 | 0.24 | | 0.41 |
| Pe6 | 0.49 | 0.37 | 0.32 | 0.27 | 0.26 | 0.36 | | | |
| Pe7 | 0.34 | 0.39 | 0.34 | 0.35 | 0.21 | 0.38 | 0.37 | | 0.24 |
| Pe8 | 0.63 | 0.39 | 0.42 | 0.27 | 0.21 | 0.27 | 0.20 | | |
| Pe9 | 0.42 | 0.50 | 0.47 | 0.51 | 0.32 | 0.51 | 0.44 | | 0.36 |
| Pe10 | 0.53 | 0.33 | 0.35 | | | 0.27 | 0.27 | | |
| Pe11 | 0.55 | 0.54 | 0.51 | 0.54 | 0.35 | 0.56 | 0.47 | | 0.36 |

TABLE 5.17

Professional Variables - Canonical Correlations with Performance Indices

| | | | | |
|---|---|---|---|---|
| λ | 0.0706 | | 0.3080 | |
| $\chi^2$ | 234.63 | | 104.57 | |
| df | 99 | | 80 | |
| $r^2$ | 0.7709 | | 0.3839 | |
| cc | 0.8780 | | 0.6236 | |
| | Pe | Pr | Pe | Pr |
| 1 | −0.460 | 0.898 | | −0.373 |
| 2 | 0.351 | 0.752 | | |
| 3 | 0.682 | 0.725 | | |
| 4 | 0.259 | 0.672 | | 0.379 |
| 5 | 0.812 | 0.470 | | |
| 6 | 0.555 | 0.685 | | 0.340 |
| 7 | 0.512 | 0.493 | 0.423 | 0.270 |
| 8 | 0.653 | | −0.490 | −0.251 |
| 9 | 0.722 | 0.385 | 0.434 | 0.332 |
| 10 | 0.561 | | −0.381 | |
| 11 | 0.805 | | 0.370 | |
| Variance | 0.364 | 0.383 | 0.087 | 0.080 |
| Redundancy | 0.281 | 0.295 | 0.034 | 0.031 |

Total Pe V = 0.850     Total Pr V = 1.00

Total Pe R = 0.347     Total Pr R = 0.377

## IV INSTITUTIONAL VARIABLES

### (i) Basic Data and Principal Components Analysis

Differences between Boards were significant for In1a and In6. The correlations between the variables were not very strong and this is also shown in the factors of the principal components analysis. After rotation the first had loadings on In5a, In5b, and In6, the first loading being negative and the other two positive, i.e. hospitals with high bed-space have long visiting hours, which is borne out by the correlations between the variables.

The second factor had negative loadings on In1a and In3 and a positive loading on In1b. The opposite signs for In1a and In1b indicate that patients either work in domestic and hospital service departments or outside the hospital, and the hospital considers that the fact that the patients are working is more important than where they work. However, hospitals where the patients are employed internally also have high bed occupancy. From the correlations it would also seem that hospitals with patients employed outside have low bed occupancy and few patients in large or over-crowded wards.

Thus a type of hospital emerges which has patients who work outside, low bed occupancy, small, uncrowded wards and long visiting hours i.e. it has high values of In1b, In5b and In6, and low values of In1a, In2, In3 and In5a. This type of hospital might be called 'progressive'. Conversely hospitals with patients working inside have low values of In1b, In5b and In6, and high values of In1a, In2, In3 and In5a. Variable In4, which has no significant correlations with any other variable seems to be independent of this concept and is the only variable with a loading on the third significant factor.

(ii) Canonical Correlations Analysis

The variables most strongly correlated with the performance indices are In1b, which has all positive correlations, and In2, In3 and In5a, which all have negative correlations. The two significant canonical factors show that the hospitals which have low in-patient numbers, high turnover and discharge rates and many out and day-patients are precisely those which were called 'progressive' above i.e. with patients working outside the hospital with small, uncrowded wards and a low bed occupancy. In4, which did not fit into this scheme, is negatively correlated with Pe8, the number of out-patient attendances, a correlation which does not have an obvious explanation.

These relationships were explored further using partial correlations. The correlations of In1b, In2 and In3 with Pe8-11 were examined. Those of In1b and In2 remained almost unaltered when the effect of Pe5, the discharge rate, was partialled out but three of the four correlations with In3 disappeared when the effect of Pe5 was removed, indicating that these correlations were mainly due to the mutual correlation with the discharge rate. Similarly the correlations of In5a with Pe8-11 all reduced and the two significant ones disappeared when the effect of Pe5 was removed. The negative correlation of bed occupancy with discharge rate suggests that fears that patients are often discharged simply to make room for new admissions are unjustified.

(iii) Selection of Variables for Further Analysis

Since In2 is negatively correlated with In1b and generally behaves in the opposite way, it was decided to discard it. Variables In5a, In5b and In6 were all fairly strongly correlated and In5a seemed to have the opposite relations to In5b and In6, so it was decided that only one of these variables was necessary. In5a was retained, since it was more strongly related to the performance indices. In4 was also retained, since it behaved independently of the other variables.

This left:

1) In1a % of Patients working in domestic and hospital service departments.
2) In1b % of Patients working elsewhere.
3) In3 % Bed Occupancy.
4) In4 No. of years elapsed since qualification of Medical Superintendent.
5) In5a % of Beds with a space less than 50 sq.ft.

TABLE 5.18

Institutional Variables - Basic Statistics

| Variable | Mean | Standard Deviation | Skewness | Kurtosis | F |
|---|---|---|---|---|---|
| In1a | 26.12 | 10.33 | 0.09 | 2.48 | 2.05* |
| In1b | 37.39 | 11.97 | 0.67** | 3.62 | 1.63 |
| In2 | 27.06 | 21.02 | 0.42 | 2.29 | 1.35 |
| In3 | 90.41 | 6.70 | -1.38** | 5.47** | 1.00 |
| In4 | 28.91 | 6.21 | -0.31 | 3.05 | 0.69 |
| In5a | 18.25 | 19.74 | 1.67** | 5.98** | 1.23 |
| In5b | 45.77 | 25.53 | -0.04 | 2.42 | 0.93 |
| In6 | 44.03 | 20.89 | -0.76** | 1.82** | 3.96** |

* Significant at 5% level

** Significant at 1% level

TABLE 5.19

<u>Institutional Variables - Correlation Matrix</u>

| | In1a | In1b | In2 | In3 |
|---|---|---|---|---|
| In1a | 1 | −0.30** | 0.16 | 0.11 |
| In1b | — | 1 | −0.25* | −0.29** |
| In2 | | (—) | 1 | 0.14 |
| In3 | | — | | 1 |
| In4 | | | | |
| In5a | | (—) | (+) | |
| In5b | | | — | |
| In6 | | | | |

| In4 | In5a | In5b | In6 |
|---|---|---|---|
| 0.07 | −0.05 | −0.05 | 0.06 |
| −0.14 | −0.24* | 0.19 | 0.06 |
| 0.18 | 0.20* | −0.30** | −0.15 |
| 0.01 | 0.08 | −0.13 | −0.12 |
| 1 | 0.07 | −0.07 | −0.03 |
| | 1 | −0.46** | −0.24* |
| | — | 1 | 0.28** |
| | | + | 1 |

TABLE 5.20

Institutional Variables - Principal Components Analysis

No. of eigenvalues greater than 1 = 3, explaining 56% of the variance.

| | 1 | 2 | 3 |
|---|---|---|---|
| Eigenvalue | 2.16 | 1.33 | 1.03 |
| % Variance explained | 26.98 | 16.62 | 12.83 |
| Components | | | |
| In1a | | 1.00 | |
| In1b | 0.88 | | |
| In2 | -0.87 | | |
| In3 | | | -0.75 |
| In4 | | | 1.00 |
| In5a | -0.92 | | |
| In5b | 1.00 | | |
| In6 | | | |

TABLE 5.21

Institutional Variables - Rotated Factor Matrix

No. of eigenvalues greater 1 = 3, explaining 56% of the Variance.

| | 1 | 2 | 3 |
|---|---|---|---|
| Eigenvalue | 1.84 | 1.54 | 1.12 |
| % Variance explained | 22.94 | 19.23 | 14.03 |
| Components | | | |
| In1a | | -0.87 | |
| In1b | | 1.00 | |
| In2 | | | |
| In3 | | -0.89 | |
| In4 | | | 1.00 |
| In5a | -0.98 | | |
| In5b | 1.00 | | |
| In6 | 0.85 | | |

TABLE 5.22

Institutional Variables - Correlation Matrix with Performance Indices

| | In1a | In1b | In2 | In3 | In4 | In5a | In5b | In6 |
|---|---|---|---|---|---|---|---|---|
| Pe1 | | | | | | | | |
| Pe2 | | | | | | | | |
| Pe3 | | | −0.22 | | | | | |
| Pe4 | | | | −0.34 | | | | |
| Pe5 | | 0.23 | −0.25 | −0.36 | | | | |
| Pe6 | | | | | | −0.20 | | |
| Pe7 | | | −0.25 | | | | | |
| Pe8 | | 0.35 | −0.20 | −0.22 | −0.20 | | | |
| Pe9 | | 0.36 | −0.32 | −0.24 | | −0.21 | | |
| Pe10 | | | | −0.33 | | −0.20 | | |
| Pe11 | | 0.34 | −0.33 | −0.31 | | | | |

TABLE 5.23

<u>Institutional Variables - Canonical Correlations with Performance Indices</u>

| | | | | |
|---|---|---|---|---|
| λ | 0.0393 | | 0.3375 | |
| $\chi^2$ | 288.15 | | 96.80 | |
| df | 88 | | 70 | |
| $r^2$ | 0.8837 | | 0.4040 | |
| cc | 0.9401 | | 0.6356 | |
| | Pe | In | Pe | In |
| 1 | −0.217 | | | −0.444 |
| 2 | | 0.284 | | 0.869 |
| 3 | | | 0.300 | −0.429 |
| 4 | 0.373 | −0.982 | | |
| 5 | 0.367 | | 0.289 | −0.469 |
| 6 | | | 0.284 | −0.215 |
| 7 | | | 0.327 | |
| 8 | 0.261 | | 0.523 | |
| 9 | 0.241 | | 0.556 | |
| 10 | 0.379 | | | |
| 11 | 0.322 | | 0.482 | |
| Variance | 0.066 | 0.137 | 0.116 | 0.177 |
| Redundancy | 0.054 | 0.121 | 0.047 | 0.071 |
| | Total Pe V = 0.792 | | Total In V = 1.00 | |
| | Total Pe R = 0.182 | | Total In R = 0.248 | |

## V COSTING VARIABLES

### (i) Basic Data and Principal Components Analysis

The costing data were initially divided into those for in-patients and those for out-patients, since the latter were available for 62 hospitals only, these being the one with out-patient clinics of their own as opposed to facilities in a general hospital. Differences between Boards were found for IC3b and 4 but for no out-patient costing variables.

All the correlations were positive and they were generally very strong, indicating that if a hospital spends a lot in one area it spends more on everything else, rather than spending on one aspect at the expense of others. This bears out the findings of Moores and Casmas (1972) on subnormality hospitals and of Ullmann (1967) in the United States.

For the in-patient variables there were two significant factors in the principal components analysis. After rotation the first had loadings on IC1, IC2 and IC5 and appears to be an overall expenditure factor. The second had loadings on IC3a, IC3c and IC4 and appears to be a treatment factor.

The partial correlations confirmed the strong correlations as most of them remained significant. However some of the inter-correlations between IC3a, IC3b and IC3c were reduced when the effect of IC4 was removed.

For the out-patient variables there were not as many significant correlations but they too were all positive. The first component had loadings on ICO2, ICO4 and ICO5 and is again an overall expenditure factor. The second factor had a negative loading on ICO1 and a positive loading on ICO3 and seems to be a treatment factor, with an emphasis either on drugs or on traditional methods in a treatment department. Again the correlations remained significant when the the partial correlations were examined.

The correlations between the in-patient and out-patient variables were also examined. The only significant correlations were negative ones between ICO5 and some of the in-patient variables and between IC2 and ICO3. The negative correlations are to be expected since a hospital which spends a lot on in-patients will have a high value of IC5 and the other in-patient variables, and therefore a low value of ICO5. The lack of other significant correlations indicates that the two sets of variables are weakly related.

(ii) <u>Canonical Correlations Analysis</u>

The in-patient and out-patient costing variables were again analysed separately.

For the in-patient variables there was only one significant correlation but the redundancy of each of the two factors due to the other was very high. The loadings on all the variables were positive, except that on Pel, which was negative. The correlation matrix showed that IC1, IC2, IC3c, IC4 and IC5 were most strongly related to the performance variables, all the correlations being positive, except those with Pel, which were negative. Hospitals with high turnover and an emphasis on out and day-patient rather than in-patient care are those with a high level of expenditure.

The partial correlations showed that several of these correlations were spurious. For instance the correlations of IC1 with Pe3 and Pe9 disappeared and that with Pe8 was reduced when the effect of Pe5 was eliminated. The correlations of costing variables with hospital size were also examined and these were found to be negative, like those of Pel. It seems likely that the negative correlations of Pel are due to the fact that it is large hospitals which tend to have more in-patients per unit catchment population.

The relationships between the out-patient costing variables and the performance indices were much less strong, the only significant correlations being negative ones between IC05 and some performance indices and two positive correlations between IC01 and Pe9 and Pell, variables dealing with day-patients.

The correlations of IC05 with Pe9 and Pell disappear when the effect of Pe5 is removed,so it appears to be the discharge rate which determines the greater expenditure on in-patients.

As might be expected there was no significant canonical correlation. However the first pair of factors was examined. The significant loadings were negative on all the performance indices, except Pel and on IC01, and positive on Pel and IC03, IC04 and IC05. Hospitals with rapid turnover and an orientation to out and day-patient care spend relatively less on their out-patients, except on drugs. In other words, when there is a lot of work in out-patient departments due to rapid discharge then the cost per out-patient is less and the cost per week of in-patient treatment relatively greater.

(iii) Selection of variables for further analysis

As with the professional variables, it was decided to use the factor scores on the two significant factors for both the in-patient and the out-patient variables since the inter-correlations were so strong. In both cases the first factor was an overall expenditure factor and the second was a treatment factor. As before the factors were scaled to have a mean of zero and unit variance. Thus the variables chosen were:

1) C1 Overall in-patient expenditure.
2) C2 In-patient treatment "
3) CO1 Overall out-patient "
4) CO2 Out-patient treatment "

Analyses of variance were also carried out on these variables. C1 was found to vary between Boards with the F test being significant at the 1% level. CO2 gave an F test significant at the 5% level. The two remaining variables did not differ significantly.

TABLE 5.24

Costing Variables (In-Patients) - Basic Statistics

| Variable | Mean | Standard Deviation | Skewness | Kurtosis | F |
|---|---|---|---|---|---|
| IC1 | 0.30 | 0.06 | -0.24 | 2.81 | 1.75 |
| IC2 | 6.49 | 1.06 | 0.69** | 3.57 | 1.59 |
| IC3a | 0.07 | 0.05 | 1.65** | 6.52** | 1.24 |
| IC3b | 0.06 | 0.03 | 0.54 | 3.41 | 2.18* |
| IC3c | 0.38 | 0.19 | 0.45 | 2.76 | 1.33 |
| IC4 | 0.55 | 0.23 | 0.46 | 2.52 | 1.01 |
| IC5 | 14.69 | 2.29 | 1.13** | 5.10** | 2.13* |

TABLE 5.25

Costing Variables (Out-Patients)[1] - Basic Statistics

| Variable | Mean | Standard Deviation | Skewness | Kurtosis | F |
|---|---|---|---|---|---|
| ICO1 | 23.10 | 30.47 | 1.51** | 4.50 | 0.65 |
| ICO2 | 143.93 | 134.14 | 2.37** | 9.96** | 1.11 |
| ICO3 | 47.69 | 72.94 | 2.41** | 8.77** | 1.51 |
| ICO4 | 281.97 | 186.64 | 2.29** | 9.82** | 1.26 |
| ICO5 | 19.66 | 13.58 | 1.99** | 7.70** | 1.76 |

* Significant at 5% level

** Significant at 1% level

1. 62 Hospitals only

TABLE 5.26

Costing Variables (In-Patients) - Correlation Matrix

| | IC1 | IC2 | IC3a | IC3b | IC3c |
|---|---|---|---|---|---|
| IC1 | 1 | 0.66** | 0.14 | 0.34** | 0.38** |
| IC2 | + | 1 | 0.25* | 0.47** | 0.43** |
| IC3a | | (+) | 1 | 0.25* | 0.14 |
| IC3b | + | + | (+) | 1 | 0.48** |
| IC3c | + | + | | + | 1 |
| IC4 | + | + | + | + | + |
| IC5 | + | + | (+) | + | + |

| IC4 | IC5 |
| --- | --- |
| 0.42** | 0.58** |
| 0.56** | 0.91** |
| 0.44** | 0.22* |
| 0.59** | 0.54** |
| 0.91** | 0.58** |
| 1 | 0.66** |
| + | 1 |

TABLE 5.27

Costing Variables (Out-Patients) - Correlation Matrix

| | ICO1 | ICO2 | ICO3 | ICO4 | ICO5 |
|---|---|---|---|---|---|
| ICO1 | 1 | 0.38** | −0.16 | 0.21 | 0.19 |
| ICO2 | + | 1 | −0.01 | 0.88** | 0.83** |
| ICO3 | | | 1 | 0.37** | 0.43** |
| ICO4 | | + | + | 1 | 0.96** |
| ICO5 | | + | + | + | 1 |

TABLE 5.28

Costing Variables (In-Patients and Out-Patients) - Correlation Matrix

| | IC1 | IC2 | IC3a | IC3b | IC3c | IC4 | IC5 |
|---|---|---|---|---|---|---|---|
| ICO1 | 0.12 | 0.08 | −0.03 | −0.00 | −0.02 | −0.03 | 0.01 |
| ICO2 | −0.07 | −0.08 | 0.01 | 0.05 | −0.06 | −0.08 | −0.09 |
| ICO3 | −0.12 | −0.22** | −0.08 | 0.02 | −0.01 | −0.02 | −0.19 |
| ICO4 | −0.13 | −0.16 | −0.07 | 0.06 | −0.04 | −0.07 | −0.15 |
| ICO5 | −0.28 | −0.33** | −0.12 | −0.04 | −0.14 | −0.20** | −0.33** |

TABLE 5.29

Costing Variables (In-Patients) - Principal Components Analysis

No. of eigenvalues greater than 1 = 2, explaining 72% of the variance.

| | 1 | 2 |
|---|---|---|
| Eigenvalue | 4.00 | 1.02 |
| % Variance explained | 57.14 | 14.58 |
| Components | | |
| IC1 | 0.76 | -0.72 |
| IC2 | 0.95 | |
| IC3a | | 1.00 |
| IC3b | 0.79 | |
| IC3c | 0.87 | |
| IC4 | 0.99 | |
| IC5 | 1.00 | |

TABLE 5.30

Costing Variables (Out-Patients) - Principal Components Analysis

No. of eigenvalues greater than 1 = 2, explaining 85% of the variance.

| | 1 | 2 |
|---|---|---|
| Eigenvalue | 2.98 | 1.27 |
| % Variance explained | 59.58 | 25.33 |
| Components | | |
| ICO1 | | -0.91 |
| ICO2 | 0.93 | |
| ICO3 | | 1.00 |
| ICO4 | 1.00 | |
| ICO5 | 0.99 | |

TABLE 5.31

Costing Variables (In-Patients) - Rotated Factor Matrix

No. of eigenvalues greater than 1 = 2, explaining 72% of the variance.

| | 1 | 2 |
|---|---|---|
| Eigenvalue | 2.89 | 2.13 |
| % Variance explained | 41.25 | 30.47 |
| Components | | |
| IC1 | 0.92 | |
| IC2 | 1.00 | |
| IC3a | | 0.91 |
| IC3b | | |
| IC3c | | 0.79 |
| IC4 | | 1.00 |
| IC5 | 0.97 | |

TABLE 5.32

Costing Variables (Out-Patients) - Rotated Factor Matrix

No. of eigenvalues greater than 1 = 2, explaining 85% of the variance.

| | 1 | 2 |
|---|---|---|
| Eigenvalue | 2.99 | 1.26 |
| % Variance explained | 59.82 | 25.13 |
| Components | | |
| ICO1 | | -0.89 |
| ICO2 | 0.93 | |
| ICO3 | | 1.00 |
| ICO4 | 1.00 | |
| ICO5 | 0.99 | |

TABLE 5.33

Costing Variables (In-Patients) -

| | IC1 | IC2 |
|---|---|---|
| Pe 1 | -0.22 | |
| Pe 2 | 0.21 | |
| Pe 3 | 0.38 | 0.31 |
| Pe 4 | 0.26 | |
| Pe 5 | 0.42 | 0.40 |
| Pe 6 | 0.41 | 0.32 |
| Pe 7 | | 0.34 |
| Pe 8 | 0.44 | 0.35 |
| Pe 9 | 0.33 | 0.47 |
| Pe10 | 0.37 | 0.25 |
| Pe11 | 0.35 | 0.48 |

Correlation Matrix with Performance Indices

| IC3a | IC3b | IC3c | IC4 | IC5 |
|---|---|---|---|---|
| | | | | −0.24 |
| | | 0.21 | 0.20 | |
| | | | | 0.32 |
| | | | | |
| | | | 0.23 | 0.43 |
| | | 0.26 | 0.22 | 0.33 |
| | | 0.22 | 0.26 | 0.35 |
| | | 0.22 | | 0.34 |
| | 0.21 | 0.37 | 0.42 | 0.51 |
| | | | | 0.27 |
| | 0.22 | 0.36 | 0.41 | 0.54 |

TABLE 5.34

Costing Variables (Out-Patients) -

| | ICO1 | ICO2 |
|---|---|---|
| Pe 1 | | |
| Pe 2 | | |
| Pe 3 | | |
| Pe 4 | | |
| Pe 5 | | |
| Pe 6 | | |
| Pe 7 | | |
| Pe 8 | | |
| Pe 9 | 0.27 | |
| Pe10 | | |
| Pe11 | 0.29 | |

Correlation Matrix with Performance Indices

| IC03 | IC04 | IC05 |
|---|---|---|
| | | −0.25 |
| | | −0.25 |
| | | −0.25 |
| | | −0.23 |

TABLE 5.35

Costing Variables (In-Patients) - Canonical Correlations with Performance Indices

| | | |
|---|---|---|
| $\lambda$ | 0.2319 | |
| $\chi^2$ | 130.79 | |
| df | 77 | |
| $r^2$ | 0.4559 | |
| cc | 0.6752 | |
| | Pe | IC |
| 1 | -0.464 | 0.758 |
| 2 | 0.228 | 0.824 |
| 3 | 0.561 | 0.226 |
| 4 | 0.313 | 0.404 |
| 5 | 0.719 | 0.535 |
| 6 | 0.627 | 0.563 |
| 7 | 0.483 | 0.925 |
| 8 | 0.616 | |
| 9 | 0.718 | |
| 10 | 0.537 | |
| 11 | 0.777 | |
| Variance | 0.328 | 0.418 |
| Redundancy | 0.150 | 0.191 |
| | Total Pe V = 0.716 | Total IC V = 1.00 |
| | Total Pe R = 0.206 | Total IC R = 0.272 |

TABLE 5.36

Costing Variables (Out-Patients) - Canonical Correlations with Performance Indices

| | | |
|---|---|---|
| $\lambda$ | 0.2754 | |
| $\chi^2$ | 68.98 (N.S.) | |
| df | 55 | |
| $r^2$ | 0.4848 | |
| cc | 0.6963 | |
| | Pe | ICO |
| 1 | 0.475 | −0.425 |
| 2 | −0.222 | |
| 3 | −0.625 | 0.256 |
| 4 | | 0.278 |
| 5 | −0.680 | 0.469 |
| 6 | −0.525 | |
| 7 | −0.649 | |
| 8 | −0.457 | |
| 9 | −0.865 | |
| 10 | −0.643 | |
| 11 | −0.885 | |
| Variance | 0.363 | 0.111 |
| Redundancy | 0.176 | 0.054 |

Total Pe V = 0.575  Total ICO V = 1.00

Total Pe R = 0.200  Total ICO R = 0.169

## VI SOCIO-MEDICAL VARIABLES

### (i) Basic Data and Principal Components Analysis

All the variables except S4 had significant F values in the analysis of variance, indicating that there are large differences between regions in the type of catchment population. There were four significant factors in the principal components analysis. The first two dealt with the variables obtained from Registrar General's Data (S1-3c). After rotation the first factor had positive loadings on S1, S2b and S3c and a negative loading on S3a, indicating that catchment populations with a population in the lower class groups had more men and more married women. The second factor had positive loadings on S2a and S3b, indicating that catchment populations with a high percentage in the non-manual and skilled manual classes had more married men. The correlations between these variables were as would be expected from their loadings, with the addition of a positive correlation between S2a and S3b, which would be expected, and negative correlations between S3b and S3a and S3c.

The partial correlations between the variables with loadings on the first factor showed that S1 and S2b were always positively correlated and S3a and S3c were always negatively correlated, since they did not alter on partialling. The correlations of S1 with S3a, and of S2b with S3c, disappear when either of the remaining two variables is eliminated and so seem to be spurious.

The two final factors dealt with the last three variables, concerned with the type of patients admitted to hospital. The first of these factors had a positive loading on S5 and a negative loading on S6, so that hospitals with more old admissions had fewer male admissions, presumably because of the lower average age at death of men. The final factor had a loading only on S4. It seems that the percentage of informal patients is independent of the type of patients admitted and the only significant correlation of S4 is with S2a.

The remaining correlations were positive ones between S2a and S5, and S3b and S6, and negative ones between S2a and S6, and S3b and S5. These do not have obvious explanations. The partial correlations indicated that the correlations of S2a and S3b with S6 were genuine, since these did not change on partialling. The positive correlation of S2a and S3b appears to lessen the correlations of S2a and S3b with S5, since these both increase when the effect of the other variable is removed.

(ii) Canonical Correlations Analysis

Two canonical correlations were significant. In the first pair there were negative loadings on Pe2, Pe3, Pe5 and S6 and positive loadings on Pe4, S2a, S2b and S5. Hospitals with low admission, turnover and discharge, and high death rates have fewer male admissions, more old admissions and are in a catchment population where many people are married. It would be expected that death rates would be higher where there are more old patients and possibly lower turnover and discharge rates also. The connection between more old and fewer male admissions was noted above.

The second pair of factors has negative loadings on Pe3, Pe5, the day-patient variables Pe7, Pe9 and Pell and on Sl, S2a, S2b, S3b, S3c and S4. There are also positive loadings on Pel, S3a and S5. Hospitals with few informal admissions and many old admissions have more in-patients per unit catchment population, low turnover and discharge rates and few day-patients. They seem to be in a population with more people in the higher class groups, fewer men and fewer married people. Previous work (Baldwin, 1971) suggests that a catchment population with a low proportion of married people will have high in-patient numbers and lower discharge and turnover rates, and this agrees with the loadings on Pel, Pe3 and Pe5, and on S2a and S2b in this pair of factors.

All the correlations are as would be expected from the above relationships, except for a positive correlation between Pe4 and S6. Partial correlations were also examined in an attempt to clarify the relationships. The correlation between Pe4 and S2a disappeared when S5, the % Admissions over 65, was eliminated. The lack of correlation between Pe3, Pe5 and all the socio-medical variables except S4 was examined further by partialling, but the only ones to change were those with S5, which both became significant and negative when the effect of Pe4 was removed, implying that a high number of older patients means a low turnover even when the increased death rate is accounted for.

(iii) Selection of Variables for Further Analysis

Since the picture was not very clear with regard to the catchment population data (S1-S3c), and since these data are not in fact amenable to change it was decided not to include them in further analysis. The remaining three variables were all retained:

1) S4 % of Admitted Patients who are informal admissions.

2) S5 % of Admitted Patients who are aged 65 or over.

3) S6 % of Admitted Patients who are male.

Finally a word may be said about the results of the analyses of variance which examined the differences in the individual variables between Regional Hospital Boards. The only group of variables with a large number of significant differences was the group of socio-medical variables, all of which had significant F-Ratios except S4. It is thus clear that there is wide variation in the composition of hospitals' catchment populations. However this does not lead to very large variation in either the performance variables or the other explainer variables. Only one performance variable had a significant F-Ratio, Pe1, and this may be partly due to its negative correlations with S2a, S2b and S3b.

Among the explainer variables nine had significant F-Ratios, but only two of these (for Pr1a and In6) were significant at the 1% level. The other variables were E1c, E2a, E2b, Pr2b, IC3b and IC5. Analysis of variance was also carried out on the new summary variables, which were linear combinations of the original variables and which were to be used in the further analysis, i.e. E2, P1, P2, C1, C2, C01 and CO2. Only E2, C1 and CO2 were significant, C1 at the 1% level. It appears therefore that variations in one aspect of staffing are compensated for by other aspects, but variations in overall costing have a cumulative effect.

TABLE 5.37

Socio-Medical Variables - Basic Statistics

| Variable | Mean | Standard Deviation | Skewness | Kurtosis | F |
|---|---|---|---|---|---|
| S1 | 48.44 | 1.24 | -1.17** | 4.78** | 5.72** |
| S2a | 69.82 | 2.51 | -1.52** | 7.26 | 2.52** |
| S2b | 63.82 | 3.92 | -1.44** | 7.02** | 4.69** |
| S3a | 14.80 | 4.04 | 0.88** | 3.51 | 3.72** |
| S3b | 55.11 | 4.53 | -0.38 | 2.21 | 3.15** |
| S3c | 26.10 | 4.16 | -0.03 | 3.33 | 6.06** |
| S4 | 78.97 | 6.88 | -0.77** | 4.08 | 1.30 |
| S5 | 20.71 | 4.83 | 0.39 | 2.69 | 2.11* |
| S6 | 39.72 | 4.15 | -0.26 | 3.10 | 2.54** |

* Significant at 5% level

** " " 1% "

TABLE 5.38

Socio-Medical Variables - Correlation Matrix

| | S1 | S2a | S2b | S3a | S3b |
|---|---|---|---|---|---|
| S1 | 1 | −0.07 | 0.79** | −0.55** | −0.01 |
| S2a | | 1 | 0.53** | −0.09 | 0.37** |
| S2b | + | + | 1 | −0.53** | 0.19 |
| S3a | − | | − | 1 | −0.27** |
| S3b | | + | | − | 1 |
| S3c | + | | + | − | (−) |
| S4 | | + | | | |
| S5 | | + | | | − |
| S6 | | (−) | | | (+) |

| S3c | S4 | S5 | S6 |
|---|---|---|---|
| 0.44** | 0.04 | −0.16 | 0.19 |
| −0.11 | 0.26** | 0.29** | −0.23* |
| 0.32** | 0.15 | 0.04 | 0.02 |
| −0.74** | 0.05 | 0.17 | −0.19 |
| −0.20* | −0.13 | −0.26** | 0.22* |
| 1 | −0.02 | −0.05 | 0.11 |
| | 1 | 0.15 | 0.08 |
| | | 1 | −0.33** |
| | | − | 1 |

TABLE 5.39

Socio-Medical Variables - Principal Components Analysis

No. of eigenvalues greater than 1 = 4, explaining 80% of the variance.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalue | 2.80 | 1.81 | 1.48 | 1.07 |
| % Variance explained | 31.14 | 20.12 | 16.49 | 11.89 |
| Components | | | | |
| S1 | 0.96 | | | |
| S2a | | 1.00 | | |
| S2b | 0.96 | | | |
| S3a | -1.00 | | | |
| S3b | | | -1.00 | |
| S3c | 0.79 | | | |
| S4 | | | | 1.00 |
| S5 | | 0.74 | | |
| S6 | | | | |

TABLE 5.40

Socio-Medical Variables - Rotated Factor Matrix

No. of eigenvalues greater than 1 = 4, explaining 80% of the variance.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalue | 2.68 | 1.65 | 1.63 | 1.22 |
| % Variance explained | 29.73 | 18.32 | 18.08 | 13.51 |
| Components | | | | |
| S1 | 0.98 | | | |
| S2a | | 0.95 | | |
| S2b | 0.90 | | | |
| S3a | -1.00 | | | |
| S3b | | 1.00 | | |
| S3c | 0.95 | | | |
| S4 | | | | 1.00 |
| S5 | | | 0.93 | |
| S6 | | | -1.00 | |

TABLE 5.41

Socio-Medical Variables - Correlation Matrix with Performance Indices

| | S1 | S2a | S2b | S3a | S3b | S3c | S4 | S5 | S6 |
|---|---|---|---|---|---|---|---|---|---|
| Pe 1 | | −0.39 | −0.38 | | −0.20 | | | | |
| Pe 2 | −0.21 | | −0.29 | | | | | | |
| Pe 3 | | | | | | | 0.26 | | |
| Pe 4 | | 0.30 | | | | | | 0.55 | |
| Pe 5 | | | | | | | 0.27 | | |
| Pe 6 | | | | | | | | | |
| Pe 7 | | 0.28 | | | 0.28 | | | | |
| Pe 8 | | | | | | | 0.20 | | |
| Pe 9 | | 0.22 | | | 0.29 | | 0.26 | | |
| Pe10 | | | | | | | | | |
| Pe11 | | 0.23 | | | 0.30 | | 0.26 | | |

TABLE 5.42

Socio-Medical Variables - Canonical Correlations with Performance Indices

| | | | | |
|---|---|---|---|---|
| λ | 0.1258 | | 0.3184 | |
| $\chi^2$ | 183.45 | | 102.03 | |
| df | 99 | | 80 | |
| $r^2$ | 0.6048 | | 0.3268 | |
| cc | 0.7777 | | 0.5717 | |
| | Pe | S | Pe | S |
| 1 | | | 0.766 | -0.343 |
| 2 | -0.279 | 0.585 | | -0.719 |
| 3 | -0.252 | 0.294 | -0.440 | -0.707 |
| 4 | 0.664 | | | 0.490 |
| 5 | -0.228 | | -0.353 | -0.518 |
| 6 | | | | -0.229 |
| 7 | | | -0.474 | -0.255 |
| 8 | | 0.881 | | 0.237 |
| 9 | | -0.224 | -0.424 | |
| 10 | | | | |
| 11 | | | -0.455 | |
| Variance | 0.061 | 0.148 | 0.143 | 0.205 |
| Redundancy | 0.037 | 0.089 | 0.047 | 0.067 |
| | Total Pe V = 0.902 | | Total S V = 1.00 | |
| | Total Pe R = 0.175 | | Total S R = 0.224 | |

## VII SUMMARY VARIABLES

The analysis so far had revealed a group of performance variables which consistently appeared together. Hospitals with few in-patients usually had large numbers of out and day-patients and high turnover, death and discharge rates. They often also had high admission rates. These hospitals will be called 'revolving door' hospitals because of their rapid turnover and discharge rates and their use of facilities in the community. Their relationship with the explainer variables has been partially examined above and will now be summarized.

'Revolving door' hospitals tended to be accessible to their catchment population and had good local authority provision, although few social workers. The staffing levels were high and so was expenditure. Among the institutional variables it was those described as 'progressive' (with high values of In1b, In5b and In6 and low values of In1a, In2, In3 and In5a) which were positively connected with the 'revolving door' characteristics. The relationship with the socio-medical variables was less clear but hospitals of the 'revolving door' type appeared to have more informal and fewer old admissions, and to be in catchment populations with more married people.

To explore these relationships further a canonical correlations analysis was carried out between the six performance and nineteen explainer summary variables. A variable giving the size of a hospital (S)[1] was added to the explainer variables in view of its relationship with performance, staffing and costing variables discussed earlier.

Of the six canonical correlations all but one were significant at the 5% level, and three of those at the 0.1% level. The first pair of factors linked the 'revolving door' characteristics previously identified. On the performance side there was a high negative loading on Pe1 and high positive loadings on Pe2, 5, 8 and 9. On the explainer side there were negative loadings on S, In3, In5a, and S5 and positive loadings on P1, C1, C2, E1a, In1b and S4. In other words hospitals with few inpatients, many out and day-patients and high admission and discharge rates are small, have high staffing and expenditure, are accessible, have patients working outside, low bed occupancy, uncrowded wards and have more informal and fewer old admissions.

The second pair of factors also linked some of the 'revolving door' characteristics but with the opposite signs. On the performance side there were negative loadings on Pe4, 8 and 9. On the explainer side there were negative loadings on P1, C1, E1a, E3a, In1b, S4, S5, CO1 and CO2 and positive loadings on S, E1b and In3. That is, hospitals with low death rates and few out or day-patients are large and inaccessible, with low staffing and expenditure both on in-patients and out-patients. They

---

1. The mean hospital size was 1206 patients, with standard deviation 535, skewness 0.97 and kurtosis 3.85.

also have poor contact with the local authority, few people working outside the hospital, high bed occupancy and few old or informal admissions. It is probable that the low death rate is due mainly to the low proportion of admissions over 65 and this may not necessarily be an important characteristic of this type of hospital.

The third pair of factors connected variables which were not previously seen to be related. The performance variables had a positive loading on Pe1 and a negative loading on Pe8. The explainer variables had positive loadings on S, P2, C2, E1a, In4 and S6 and negative loadings on In1b, In3, CO1 and CO2. Thus hospitals with an emphasis on in-patient as against out-patient care are large, have more training staff, are accessible, have a high proportion of male admissions, few patients working outside and low bed occupancy. As would be expected, more is spent on in-patient treatment and less on out-patients and the medical superintendent is older, indicating a more traditional kind of hospital.

The fourth pair of factors was more difficult to understand, as explainer variables with some 'revolving door' characteristics were negatively related to some 'revolving door' characteristics of performance variables. The performance variables had positive loadings on Pe1, 2 and 9 and negative loadings on Pe4 and 5. The explainer variables had positive loadings on C2, E1a, In1b, In3 and E2 and negative loadings on E1b, E1a, In5a and S5. In other words, hospitals with large numbers of in-patients and day-patients, high admission rates and low death and discharge rates have high treatment expenditure, are accessible, have poor local authority contact but many social workers. They also have high bed-occupancy, few crowded wards, many patients working outside and few old admissions.

It appears that where a high admission rate leads to a build up of in-patients but not to high discharge rates the hospital may still be accessible, have many patients working outside, few crowded wards and few admissions over 65, but the only emphasis in expenditure is on treatment, bed occupancy is high instead of low and there are more social workers. In the 'revolving door' hospital, on the other hand, as shown in the first pair of factors, there are high staffing-ratios and overall expenditure, many informal admissions and the hospital is small. Day-patient numbers seem to follow the same pattern as admission rates.

The fifth pair of factors linked hospitals with low values of Pe1, Pe2, Pe4 and Pe5 with low values of P2, In4 and E2 and high values of S6. These hospitals have low in-patient numbers and admission, death and discharge rates. They also have few training staff or social workers, many male admissions and a younger medical superintendent.

It was now possible to identify different types of hospital as characterized by various performance and explainer variables but there still remained the question of the more detailed inter-relationships between the variables, and of the separate and combined influence of the explainer variables on the performance variables. The way in which this was studied is explained in the next Chapter. A list of the variables used in this part of the analysis is given overleaf.

1) Pel No. of in-patients per 1000 Catchment Population (U.C.P.).

2) Pe2 No. of annual admissions per U.C.P.

3) Pe4 Patient Death rate.

4) Pe5 Patient Discharge rate.

5) Pe8 Total no. of out-patient attendances per annum per U.C.P.

6) Pe9 Total no. of day-patient attendances per annum per U.C.P.

7) Ela Index of hospital accessibility.

8) Elb Index of hospital inaccessibility.

9) E2 No. of social workers per U.C.P.

10) E3a 'Official' contact with the Local Authority.

11) E4 Involvement of Voluntary Organizations.

12) Pl Overall Staffing.

13) P2 Training and Instruction Staff.

14) Inla % of Patients working in domestic and hospital service departments.

15) Inlb % of Patients working elsewhere.

16) In3 Average % Bed Occupancy.

17) In4 No. of years elapsed since qualification of Medical Superintender

18) In5a % of Beds with a space of less than 50 sq.ft.

19) Cl Overall in-patient expenditure.

20) C2 In-patient treatment expenditure.

21) CO1 Overall out-patient expenditure.

22) CO2 Out-patient treatment expenditure.

23) S4 % of Admitted Patients who are Informal Admissions.

24) S5 % of Admitted Patients who are aged 65 or over.

25) S6 % of Admitted Patients who are male.

26) S Size.

TABLE 5.43

Canonical Correlations between Summary Explainer and Performance Variables

| | | | | | |
|---|---|---|---|---|---|
| λ | | 0.0272 | | 0.1089 | |
| $\chi^2$ | | 308.25*** | | 190.34*** | |
| df | | 120 | | 95 | |
| $r^2$ | | 0.7503 | | 0.5402 | |
| cc | | 0.8662 | | 0.7350 | |
| | | Pe | Exp. | Pe | Exp. |
| S | 1 | −0.394 | −0.285 | | 0.349 |
| P1 | 2 | 0.448 | 0.909 | | −0.286 |
| P2 | 3 | | | −0.797 | |
| C1 | 4 | 0.873 | 0.576 | | −0.317 |
| C2 | 5 | 0.480 | 0.206 | −0.340 | |
| E1a | 6 | 0.690 | 0.320 | −0.532 | −0.200 |
| E1b | 7 | | | | 0.388 |
| E3a | 8 | | | | −0.284 |
| E4 | 9 | | | | |
| In1a | 10 | | | | |
| In1b | 11 | | 0.345 | | −0.331 |
| In3 | 12 | | −0.384 | | 0.319 |
| In4 | 13 | | | | |
| In5a | 14 | | −0.321 | | |
| S4 | 15 | | 0.276 | | −0.246 |
| S5 | 16 | | −0.334 | | −0.781 |
| S6 | 17 | | | | |
| E2 | 18 | | | | |
| CO1 | 19 | | | | −0.286 |
| CO2 | 20 | | | | −0.255 |
| Variance | | 0.305 | 0.104 | 0.178 | 0.086 |
| Redundancy | | 0.229 | 0.078 | 0.096 | 0.046 |

Total Pe V = 1.000      Total Exp. V = 0.396

"   " R = 0.467      "   " R = 0.187

continued/

TABLE 5.43 (continued)

| | | | | | |
|---|---|---|---|---|---|
| λ | | 0.2368 | | 0.4107 | |
| $\chi^2$ | | 125.36*** | | 79.70** | |
| df | | 72 | | 51 | |
| $r^2$ | | 0.4234 | | 0.3091 | |
| cc | | 0.6507 | | 0.5560 | |
| | | Pe | Exp. | Pe | Exp. |
| S | 1 | 0.383 | 0.339 | 0.508 | |
| P1 | 2 | | | 0.229 | |
| P2 | 3 | | 0.259 | −0.478 | |
| C1 | 4 | | | −0.260 | |
| C2 | 5 | −0.335 | 0.592 | | 0.249 |
| E1a-v | 6 | | 0.374 | 0.419 | 0.237 |
| E1b-v | 7 | | | | −0.412 |
| E3a | 8 | | | | −0.299 |
| E4 | 9 | | | | |
| In1a | 10 | | | | |
| In1b | 11 | | −0.226 | | 0.225 |
| In3 | 12 | | −0.282 | | 0.490 |
| In4 | 13 | | 0.371 | | |
| In5a | 14 | | | | −0.264 |
| S4 | 15 | | | | |
| S5 | 16 | | | | −0.334 |
| S6 | 17 | | 0.333 | | |
| E2 | 18 | | | | 0.393 |
| CO1 | 19 | | −0.219 | | |
| CO2 | 20 | | −0.272 | | |
| Variance | | 0.050 | 0.065 | 0.131 | 0.057 |
| Redundancy | | 0.021 | 0.027 | 0.040 | 0.017 |

continued/

TABLE 5.43 (continued)

| | | | | | |
|---|---|---|---|---|---|
| $\lambda$ | | 0.5944 | | 0.8265 | |
| $\chi^2$ | | 49.07* | | 19.38 | |
| df | | 32 | | 15 | |
| $r^2$ | | 0.2808 | | 0.1734 | |
| cc | | 0.5299 | | 0.4165 | |
| | | Pe | Exp. | Pe | Exp. |
| S | 1 | −0.524 | | 0.397 | −0.315 |
| P1 | 2 | −0.852 | | | |
| P2 | 3 | −0.337 | −0.205 | | |
| C1 | 4 | −0.291 | | −0.202 | 0.326 |
| C2 | 5 | | | 0.729 | |
| E1a-v | 6 | | | −0.218 | |
| E1b-v | 7 | | | | 0.509 |
| E3a | 8 | | | | |
| E4 | 9 | | | | −0.249 |
| In1a | 10 | | | | 0.257 |
| In1b | 11 | | | | 0.277 |
| In3 | 12 | | | | |
| In4 | 13 | | −0.293 | | −0.303 |
| In5a | 14 | | | | −0.228 |
| S4 | 15 | | | | |
| S5 | 16 | | | | |
| S6 | 17 | | 0.215 | | 0.251 |
| E2 | 18 | | −0.523 | | 0.362 |
| CO1 | 19 | | | | |
| CO2 | 20 | | | | |
| Variance | | 0.204 | 0.031 | 0.132 | 0.054 |
| Redundancy | | 0.057 | 0.009 | 0.023 | 0.009 |

CHAPTER 6

# CAUSAL ANALYSIS - METHODS AND RESULTS

## I METHOD OF ANALYSIS

We have so far identified several sets of variables which are related to one another, and have selected the variables which appear most informative in each set, but we have little information about which correlations between variables are due to their mutual correlation with other variables, or about the inter-relationships between the sets of variables. The dangers of equating correlation and causation have been widely recognised, for example by Bernard Shaw (1906) when commenting on the correlation between longevity and the wearing of tall hats - both being characteristics of the upper classes. In such simple situations the intervening variable is easily identified but in the processes presently under examination the most useful way to ascertain which variables are truly correlated and which correlations are spurious is by means of partial correlation and multiple regression, once the probable order of influence has been established (Kendall and Stuart, 1967).

The aim of the present study is to examine the influence of explainer variables on performance variables. Thus, by their very definition the latter will be the final variables in the chain of influence, at least for any particular year. The ordering of the explainer variables is more difficult to ascertain and some of the usual conditions for multiple regression have to be relaxed, as explained more fully below.

In the simplest case, when there are K independent variables ($X_1$, $X_2$ ... $X_k$) which have a linear relationship with the dependent variable ($X_o$), we have a single equation system for each of the n observations of the form

$$x_{oi} = a_1x_{1i} + a_2x_{2i} + .... + a_kx_{ki} + u_i \quad (i=1....n)$$

where $u_i$ is an error term and the variables have been taken as standardized for simplicity. This assumes that the variables are all normally distributed, that the error term $u_i$ has zero expectation and constant variance and that the $u_i$ are pairwise uncorrelated. In addition, the rank of the matrix of observations $\underline{X}$ must be K(K<n) and the matrix of cross-products ($\underline{X}'\underline{X}$) must be non-singular (Kendall and Stuart, 1967). In this situation the parameters $a_1....a_k$ can be estimated by least squares which gives best linear unbiassed estimators.

This system can be extended to one with several simultaneous equations, in which the variables are still linearly dependent and the error terms satisfy the conditions above, and in which there is no feed-back between variables i.e. it is true that when $X_1$ is an independent variable for $X_2$ it cannot also be affected by $X_2$. If the order of influence of the variables can be established the resulting equations form a recursive system:

$$x_{1i} = u_{1i}$$

$$x_{2i} = a_{21}x_{1i} + u_{2i}$$

$$x_{3i} = a_{31}x_{1i} + a_{32}x_{2i} + u_{3i}$$

$$\vdots$$

$$x_{ki} = a_{k1}x_{1i} + a_{k2}x_{2i} + \ldots\ldots + a_{k,k-1}\, X_{k-1,i} + u_{ki}$$

Since the error terms still satisfy the conditions for the single equation system above, the coefficients $a_{pq}$ can still be estimated by least squares.

Before extending this system further a distinction must be drawn between exogenous and endogenous variables. An exogenous variable is one whose value is determined outside the system under consideration and an endogenous variable is one whose value is determined by the simultaneous interaction of the relations in the system. The system can now be extended to one in which there are g endogenous variables and g simultaneous equations of which the $j^{th}$ equation has the form:

$$a_{j1}Y_{1i} + a_{j2}Y_{2i} + \ldots .\ a_{jg}Y_{gi} + b_{j1}X_{1i} + b_{j2}X_{2i} + \ldots b_{jk}X_{ki} = u_{ji} \quad (i = 1 \ldots\ldots n)$$

where the $Y_j$ are endogenous variables and the $X_j$ are exogenous variables. Since the $X_j$ are exogenous variables they will not be correlated with the error terms $u_j$ but the $Y_j$ will be correlated with $u_j$ and the least squares estimators will thus be biassed and inconsistent.

This difficulty can be overcome by using two stage least squares. The first equation can be normalized by setting $a_{11} = 1$ to obtain

$$y_{1i} = - a_{12}y_{2i} \ldots\ldots - a_{1g}y_{gi} - b_{11}x_{1i} - \ldots\ldots - b_{1k}x_{ki} + u_{1i} \quad (i = 1 \ldots\ldots n)$$

and the other equations can be normalized similarly. If each $Y_j$ except $Y_1$ is regressed on the $x_i$, using ordinary least squares, to obtain an estimate $\hat{Y}_j$, then the $\hat{Y}_j$ will be uncorrelated with the error terms $U_j$. If $Y_1$ is then regressed on $\hat{Y}_2 \ldots\ldots \hat{Y}_g$ and $X_1 \ldots\ldots X_k$ using ordinary least squares the resulting estimators will be consistent. The procedure for the other $Y_j$ is similar. Other methods also overcome the difficulty but two stage least squares appears to be the best compromise between efficiency and ease of computation (Cragg, 1967).

The above procedure is only possible provided the system of simultaneous equations is identified i.e. that there are some restrictions, external to the system, on the parameters $a_{pq}$, $b_{pq}$. The problem is discussed by, for example, Johnston (1972) and in the particular system under consideration the necessary order condition for identifiability has been satisfied. This condition states that the total number of variables excluded from an equation must be at least as great as the total number of endogenous variables in the model, less one.

For the analysis the situation was simplified by using a block-recursive system (Fisher, 1966). In this the variables are divided up into groups or blocks, such that for variables within a block there may be feedback and reciprocal causation but relationships between blocks are recursive. That is, we can order the blocks so that variables in one block will effect variables within that block, and in higher numbered blocks, but not variables in lower numbered blocks. When estimating the parameters within a particular block all variables in blocks below it can be considered exogenous and two stage least squares can be used to estimate the parameters.

Once the parameters have been estimated the magnitude and sign of the direct and indirect effect of any variable on any endogenous variable in the same block, or a higher numbered block, can be found. The parameter $a_{ij}$ in the regression of the endogenous variable $Y_i$ on $Y_j$ measures the fraction of the standard deviation of $Y_i$ for which the designated variable $Y_j$ is directly responsible. (Wright, 1960). Thus $a_{ij}^2$ measures the proportion of the variance of $y_i$ for which $y_j$ is directly responsible. The correlation, $r_{ij}$, between the two variables can then be separated as the sum of the direct effect via the parameter $a_{ij}$ and the indirect effect via the other variables in the system

$$\text{i.e.} \quad r_{ij} = a_{ij} + \sum_k a_{ik} r_{jk}$$

where K includes all variables on which the regression of $Y_i$ is significant. Then $\sum_k a_{ik} r_{jk}$ is the indirect effect of $Y_j$ on $Y_i$.

The programme used for the two stage least squares regression was written by the author and a copy is given in Appendix 3.

It is recognized that there is some controversy as to how far causal inferences can be drawn from statistical techniques, particularly over the question of direct and indirect effects as described by Wright (1960). However it is certainly true that regression analysis will produce coefficients which give the magnitude and effect of variables on one another in a purely statistical sense. If the causal ordering of the variables has been established then it is possible to say how alteration of one variable in the chain will affect others which follow it. Whether the ensuing result is due to the alteration or to the effect of other variables, which have not been measured is again a question which cannot be directly answered by a statistical exercise but only by the trial inclusion of the proposed variables into the system. In either case though, the direction and magnitude of the effect can be established.

## II GROUPING OF VARIABLES INTO BLOCKS

The 26 variables were divided into four blocks and the reasons for the division are given below:

Group I <u>External Variables</u> : S, Ela, Elb, S4, S5, S6.

These variables were considered to be exogenous and their inter-relationships were not analysed.

Group II <u>Basic Staffing and Costing Variables</u> : Pl, P2, Cl, C2, E3a, E4, In4, E2.

The following relationships were postulated between these variables and those in Group I :

| | | | |
|---|---|---|---|
| Pl depends on | Cl,C2 | and | S,Ela,Elb,S5 |
| P2 " " | Cl | and | S,Ela,Elb,S4,S5 |
| Cl " " | Pl,P2,In4 | and | S,S5 |
| C2 " " | Pl,P2,In4 | and | S,S5 |
| E3a " " | | | S,Ela,Elb,S4,S5 |
| E4 " " | Cl,In4 | and | Ela,Elb,S4,S5 |
| In4 " " | | | S,Ela,Elb |
| E2 " " | | | S,Ela,Elb,S4,S5,S6. |

Group III <u>Institutional Variables</u> : Inla, Inlb, In3, In5a.

The following relationships were postulated between these variables and those in groups I and II:

| | | | |
|---|---|---|---|
| Inla depends on | Inlb | and | S,Ela,Elb,S4,S5,E3a,E2 |
| Inlb " " | Inla | and | S,Ela,Elb,S4,S5,E3a,E2 |
| In3 " " | In5a | and | S,S5,Pl,Cl,E3a,E2 |
| In5a " " | In3 | and | s,S5,Pl,Cl,E3a,E2 |

Group IV Performance Variables : Pe1, Pe5, Pe8, Pe9

The following relationships were postulated between these variables and those in groups I, II and III:

Pe1 depends on Pe5 and E1a,E1b,S4,S5,P1,P2,C1,C2,In4,E2,S,E3a

Pe5 " " Pe8,Pe9 and S4,S5,P1,P2,C1,C2,E4,In4,E2,In1b, In3,In5a,S,E3a

Pe8 " " Pe5 and E1a,E1b,S4,S5,P1,P2,C1,C2,In4,E2,E3a

Pe9 " " Pe5 and E1a,E1b,S4,S5,P1,P2,C1,C2,In4,E2,E3a

Variables Pe2, Pe4, ICO1, ICO2 were excluded at this stage to simplify the analysis.

(i) Group I - External Variables. This group contained the variables which were seen as characteristics of an existing situation, i.e. hospital size, accessibility and the socio-medical variables, and which were not amenable to change by the other variables under consideration.

(ii) Group II - Basic Staffing and Costing Variables. This group of variables was thought to be affected by the varying demands made on the hospital by the external variables in group I and also by policy decisions within the hospital. Within the group the staffing and costing variables are strongly correlated and may be inter-dependent. The work of voluntary organizations may be affected by the resources available within the hospital i.e. by expenditure as well as by the external variables. Finally, the date of qualification of the medical superintendent, which is taken to be one indicator of hospital policy, might therefore affect other policy variables such as allocation of expenditure on treatment, and the activity of voluntary organizations.

(iii) Group III - Institutional Variables. This group of variables was thought to be affected not only by the basic demands made on a hospital by the variables in group I but also by changes in staffing and expenditure levels and by contact with the local authority and with social workers. These relationships did not logically appear to be reciprocal. The group was divided into two sub groups, the first containing In1a and In1b and the second containing In3 and In5a. The variables within the groups were thought to be mutually dependent but the sub groups were thought to be independent and were analysed separately.

(iv) Group IV - Performance Variables. This final group of variables contained the most important performance variables, whose variation was the primary object of interest in the analysis, and which were affected by most of the other variables. Discharge rate and out and day-patient attendances were strongly correlated and may be inter-dependent. In addition, discharge rate was thought to affect in-patient numbers.

It should be noted at this point that the results obtained will, of course, depend heavily on the assumptions made above.

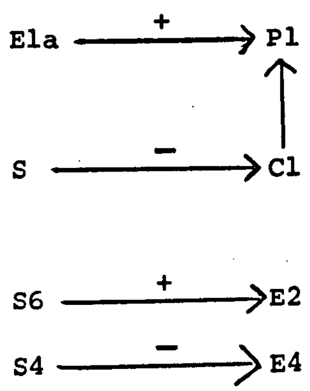
Arguments could be put forward for different proposed chains of influence but the ones given here appeared to be the most probable in the light of current thinking.

## III RESULTS OF THE ANALYSIS

The only regressions which were retained were those in which the regression coefficient was significant at the 5% level or above. The results of the regressions are given in Table 6.1 which gives the regression coefficient ($\beta$), its standard error ($\sigma$), the correlation coefficient between the endogenous and the designated variables (r), and the indirect effect on the endogenous variable of the designated variable (Ind = r − β). The multiple correlation coefficient ($R^2$) is also given, which is the percentage of variance explained in the endogenous variable. The relationships found within each group are also illustrated by diagrams. The results are presented first for each group and then commented on together.

### (i) Group II Basic Staffing and Costing Variables

Diagram 6.1 - Regressions of Group II




The overall level of expenditure increased the overall level of staffing (as expected) but the relationship was not reciprocal. Size had a negative effect on expenditure and no other direct effects.

Accessibility increased staffing levels. A high percentage of male admissions increased the numbers of social workers. Low levels of informal admissions increased voluntary organization activity. No other regressions were significant.

TABLE 6.1

RESULTS OF REGRESSIONS

Group II - Basic Staffing and Costing

| Dependent Variable | Independent Variables | β | α | r | Ind | $R^2$ |
|---|---|---|---|---|---|---|
| P1 | C1 | 0.88 | 0.13 | 0.73 | −0.15 | 70 |
| | E1a | 0.21 | 0.07 | 0.24 | 0.03 | |
| C1 | S | −0.52 | 0.09 | −0.52 | 0 | 27 |
| E2 | S6 | 0.29 | 0.10 | 0.29 | 0 | 8 |
| E4 | S4 | −0.31 | 0.10 | −0.31 | o | 10 |

Group III - Institutional Variables

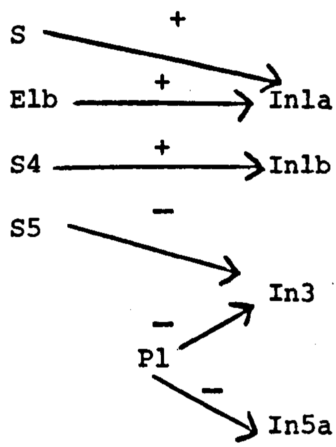
| Dependent Variable | Independent Variables | β | α | r | Ind | $R^2$ |
|---|---|---|---|---|---|---|
| In1a | S | 0.19 | 0.10 | 0.21 | 0.02 | 12 |
| | E1b | 0.27 | 0.10 | 0.28 | 0.01 | |
| In1b | S4 | 0.34 | 0.09 | 0.34 | 0 | 12 |
| In3 | S5 | −0.32 | 0.09 | −0.30 | 0.02 | 25 |
| | P1 | −0.41 | 0.09 | −0.38 | 0.03 | |
| In5a | P1 | −0.33 | 0.10 | −0.33 | 0 | 11 |

Group IV - Performance Variables

| Dependent Variable | Independent Variables | β | α | r | Ind | $R^2$ |
|---|---|---|---|---|---|---|
| Pe1 | Pe5 | −0.52 | 0.11 | −0.48 | 0.04 | 37 |
| | E2 | 0.35 | 0.08 | 0.33 | −0.02 | |
| Pe5 | P1 | 0.93 | 0.10 | 0.70 | −0.23 | 58 |
| | P2 | 0.16 | 0.07 | 0.13 | −0.03 | |
| | C1 | −0.28 | 0.10 | 0.43 | 0.71 | |
| | C2 | −0.19 | 0.07 | 0.06 | 0.25 | |
| | E2 | 0.15 | 0.07 | 0.04 | −0.11 | |
| | S4 | 0.14 | 0.07 | 0.27 | 0.13 | |
| Pe8 | P1 | 0.47 | 0.09 | 0.47 | 0 | 22 |
| Pe9 | P1 | 0.61 | 0.07 | 0.65 | 0.04 | 50 |
| | E1b | −0.29 | 0.07 | −0.38 | −0.09 | |

(ii) Group III Institutional Variables

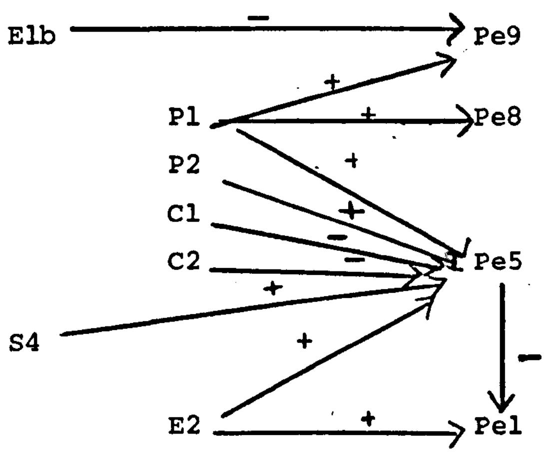
Diagram 6.2 - Regressions of Group III




No direct regressions between variables within the group were significant but both bed occupancy and In5a, the percentage of beds with low bed space, were lowered by high staffing levels. Bed occupancy was also lowered in a hospital with more old admissions. The number of patients working in the hospital was increased by inaccessibility and by the size of the hospital, and the number of patients working elsewhere was higher in a hospital with more informal admissions.

(iii) <u>Group IV Performance Variables</u>

Diagram 6.3 - Regressions of Group IV



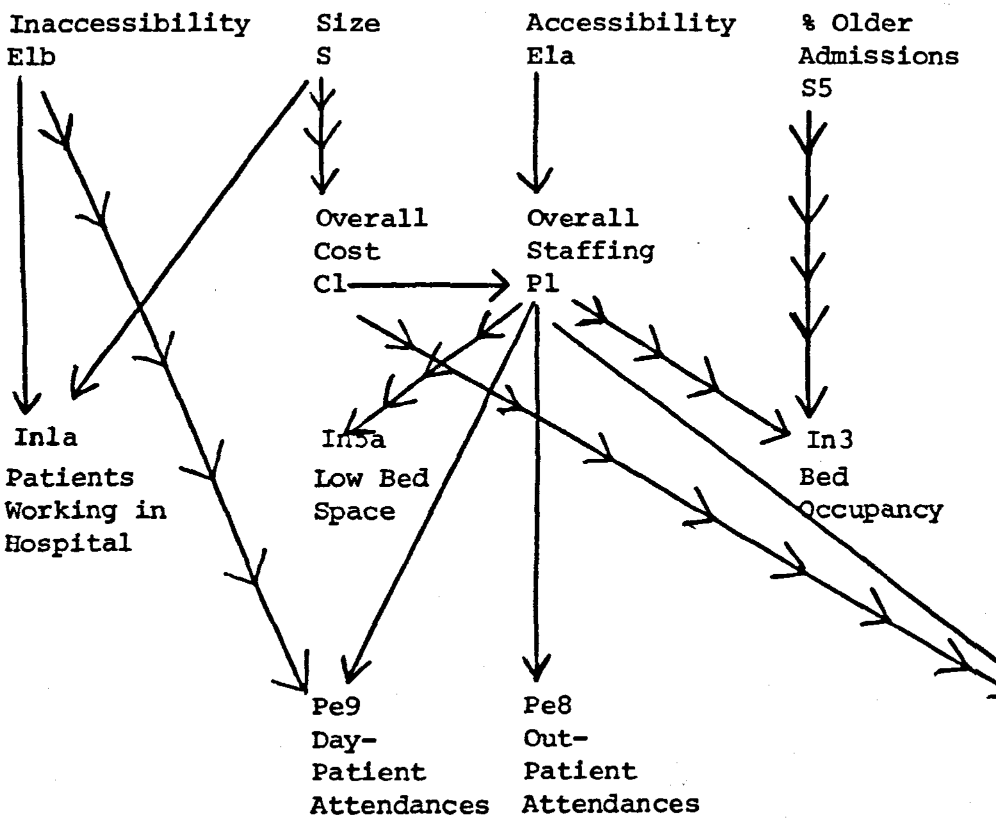

The only significant regression between the performance variables was the negative regression of the number of in-patients on the discharge rate. In addition both in-patient numbers and discharge rate were increased by the number of social workers. High overall staffing levels increased discharge rates and out and day-patient numbers, and day-patient numbers were decreased by inaccessibility. The other significant regressions were all on discharge rate which was increased by high training staff levels and large numbers of informal admissions and decreased by both costing variables.

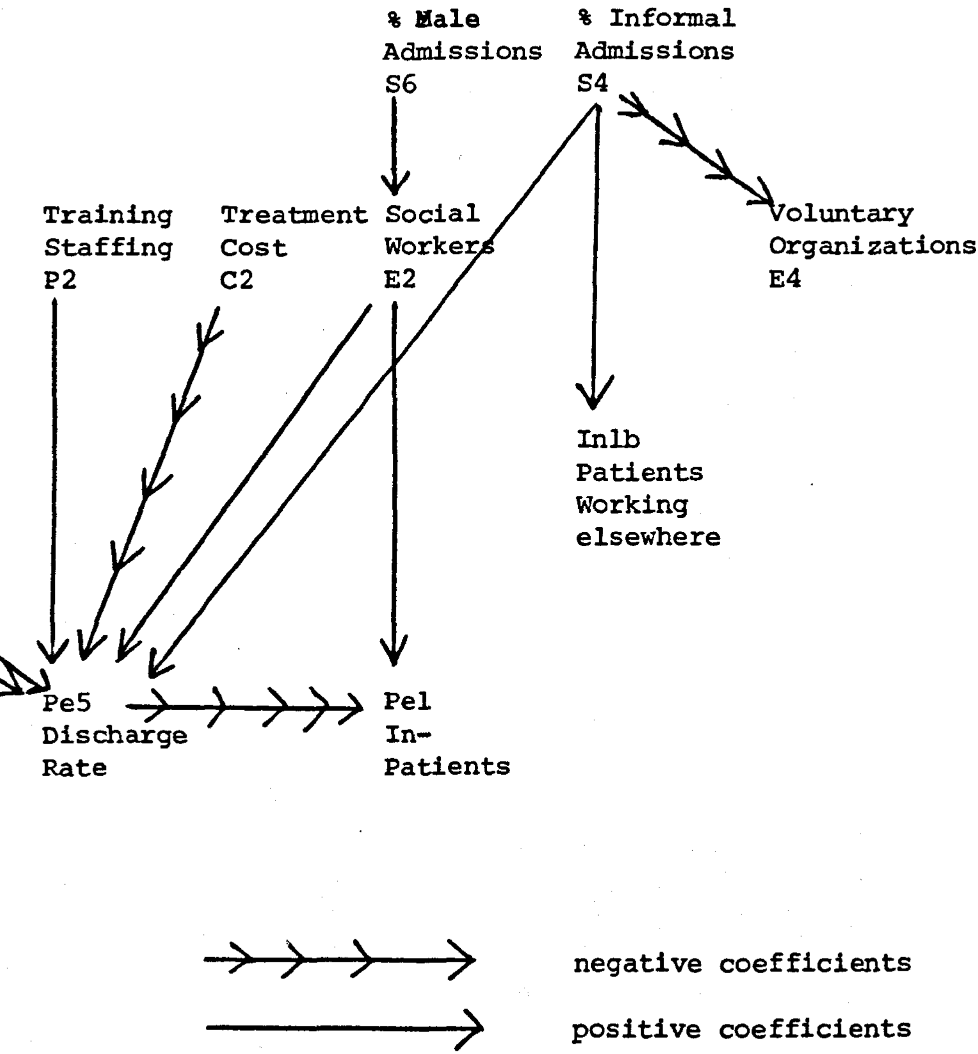
These regressions must be looked at together to examine the combined effects of the explainer variables on the performance variables (see Diagram 6.4). Two things stand out immediately. First, discharge rate is the performance variable with most variance explained and second, the group II variables are the most useful in explaining variance in the performance variables. The correlations of the institutional variables with each other and with the performance variables all appear to be due to variables in groups I and II. The only direct effects of external variables on performance variables are those of Elb on Pe9 and of S4 on Pe5. Otherwise all the effects are indirect, through the variables in group II. In fact two of the variables in group II, In3a and In4, did not have any significant relationships.

The negative direct effect of the two costing variables on the discharge rate is perhaps the most surprising result. High expenditure seems to lower the discharge rate directly although overall expenditure also raises the overall staffing level, which in turn raises the discharge rate, and it is this indirect effect which is the most important. This finding to some extent supports that of Jones and Sidebotham (1962) who found that high cost hospitals were more efficient (i.e. the cost per short stay case was lower) if the expenditure was on staff, equipment and patient facilities rather than on the maintenance and upkeep of the hospital. Similarly, Ullmann (1967) found that certain areas of expenditure, i.e. % expenditure spent on food and shelter, had a negative association with his measures of effectiveness when size and staffing were held constant.

Hospital size decreases expenditure but does not affect staffing levels directly. Nor does it affect either in-patient numbers per unit catchment population or the discharge rate directly, contrary to the findings of Ullmann (1967) mentioned in chapter 2. This may, of course, be partly due to the difference in the indices used as well as to the difference between British and American hospitals. The only

Diagram 6.4 - Combined Regression Diagram





% Male
Admissions
S6
% Informal
Admissions
S4
Training
Staffing
P2
Treatment
Cost
C2
Social
Workers
E2
Voluntary
Organizations
E4
Inlb
Patients
Working
elsewhere
Pe5
Discharge
Rate
Pel
In-
Patients
negative coefficients
positive coefficients

other variable on which size has a significant effect is Inla, the percentage of patients working in the hospital which increases with size. Inla is also increased by inaccessibility, Ela, as expected (ch.3, p.34). Accessibility increases the overall staffing level but has no effect on the other environmental variables and no direct effect on the performance variables except to increase the number of day-patients.

The type of patient admitted is of some importance. When there are large numbers of informal admissions the discharge rate increases and more patients work outside the hospital. The activity of voluntary organizations decreases, presumably because they are less needed. A high percentage of old admissions lowers the bed occupancy rate. Large numbers of male admissions increase the number of social workers, and this in turn increases both the discharge rate and the number of in-patients. This may be partly due to the fact that a population with more men has fewer old people and so might be of the type which can be discharged more easily, although the direct effects of S5 and S6 on discharge rate are not significant.

The fact that the number of social workers, E2, increases both discharge rate and in-patient numbers at first appears to contradict the fact that a high discharge rate lowers in-patient numbers but this is not necessarily so. The two effects can work simultaneously and it is the positive, direct effect of E2 on Pel which is the larger. It may be that a large number of social workers indicates a population with a high incidence of mental illness and therefore a greater need for attention both within the community from social workers and in hospital, while at the same time the large number of social workers inceases activity within the hospital and eases discharge into the community.

Robin and Hakki (1972) found that 'A hospital-based social work service and a local authority service closely related to the hospital are more effective than an independent community-based service in preventing hospital chronicity'. Thus high values of E2 in conjunction with high values of E3a would be expected to raise the discharge rate, while high values of E2 in conjunction with low values of E3a would be expected to raise in-patient numbers. In fact E3a does not have a significant effect on either Pe1 or Pe5, and the partial correlations of E2 with Pe1 and Pe5 when the effect of E3a is eliminated remain almost unchanged, so the evidence neither confirms nor refutes Robin and Hakki's findings. This may, of course, be due to the inadequacy of E3a as a measure of liaison.

Pe8 and Pe9, the numbers of out and day-patient attendances are the two performance variables giving an idea of the usage of community care facilities provided by the hospital. They are both increased by high staffing levels within the hospital and it appears that their correlation with the discharge rate is due to this common antecedent variable. Surprisingly, neither the type of admissions, the number of social workers, nor the amount of liaison with the local authority, affects these two variables. Inaccessibility lowers the number of day-patient attendances but does not affect out-patient attendances except indirectly.

In the next chapter we consider the way in which the causal analysis helps in explaining the differences between psychiatric hospitals.

CHAPTER 7

## CONCLUSIONS

The purpose of the present study was to examine different facets of a psychiatric hospital's functioning and therapeutic performance. An attempt was made to explain variations in performance using a number of explainer variables, which included measures of the other functions of a hospital, as outlined in chapter 3.

We first consider these different hospital functions and examine how they are effected in conjunction with one another. The custodial function was measured by the percentage of informal admissions, S4. Since high values of S4 raise the discharge rate it seems that, as expected, the custodial function is to some extent incompatible with the therapeutic one. On the other hand, large numbers of informal admissions, for example, lower the involvement of voluntary organizations. Thus aspects of the socialization function can be compatible with the custodial one.

The second function of a psychiatric hospital is the protection of patients while they are in hospital. The resources devoted to patients were the measure used for this function. It was not possible to separate out the resources devoted to particular types of patient, so expenditure and In5a, the percentage of beds with small bed-space, were the criteria used. The latter variable had no direct effect on any of the performance indices or, indeed, on any other variable. It was decreased by high staffing and therefore indirectly by high expenditure. The only effects of high expenditure on performance indices were a negative direct effect, and a larger positive indirect effect, on discharge rate ( as was examined in chapter 6). It therefore appears that protection of the patient is possible while the therapeutic function is being carried out effectively and that different aspects of this protection of the patient are mutually compatible.

The socialization function of a hospital can be partially assessed by its liaison with the local authority, the involvement with voluntary organizations, the number of social workers in the community and the percentage of patients working inside and outside the hospital. Of these variables only E2, the number of social workers, affected any performance variables directly, i.e. the number of in-patients and the discharge rate, both of which were raised. These relationships were examined in more detail in the previous chapter (p.137) and it appears that this aspect of the socialization function may impair or improve different parts of a hospital's therapeutic efficiency. The involvement of voluntary organizations and the percentage of patients working outside the hospital are both affected by the percentage of informal admissions, as examined above. It thus appears that most aspects of a hospital's socialization function can be carried out without affecting the other functions. The exceptions are some parts of the custodial function and the aspect of the therapeutic function which is indicated by in-patient numbers. Different aspects of the socialization function do not conflict with one another.

A hospital's therapeutic function is measured by the performance variables and the analysis has shown that certain aspects of all the other functions had an effect on the therapeutic one. The analysis in chapter 5 demonstrated the existence of a group of performance variables which consistently appeared together. The hospitals with high values on these variables were called 'revolving door' hospitals. They had few in-patients, large numbers of out and day-patients and high discharge rates. Various explainer variables were found to be correlated with these performance variables. The hospitals were accessible, had few social workers, high staffing and expenditure and were 'progressive' on the institutional indices. There were more informal and fewer old admissions and the hospitals were usually small.

The analysis in chapter 6 has shown that some of these relationships were spurious and, in fact, the only significant relationship between the performance variables was the negative one between in-patient numbers and discharge rate, the remaining correlations apparently being due to common causal variables. Similarly the institutional variables appear to be related to the performance variables mainly because they had a common cause in high staffing and some of the external variables. Social worker numbers increased both in-patient numbers and the discharge rate, although the negative indirect effect on the latter is the one which had appeared earlier. Accessibility only affected day-patient numbers directly and otherwise had an indirect effect on the performance indices. Similarly, the percentage of informal admissions directly affected only the discharge rate. The staffing variables affected all the performance indices directly except in-patient numbers, and, as expected, high staffing increased those performance variables listed at the end of chapter 5. In contrast the costing variables had a direct effect only on the discharge rate and this effect was negative, although the indirect effect of overall expenditure, through the staffing variables, was larger and positive. Hospital size did not affect any of the performance variables directly.

It has thus been possible to examine the ways in which a hospital fulfils its therapeutic function by observing the performance variables and the way they affect one another and are affected by the explainer variables. Several of these explainer variables are also indicators of a hospital's efficiency in some of its other spheres of activity. The direct and indirect effects of the explainer variables on the performance indices have been ascertained and those which are redundant in explaining variation in the performance indices have been identified.

It is possible to examine different ways of attempting to attain therapeutic efficiency using particular combinations of values of the performance indices, as was done above for the 'revovling door' type of hospital. It follows from this that, once the aims of the psychiatric service have been determined, a particular combination of values of the performance indices can be chosen as most conducive to achieving those aims; furthermore, several explainer variables exist which are amenable to change in order to secure this desired combination of values. For instance an increase in expenditure on staffing should increase discharge rates if this were to be considered desirable; the size of the regression coefficient would indicate the likely magnitude of the resulting change. Similarly use of community care facilities would also increase if staff-patient ratios increased.

The decision about which particular combination of the performance indices is desirable is clearly a medical one which belongs ultimately to the Department of Health and Social Security. However this study has identified some of the most important sources of variation in the efficiency of psychiatric hospitals, and has proposed a causal explanation of variation in some aspects of their therapeutic efficiency. Thus this study has illustrated the methods which can be used in forming this kind if decision. It is true that more adequate measures of therapeutic efficiency might include such variables as a re-admission rate, and a case could be made for the inclusion of many other explainer variables, but the methods illustrated above could be applied in these cases to produce similar kinds of conclusion.

The particular achievement of this study has been to effect the reduction of a large number of variables by the use of principal components analysis and canonical correlations analysis and to explore their inter-relationships by means of two stage least squares regression. As a consequence it has been found that the therapeutic, socialization and protection functions of a hospital are generally mutually compatible; but that the custodial function is incompatible with certain aspects of the socialization function, although compatible with the other functions. It can thus be seen that multivariate analytical techniques along the lines of this study can be usefully applied in clarifying a complicated situation in the psychiatric service.

The success of the method employed in the particular case studied herein opens up possibilities for further research in other areas. Current DHSS policy favours a 'comprehensive' psychiatric service 'in which the emphasis is on rehabilitation, on the preservation of continuity of the patient's personal relationships and of his contacts with the local community' (DHSS, 1971, p.155). The above method of successfully differentiating direct and indirect causes and spurious correlations could be applied to the analysis of data relevant to the question of rehabilitation rather than performance and similar clarification would be achieved. This would require both clincial data and data relating to the personal circumstances of individuals, much of which can only be obtained from case-registers (see e.g. DHSS, 1970a and 1970b). Once appropriate variables had been selected it would be possible to reduce their number by eliminating those variables which did not relate to the chosen measures of rehabilitation. The interactions between the remaining variables could then be explored.

Similarly, other problems which involve the examination of a comprehensive set of data, could be profitably tackled using the methods of applied statistics illustrated above.

## APPENDIX 1 : CANONICAL CORRELATIONS

A full derivation of canonical correlations is given in Anderson (1968) and the concept of redundancy is explained in Cooley and Lohnes (1971) and Stewart and Love (1968).

We begin with two vector variables $\underline{z}_1$ with $P_1$ elements and $\underline{z}_2$ with $P_2$ elements and a sample of size N.* Let the correlation matrix be $\underline{R}$

$$\underline{R} = \begin{bmatrix} \underline{R}_{11} & \underline{R}_{12} \\ \underline{R}_{21} & \underline{R}_{22} \end{bmatrix}$$

where $\underline{R}_{11}$ is the correlation matrix for the elements of $\underline{z}_1$, $\underline{R}_{22}$ is the correlation matrix for the elements of $\underline{z}_2$ and $\underline{R}_{12}$ is the matrix of intercorrelations. For simplicity we take $P_2 \leq P_1$.

We seek sets of weights $\underline{c}$ and $\underline{d}$ such that

$$x = \underline{c}' \underline{z}_1 \qquad y = \underline{d}' \underline{z}_2$$

where x and y both have zero mean and unit variance and also

$$R_c = \frac{1}{N} \sum_{i=1}^{N} x_i y_i \text{ is maximised}$$

---

*Matrices and vectors are indicated by being underlined and capital letters are used to distinguish matrices.

Then x and y are canonical factors and $R_c$ is the canonical correlation.

The problem reduces to the solution of the equation

$$(\underline{R}_{22}^{-1} \underline{R}_{21} \underline{R}_{11}^{-1} \underline{R}_{12} - \lambda_j \underline{I}) \underline{d}_j = 0$$

subject to the restriction equation

$$\underline{d}_j' \underline{R}_{22} \underline{d}_j = 1$$

where the $\lambda_j$ i.e. the eigenvectors of the matrix $\underline{R}_{22}^{-1} \underline{R}_{21} \underline{R}_{11}^{-1} \underline{R}_{12}$ are the squared canonical correlations and the eigenvectors, suitably scaled, are the $\underline{d}_j$ i.e. the weights for the $\underline{z}_2$ vector. The canonical weights for the other vector $\underline{z}_1$ are given by

$$\underline{c}_j = \frac{(\underline{R}_{11}^{-1} \underline{R}_{12} \underline{d}_j)}{\sqrt{\underline{d}_j}}$$

The significance test used was derived by Bartlett (1941, 1947) and uses Wilk's lambda.

$$\Lambda = \prod_{i=1}^{P_2} (1 - \lambda_i).$$

$\Lambda$ is distributed approximately as chi-square with $P_1 P_2$ degrees of freedom:

$$\chi 2 = - [(N - 1) - 1/2 (1 + P_1 + P_2)] \log_e \Lambda$$

which can be used to test the null hypothesis that $\underline{z}_1$ is unrelated to $\underline{z}_2$.

If this hypothesis is rejected the relationship is tested with some of the canonical correlations removed. With r relations removed

$$\Lambda' = \prod_{i=r+1}^{P_2} (1 - \lambda_i)$$

and $\chi 2 = -\left[(N-1) - 1/2\ (1 + P_1 + P_2)\right] \log_e \Lambda'$

with $(P_1 - r)\ (P_2 - r)$ degrees of freedom.

(q)

Once the number of significant relationships had been established the redundancy of one vector variable with respect to the other was examined. First the correlation between the canonical factors and the original variables was derived:

$$\underline{s}_1 = \frac{1}{N} \sum_{i=1}^{N} \underline{z}_{1i}\, x_i$$

which simplifies to $\underline{s}_1 = \underline{R}_{11}\, \underline{c}$ and similarly $\underline{s}_2 = \underline{R}_{22}\underline{d}$. The proportion of variance extracted from the first set of variables by the canonical factor x is

$$\frac{\underline{s}_1' \underline{s}_1}{P_1}$$

The proportion of variance in the factor x explained by the other set of variables $(\underline{z}_2)$ is $R_c^2$, the square of the canonical correlation between x and y since x is orthogonal to all the other factors derived from that set. Then the redundancy of the first set of variables given the second set which is displayed by the canonical factor x is

$$R_{dx} = \frac{\underline{s}_1' \underline{s}_1}{P_1} \cdot R_c^2.$$

Similarly the redundancy of the second set given the first displayed by the factor y is

$$R_{dy} = \frac{\underline{s}_2' \, \underline{s}_2}{P_2} \cdot R_c^{\,2}$$

These redundancies may be summed so that the total redundancy of the first set of variables $(\underline{z}_1)$ given the second $(\underline{z}_2)$ with q significant relationships is

$$R_{d1} = \sum_{k=1}^{q} R_{dx_k}$$

This is the proportion of the variance of the first set of variables explained by the second test.

Similarly the redundancy of the second set of variables given the first is

$$R_{d2} = \sum_{k=1}^{q} R_{dy_k}$$

References for Appendix 1

1. T.W. Anderson (1958) 'An Introduction to Multivariate Statistical Analysis', Wiley.

2. M.S. Bartlett (1941) 'The Statistical Significance of Canonical Correlations', Biometrika, Vol.32, pp.29-38.

3. M.S. Bartlett (1947) 'Multivariate Analysis', Journ. Royal Statistical Society Series B, Vol.9, pp.176-197.

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5. W.W. Cooley and P.R. Lohnes (1971) 'Multivariate Data Analysis', Wiley.

6. D. Stewart and W. Love (1968) 'A General Canonical Correlation Index', Psychological Bulletin, Vol.70, No.3, pp.160-163.

## APPENDIX 2 : DIAGNOSES

On 31st December 1971 the Department of Health and Social Security carried out a Census of all patients in psychiatric hospitals and units in England and Wales. Data were obtained for 245 hospitals or units in all, with an average of 250 patients. One of the items of information obtained for each patient was diagnostic category. The initial grouping gave 24 groups of International Classification of Diseases codings and these were grouped into the 12 Broad Diagnostic Groups used in the data from the Mental Health Enquiry published by the DHSS (DHSS, 1972). The groupings were as follows:

D1 Schizophrenia, schizo-affective disorders, paranoia

D2 Depressive psychoses, involutional melancholia

D3 Senile and pre-senile psychoses

D4 Alcholic psychoses

D5 Other psychoses

D6 Psychoneuroses

D7 Alcoholism

D8 Drug Dependence

D9 Personality and behaviour disorders

D10 Mental handicap

D11 Other psychiatric conditions

D12 All other conditions

An analysis of variance was carried out on each diagnostic category to test whether the average percentage of patients in each category differed between Regional Hospital Boards. The method used was that described in chapter 4 and the results are given in Table A.1 which also gives the average percentage of patients in diagnostic groups for each Board.

Although the data analysed were for a different year from that of the main study it was felt that there were unlikely to be large differences between years in the kinds of patients in a particular hospital so that the results obtained would be valid for 1967 also. The census data were not for the groups of hospitals studied in the main analysis but for the constituent hospitals and units of these groups. However if it were true that the percentage of patients in a particular diagnostic category did not differ significantly between Regional Hospital Boards when these individual hospitals or units were considered it should be true that differences would not be significant for the hospital groups of which they formed a part.

Examination of Table A.1 shows that differences between Boards were significant only for D4 Alcoholic Psychoses and D10 Mental Handicap. In both cases it appears that this is mainly due to the fact that certain Boards had a very high average percentage of patients in these categories. Since the percentage of patients with Alcoholic Psychoses was under 3%, even for the Board with the highest percentage of patients in this category, it was decided that differences for this variable could be ignored. The significant result for the percentage of patients with Mental Handicap was of more concern, since these patients generally need treatment different from that suitable for psychiatric patients. However, since the analysis was concerned with psychiatric hospitals it was decided that this difference would also be ignored.

Thus, with the exception of mentally handicapped patients, the differences in mean percentages of patients in the 12 diagnostic groups considered were sufficiently small for the assumption to be made that the kinds of patient treated in the Regional Hospital Boards were the same, so that differences in the ways hospitals functioned could not be ascribed to differences in patient diagnoses between Hospital Boards.

## TABLE A.1 : ANALYSIS OF VARIANCE OF DIAGNOSES

| Diagnosis | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Board | | | | | | |
| 1 | 29.44 | 7.73 | 18.31 | 0.63 | 7.71 | 10.45 |
| 2 | 26.10 | 10.77 | 9.51 | 0.43 | 11.27 | 11.48 |
| 3 | 29.42 | 10.75 | 11.37 | 0.37 | 12.43 | 11.26 |
| 4 | 27.36 | 11.98 | 14.67 | 0.08 | 8.85 | 16.11 |
| 5 | 24.83 | 10.58 | 5.47 | 2.36 | 7.22 | 16.68 |
| 6 | 27.34 | 14.77 | 5.70 | 0.21 | 7.42 | 7.69 |
| 7 | 26.28 | 11.76 | 16.90 | 0.65 | 9.12 | 10.60 |
| 8 | 31.91 | 9.32 | 6.15 | 1.07 | 6.14 | 7.67 |
| 9 | 37.80 | 8.05 | 11.58 | 0.16 | 10.53 | 16.83 |
| 10 | 24.57 | 9.40 | 11.91 | 0.20 | 12.81 | 11.87 |
| 11 | 32.91 | 10.55 | 10.47 | 0.37 | 13.95 | 7.43 |
| 12 | 31.94 | 9.01 | 10.35 | 0.51 | 10.84 | 4.35 |
| 13 | 24.43 | 10.81 | 15.07 | 0.45 | 11.29 | 8.06 |
| 14 | 24.80 | 6.97 | 13.61 | 0.46 | 9.38 | 5.26 |
| 15 | 35.03 | 13.70 | 11.83 | 0.50 | 17.53 | 2.85 |
| Mean | 28.62 | 10.20 | 11.67 | 0.58 | 10.24 | 9.48 |
| S.D. | 19.72 | 8.45 | 15.28 | 1.43 | 9.47 | 14.48 |
| F.Value | 0.62 | 0.89 | 1.10 | 2.15* | 1.38 | 1.16 |



* Significant at 5% level. **

| 7 | 8 | 9 | 10 | 11 | 12 | No. of hospitals |
|---|---|---|---|---|---|---|
| 0.78 | 0.06 | 7.78 | 2.09 | 3.47 | 11.56 | 20 |
| 1.01 | 0.06 | 6.32 | 2.05 | 4.58 | 16.42 | 16 |
| 1.53 | 0.23 | 9.90 | 2.97 | 2.23 | 7.54 | 22 |
| 0.43 | 0.00 | 3.36 | 3.73 | 1.71 | 11.71 | 8 |
| 0.99 | 1.06 | 6.47 | 1.49 | 4.65 | 18.22 | 13 |
| 0.39 | 0.27 | 10.04 | 0.95 | 4.12 | 21.10 | 14 |
| 1.40 | 0.75 | 4.14 | 3.33 | 2.19 | 12.89 | 16 |
| 1.10 | 0.76 | 15.14 | 1.06 | 6.75 | 12.93 | 22 |
| 0.79 | 0.17 | 6.76 | 3.39 | 1.80 | 2.13 | 11 |
| 0.96 | 0.09 | 8.37 | 3.75 | 6.35 | 9.73 | 15 |
| 0.46 | 0.15 | 9.29 | 3.00 | 2.98 | 8.45 | 13 |
| 0.77 | 0.02 | 9.66 | 9.81 | 3.46 | 9.29 | 22 |
| 0.96 | 0.12 | 5.56 | 3.57 | 3.69 | 15.99 | 28 |
| 0.82 | 0.10 | 16.45 | 4.25 | 3.78 | 14.12 | 16 |
| 1.61 | 0.00 | 3.76 | 2.40 | 4.52 | 6.26 | 9 |
| 0.96 | 0.26 | 8.62 | 3.33 | 3.84 | 12.20 | |
| 1.64 | 1.13 | 17.17 | 5.81 | 8.02 | 14.86 | |
| 0.69 | 1.31 | 0.77 | 2.93** | 0.54 | 1.58 | |

Significant at 1% level

APPENDIX 3

```
TIME =  0000  00.105

TIME =  0000  00.161

TIME =  0000  00.224
```

## APPENDIX 3 : ANALYSIS OF VARIANCE

LIST;

```
      DIMENSION N(20),SUM(20),SS(20),VARM(20),FM1(9),X(40)
    1 FORMAT(5I5)
    2 FORMAT(9A8)
    3 FORMAT(1H1)
    4 FORMAT(/)
      READ(7,1)NODDIF
      READ(7,1)K,INDEV
      READ(7,11)(N(I),I=1,K)
   11 FORMAT(15I3)
      DO 1000 IUMDAT=1,NODDIF
      WRITE(6,6)NUMDAT
    6 FORMAT(/10X,11HDATA SET NO,I5/)
      WRITE(6,15)
   15 FORMAT(/10X,4HCELL,5X,4HSIZE,14X,4HMEAN/)
      REWIND INDEV
      READ(7,2)FM1
      SUMTOT=0.0
      SSTOT=0.0
      TOTMEN=0.0
      NALL=0.0
      TOT=0.0
      DO 100 I=1,K
      NI=N(I)
      READ(INDEV,FM1)(X(J),J=1,NI)
    5 FORMAT(1X,12F10.2)
      SUM(I)=0.0
      SS(I)=0.0
      DO 10 J=1,NI
      SUM(I)=SUM(I)+X(J)
   10 SS(I)=SS(I)+X(J)**2
      DIV=N(I)
      VARM(I)=SUM(I)/DIV
      TOTADD=(SUM(I)**2)/DIV
      SUMTOT=SUMTOT+SUM(I)
      SSTOT=SSTOT+SS(I)
      TOTMEN=TOTMEN+VARM(I)
      NALL=NALL+N(I)
      TOT=TOT+TOTADD
      WRITE(6,7)I,N(I),VARM(I)
  100 CONTINUE
    7 FORMAT(10X,2I8,4F20.4)
C
      C=(SUMTOT**2)/NALL
      G=TOT-C
      GRAND=SSTOT-C
      RES=GRAND-G
```

```
      IDFGP=K-1
      DFGP=IDFGP
      IDFRES=NALL-K
      DFRES=IDFRES
      IDFTOT=NALL-1
      DFTOT=IDFTOT
      SSMGP=G/DFGP
      SSMRES=RES/DFRES
      F=SSMGP/SSMRES
      WRITE(2,12)
   12 FORMAT(/25X,3HS S,4X,3HD F,15X,3HM S)
      WRITE(2,4)
      WRITE(2,8)G,IDFGP,SSMGP
      WRITE(2,8)RES,IDFRES,SSMRES
      WRITE(2,4)
      WRITE(2,8)GRAND,IDFTOT,
    8 FORMAT(10X,F20.5,I5,F20.5)
      WRITE(2,4)
      WRITE(2,9)F
    9 FORMAT(10X, 9HF RATIO =,F15.5)
      WRITE(2,3)
 1000 CONTINUE
      STOP
      END
```

TIME = 0000 01

## APPENDIX 3 : PRINCIPAL COMPONENTS ANALYSIS

TIME = 0000 01

TIME = 0000 02

```
LIST:
      DIMENSION X(40,40),SUM(40),SS(40,40),SD(40),COV(40,40),COR(40,40)
      DIMENSION VARLAS(100)
     1,Y(40),XL(40),RNAME(10),Z(40), D(40,40),
     2FM1(9),FM2(9),FM3(9) ,
     3THIR(40),FOUR(40)
      INTEGER Q
      READ(7,100)NUMDAT
      DO 999 NODDIE=1,NUMDAT
      WRITE(2,115)NODDIE
  115 FORMAT(/10X,11HDATA SET NO,I5/)
      READ(7,90) RNAME
   90 FORMAT(10A8)
      WRITE(2,91) RNAME
   91 FORMAT(1X,10A8/)
      READ(7,100) M,N,Q,INDPC,INDCOR,INDPER
  100 FORMAT(10I5)
      WRITE (2,150) M,N
  150 FORMAT(/10X,12HNO OF VARS =,I5,5X,13HSAMPLE SIZE =,I5/)
      READ(7,101)FM1
      READ(7,101)FM2
      READ(7,101)FM3
  101 FORMAT(9A8)
      EN=N
      IF(INDCOR)9,9,340
    9 DO 10 J=1,M
      DO 11 K=1,M
   11 SS(J,K)=0.0
      THIR(J)=0.0
      FOUR(J)=0.0
   10 SUM(J)=0.0
      DO 12 I=1,N
      READ(Q,FM1)(Y(J),J=1,M)
      SOMME = 0.0
      DO 700 J=1,M
  700 SOMME = SOMME + Y(J)
      IF (SOMME) 702,702,703
  702 WRITE(2,750)I
  750 FORMAT(/5X,15HSUM = 0 FOR ROW,I5)
      EN = EN-1.0
      GO TO 751
  703 IF (INDPER) 751,751,752
  752 DO 701 J=1,M
  701 Y(J) = (Y(J)/SOMME)*100.0
  751 DO 13 J=1,M
      DO 14 K=1,J
   14 SS(K,J)=SS(K,J)+Y(J)*Y(K)
      THIR(J)=THIR(J)+Y(J)**3
      FOUR(J)=FOUR(J)+Y(J)**4
```

```
   13 SUM(J)=SUM(J)+Y(J)
   12 CONTINUE
      WRITE(2,755)EN
  755 FORMAT(/5X,17HNEW SAMPLE SIZE =,F5.0)
      WRITE(2,102)
  102 FORMAT(5X,26HSQUARES AND CROSS PRODUCTS/)
      DO 15 J=1,M
   15 WRITE(2,FM2)(SS(K,J),K=1,J)
      DO 16 J=1,M
   16 SUM(J)=SUM(J)/EN
      DO 25 J=1,M
      DO 25 K=1,M
   25 COV(K,J)=SS(K,J)/(EN-1.0)-(SUM(K)*SUM(J)*EN)/(EN-1.0)
      DO 17 J=1,M
   17 SD(J)=SQRT(COV(J,J))
      WRITE(2,103)
  103 FORMAT(//10X,5HMEANS)
      WRITE(2,FM2)(SUM(J),J=1,M)
      WRITE(2,104)
  104 FORMAT(//10X,8HSTD DEVS)
      WRITE(2,FM2)(SD(J),J=1,M)
      WRITE(2,105)
  105 FORMAT(///5X,17HCOVARIANCE MATRIX/)
      DO 18 J=1,M
   18 WRITE(2,FM2)(COV(K,J),K=1,J)
      DO 19 J=1,M
      DO 19 K=1,J
      COR(K,J)=COV(K,J)/SQRT(COV(K,K)*COV(J,J))
   19 COR(J,K)=COR(K,J)
  360 GO TO 320
  340 WRITE(2,330)
  330 FORMAT(/10X,27HINPUT IS CORRELATION MATRIX/)
      DO 331 K=1,M
  331 READ(7,FM1)(COR(K,J),J=1,M)
  320 WRITE(2,106)
  106 FORMAT(///5X,18HCORRELATION MATRIX/)
      DO 20 J=1,M
   20 WRITE(2,107)(COR(K,J),K=1,M)
      TSIG1 = 1.96/SQRT(EN-1.0)
      TSIG2 = 2.576/SQRT(EN-1.0)
      WRITE(2,760)TSIG1,TSIG2
  760 FORMAT(//5X,14H5 PER CENT R =,F8.4,5X,14H1 PER CENT R =,F8.4//)
      IF(INDCOR)350,350,351
  107 FORMAT(1X,(12(F8.5,3X)))
  350 WRITE(2,110)
  110 FORMAT(//9X,1HJ,21X,10H3RD MOMENT,15X,10H4TH MOMENT,16X,8HSKEWNESS
     1,17X,8HKURTOSIS/)
      DO 86 J=1,M
      THIR(J)=THIR(J)/EN
      FOUR(J)=FOUR(J)/EN
      THOM=THIR(J)-SUM(J)*(3.0*(SS(J,J)/EN)-2.0*SUM(J)*SUM(J))
      FORE=FOUR(J)-SUM(J)*(4.0*THIR(J)-SUM(J)*(6.0*(SS(J,J)/EN)-3.0*SUM
     1(J)*SUM(J)))
      DEN=COV(J,J)**3
      SKEW=THOM/SQRT(DEN)
      TOSS = FORE/(COV(J,J)*COV(J,J))
   86 WRITE(2,111)J,THOM,FORE,SKEW,TOSS
  111 FORMAT(5X,I5,5X,4F22.5)
  351 IF(INDPC) 95,95,96
   96 WRITE(2,97)
```

```
C
   05 CONTINUE
      EPS=1.0E-16
      DO 40 J=1,M
   40 XL(J)=COR(J,J)
      CALL JACOB (M,COR,XL,X,0,EPS,40)
      WRITE(2,400)
  400 FORMAT(1X///10X,11HEIGENVALUES/)
      WRITE(2,FM3)(XL(J),J=1,M)
      DO 41 J=1,M
      TERM=XL(J)
      DO 41 K=1,M
   41 X(K,J)=SQRT(TERM)*X(K,J)
      WRITE(2,402)
  402 FORMAT(1X//10X,24HADJUSTED FACTOR LOADINGS/)
      DO 42 K=1,M
   42 WRITE(2,FM3)(X(K,J),J=1,M)
      L=M
      DO 61 I=1,L
   61 Z(I)=XL(I)
      DO 63 I=2,L
      JUP=I-1
      DO 63 J=1,JUP
      IF(XL(J).GE.XL(I)) GO TO 63
   65 S=XL(J)
      XL(J)=XL(I)
      XL(I)=S
   63 CONTINUE
      WRITE(2,611)
  611 FORMAT(1X//5X,21HREORDERED EIGENVALUES/)
      WRITE(2,610)(XL(I),I=1,L)
  610 FORMAT(1X,12F11.5)
C
      DO 66 I=1,L
      DO 66 J=1,L
      IF(XL(I)-Z(J))66,67,66
   67 DO 68 K=1,L
   68 D(K,I)=X(K,J)
   66 CONTINUE
      WRITE(2,614)
  614 FORMAT(////5X,22HREORDERED EIGENVECTORS/)
      DO 70 I=1,L
   70 WRITE(2,610)(D(I,J),J=1,L)
C
      DO69 I=1,L
      DO 69 J=1,L
   69 X(I,J)=D(I,J)
      WRITE(2,119)
  119 FORMAT(//17X,10HEIGENVALUE,5X,18HVARIANCE EXPLAINED,5X,24HTOTAL VA
     1RIANCE EXPLAINED//)
      TOTAL=0.0
      TRACE=0.0
      DO 49 J=1,M
   49 TRACE=TRACE+XL(J)
      DO 50 J=1,M
      BIT=100.0*XL(J)/TRACE
      TOTAL=TOTAL+BIT
   50 WRITE(2,120)XL(J),BIT,TOTAL
```

```
  120 FORMAT( 5X,F20.5,2(2X,F15.3))
      WRITE(2,186)
  186 FORMAT(/5X,11HNO OF ROOTS,5X,3HD F,10X,10HCHI SQUARE/)
      PROD=XL(1)
      TRACE=XL(M)
      DO 81 IK=2,M
      K=M-IK
      EK=K
      Q=IK
      ICHIDF=((M-K-1)*(M-K+2))/2
      KUP=K+1
      PROD=PROD*XL(KUP)
      TRACE=TRACE+XL(KUP)
      CHI=-ALOG(PROD)+Q*ALOG(TRACE/Q)
      PREMCH=EN
      CHI=PREMCH*CHI
      WRITE(2,87)IK,ICHIDF,CHI
   87 FORMAT(5X,I4,10X,I4,11X,F9.3)
   81 CONTINUE
C
      WRITE(2,301)
  301 FORMAT(///5X,70HPRINCIPAL COMPONENTS WITH COLUMNS SCALED BY MAGNIT
     1UDE OF LARGEST ENTRY/)
      DO 30 J=1,M
      BIG=ABS(D(1,J))
      DO 31 I=2,M
      IF(BIG-ABS(D(I,J)))32,31,31
   32 BIG=ABS(D(I,J))
   31 CONTINUE
      DO 33 I=1,M
   33 D(I,J)=D(I,J)/BIG
  300 FORMAT(/5X,I5,F10.5)
   30 CONTINUE
      DO 35 I=1,M
   35 WRITE(2,FM3)(D(I,J),J=1,M)
C
  999 WRITE(2,1000)
 1000 FORMAT(1H1)
      STOP
      END
```

## APPENDIX 3 : CANONICAL CORRELATIONS ANALYSIS

```
                                                                                   TIME =  0000  01

:LIST:                                                                             TIME =  0000  01
      DIMENSION FM1(9),FM2(9),FM9(9)
      DIMENSION R(40,40),A(30,30),B(30,30),C(30,30),X(30),Y(30),Z(30)
      DIMENSION RNAME(10)
      DIMENSION T1(30,30),XL(30),Q(30,30)
      DIMENSION S(30,30),T(30,30),V(30,30),Z1(30),WI(30)
      COMMON Q,S,T1,XL
      INTEGER Q
      INTEGER Q1,Q2
C
  110 FORMAT(/1X,10A8/)
  404 FORMAT(1X//5X,35HDEGREES OF FREEDOM FOR CHI-SQUARE =,I6)
  405 FORMAT( //24X,15HWILK,S LAMBDA =,F15.7)
  406 FORMAT( //27X,12HCHI SQUARE =,F15.7)
  407 FORMAT(  //8X,31HSQUARED CANONICAL CORRELATION =,F15.7)
  408 FORMAT( //16X,23HCANONICAL CORRELATION =,F15.7)
  409 FORMAT(1X//5X,18HRIGHT-HAND WEIGHTS/)
  410 FORMAT(1X//6X,17HLEFT-HAND WEIGHTS/)
      WRITE(2,101)
  101 FORMAT(1X //20X,32HCANONICAL CORRELATIONS PROGRAMME//)
      READ(7,102)NODDIE
      DO 1000 NOD=1,NODDIE
      READ(7,109)RNAME
  109 FORMAT(10A8)
      WRITE(2,110)RNAME
      READ(7,102) M1,M2,N,Q1,Q2,INCOR
  102 FORMAT(10I5)
      WRITE(2,103)M1
  103 FORMAT(10X,25HNO OF VARIABLES ON LEFT =,I3)
      WRITE(2,104)M2
  104 FORMAT(10X,25HNO OF VARIABLES ON RIGHT=,I3)
      WRITE(2,105)N
  105 FORMAT(1X/10X,20HNO OF INDIVIDUALS = ,I5/)
      READ(7,106)FM1
      READ(7,106)FM2
      READ(7,106)FM9
  106 FORMAT(9A8)
      M=M1+M2
      MUP=M1+1
      EM=M
      EN=N
      EM1=M1
      EM2=M2
      IF(INCOR.EQ.1)GO TO 910
      DO 7 I=1,M
      X(I)=0.0
      DO 7 J=1,M
    7 R(I,J)=0.0
      DO 32 I=1,N
      READ(Q1,FM1)(Y(J),J=1,M1)
      READ(Q2,FM2)(Y(J),J=MUP,M)
      DO 33 J=1,M
```

```
   34 R(K,J)=R(K,J)+Y(J)*Y(K)
   33 X(J)=X(J)+Y(J)
   32 CONTINUE
      DO 36 J=1,M
   36 Y(J)=X(J)/EN
      DO 150 J=1,M2
      DO 150 K=1,M2
      JUP = J+M1
      KUP = K+M1
  150 T1(J,K)=R(JUP,KUP)
C
C     WE NOW PRINT OUT THE MEANS
      WRITE(2,111)
  111 FORMAT(15X,24HMEANS OF LEFT  VARIABLES)
      WRITE(2,112)(Y(I),I=1,M1)
  112 FORMAT(1X,11F11.3)
      WRITE(2,113)
  113 FORMAT(1X/15X,24HMEANS OF RIGHT VARIABLES)
      WRITE(2,112)(Y(I),I=MUP,M)
      DO 37 J=1,M
      DO 37 K=1,J
   37 R(K,J)=R(K,J)/(EN-1.0)-(Y(K)*Y(J)*EN)/(EN-1.0)
      DO 38 J=1,M
   38 Y(J)=SQRT(R(J,J))
C
C     HERE WE PRINT THE STANDARD DEVIATIONS
      WRITE(2,114)
  114 FORMAT(1X// 5X,38HSTANDARD DEVIATIONS OF LEFT  VARIABLES)
      WRITE(2,112)(Y(I),I=1,M1)
      WRITE(2,115)
  115 FORMAT(1X/5X,38HSTANDARD DEVIATIONS OF RIGHT VARIABLES)
      WRITE(2,112)(Y(I),I=MUP,M)
      DO 40 J=1,M
      DO 40 K=1,J
      R(K,J)=R(K,J)/(Y(K)*Y(J))
   40 R(J,K)=R(K,J)
C
      DO 17 I=1,M1
      DO 17 J=1,M1
   17 A(I,J)=R(I,J)
      DO 18 I=1,M2
      DO 18 J=1,M2
      IUP=I+M1
      JUP=J+M1
   18 B(I,J)=R(IUP,JUP)
      DO 19 I=1,M1
      DO 19 J=1,M2
      JUP=J+M1
   19 C(I,J)=R(I,JUP)
      GO TO 913
  910 WRITE(2,911)
  911 FORMAT(//10X,27HINPUT IS CORRELATION MATRIX//)
      DO 210 I=1,M1
  210 READ(31,FM1)(A(I,J),J=1,M1)
      DO 211 I=1,M2
  211 READ(31,FM1)(B(I,J),J=1,M2)
      DO 212 I=1,M1
  212 READ(31,FM1)(C(I,J),J=1,M2)
  913 WRITE(2,120)
```

```
  120 FORMAT(1X///10X,11H R11 MATRIX/)
      DO 21 I=1,M1
   21 WRITE(2,FM9)(A(I,J),J=1,M1)
      WRITE(2,123)
  123 FORMAT(1X//10X,11H R22 MATRIX/)
      DO 24 I=1,M2
   24 WRITE(2,FM9)(B(I,J),J=1,M2)
      WRITE(2,125)
  125 FORMAT(1X//10X,11H R12 MATRIX/)
      DO 26 I=1,M1
   26 WRITE(2,FM9)(C(I,J),J=1,M2)
      WRITE(2,126)
  126 FORMAT(1X///5X,40HWE NOW HAVE ALL THE CORRELATION MATRICES////)
  107 FORMAT(1H1)
      CONTINUE
C
  400 CALL MINNIE(A,M1,DETERM)
      DO 43 I=1,M2
      DO 43 J=1,M1
      T1(I,J)=0.0
      DO 43 K=1,M1
   43 T1(I,J)=T1(I,J)+C(K,I)*A(K,J)
      DO 44 I=1,M2
      DO 44 J=1,M2
      D(I,J)=0.0
      DO 44 K=1,M1
   44 D(I,J)=D(I,J)+T1(I,K)*C(K,J)
C     D NOW CONTAINS (R21*R22INVERSE*R12)
  401 FORMAT(/1X,10F13.4)
C
      DO 380 J=1,M2
      DO 380 K=1,M2
  380 S(J,K)=D(J,K)
      CALL DIRNM(M2)
      L=M2
      DO 61 I=1,L
   61 Z(I)=XL(I)
      DO 63 I=2,L
   62 JUP=I-1
      DO 63 J=1,JUP
      IF(XL(J).GE.XL(I)) GO TO 63
   65 G=XL(J)
      XL(J)=XL(I)
      XL(I)=G
   63 CONTINUE
      WRITE(2,611)
  611 FORMAT(1X//5X,21HREORDERED EIGENVALUES/)
      WRITE(2,610)(XL(I),I=1,L)
  610 FORMAT(1X,12F10.5)
C
      DO 66 I=1,L
      DO 66 J=1,L
      IF(XL(I)-Z(J))66,67,66
   67 DO 68 K=1,L
   68 D(K,I)=T1(K,J)
   66 CONTINUE
      WRITE(2,614)
  614 FORMAT(////5X,22HREORDERED EIGENVECTORS/)
      DO 64 I=1,L
   64 WRITE(2,610)(D(I,J),J=1,L)
```

```
      WRITE(2,999)
      DO 69 I=1,L
      DO 69 J=1,L
   69 T1(I,J)=D(I,J)
C
      DO 300 J=1,M2
      DO 300 K=1,M2
  300 V(J,K)=T1(J,K)
      DO 328 J=1,M2
      DO 328 K=1,M2
      S(J,K)=0.0
      DO 328 L=1,M2
  328 S(J,K)=S(J,K)+V(L,J)*B(L,K)
      DO 329 J=1,M2
      DO 329 K=1,M2
      T(J,K)=0.0
      DO 329 L=1,M2
  329 T(J,K)=T(J,K)+S(J,L)*V(L,K)
C
C     T NOW CONTAINS THE DISPERSION OF THE RIGHT SET COMPONENTS BASED
C     ON UNIT LENGTH VECTORS AS REPORTED BY SUBROUTINE DIRNM
C
      DO 330 J=1,M2
      Z1(J)=SQRT(XL(J))
      DO 330 K=1,M2
  330 V(J,K)=V(J,K)*(1.0/SQRT(T(K,K)))
C
C     V NOW CONTAINS THE ANDERSON NORMALIZED COLUMN VECTORS FOR THE
C     RIGHT SET SUCH THAT  VPRIME*R22*V= I,THE IDENTITY MATRIX.
      DO 370 J=1,M2
      DO 370 K=1,M2
      D(J,K)=0.0
      DO 370 L=1,M2
  370 D(J,K)=D(J,K)+V(L,J)*R(L,K)
      DO 371 J=1,M2
      DO 371 K=1,M2
      S(J,K)=0.0
      DO 371 L=1,M2
  371 S(J,K)=S(J,K)+D(J,L)*V(L,K)
C
      DO 331 J=1,M1
      DO 331 K=1,M2
      S(J,K)=0.0
      DO 331 L=1,M1
  331 S(J,K)=S(J,K)+A(J,L)*C(L,K)
      DO 332 J=1,M1
      DO 332 K=1,M2
      T(J,K)=0.0
      DO 332 L=1,M2
  332 T(J,K)=T(J,K)+S(J,L)*V(L,K)
      DO 333 J=1,M1
      DO 333 K=1,M2
  333 T(J,K)=T(J,K)/Z1(K)
C
C     T NOW CONTAINS THE ANDERSON NORMALIZED COLUMN VECTORS FOR THE
C     LEFT SET, SUCH THAT  TPRIME*R11*T= I, THE IDENTITY MATRIX.
C
      WRITE (2,335)
  335 FORMAT(//10X,35HLEFT SET CANONICAL WEIGHTS, COLUMNWISE/)
      DO 334 J=1,M1
```

```
      334 WRITE(2,365)J,(T(J,K),K=1,M2)
      365 FORMAT(/1X,I5,4X,12F10.3/(10X,12F10.3))
          WRITE (2,336)
      336 FORMAT(// 9X,39HRIGHT SET CANONICAL WEIGHTS, COLUMNWISE/)
          DO 366 J=1,M2
      366 WRITE(2,365)J,(V(J,K),K=1,M2)
C
          CALL MINNIE(A,M1,DETERM)
          DO 337 J=1,M1
          DO 337 K=1,M2
          S(J,K)=0.0
          DO 337 L=1,M1
      337 S(J,K)=S(J,K)+A(J,L)*T(L,K)
          WRITE(2,339)
      339 FORMAT(/10X,29HFACTOR STRUCTURE FOR LEFT SET/)
          DO 338 J=1,M1
      338 WRITE(2,365)J,(S(J,K),K=1,M2)
          SUM1=0.0
          SUM2=0.0
          DO 352 J=1,M2
          WI(J)=0.0
          DO 352 K=1,M1
      352 WI(J)=WI(J)+S(K,J)*S(K,J)
          DO 353 J=1,M2
          WI(J)=WI(J)/EM1
          SUM1=SUM1+WI(J)
          X(J)=WI(J)*XL(J)
      353 SUM2=SUM2+X(J)
          WRITE(2,354)
      354 FORMAT(/15X,40HFACTOR  VARIANCE EXTRACTED    REDUNDANCY/)
          DO 355 J=1,M2
      355 WRITE(2,356)J,WI(J),X(J)
      356 FORMAT(15X,I3,10X,F10.3,7X,F10.3)
          WRITE(2,357)SUM1
      357 FORMAT(/5X,23HTOTAL LEFT SET VARIANCE,F10.3)
          WRITE(2,358)SUM2
      358 FORMAT(/3X,25HTOTAL LEFT SET REDUNDANCY,F10.3/)
C
          DO 340 J=1,M2
          DO 340 K=1,M2
          S(J,K)=0.0
          DO 340 L=1,M2
      340 S(J,K)=S(J,K)+B(J,L)*V(L,K)
          WRITE(2,341)
      341 FORMAT(/10X,30HFACTOR STRUCTURE FOR RIGHT SET/)
          DO 367 J=1,M2
      367 WRITE(2,365)J,(S(J,K),K=1,M2)
          SUM1=0.0
          SUM2=0.0
          DO 360 J=1,M2
          WI(J)=0.0
          DO 360 K=1,M2
      360 WI(J)=WI(J)+S(K,J)*S(K,J)
          DO 361 J=1,M2
          WI(J)=WI(J)/EM2
          SUM1=SUM1+WI(J)
          X(J)=WI(J)*XL(J)
      361 SUM2=SUM2+X(J)
          WRITE(2,354)
          DO 362 J=1,M2
```

```
  362 WRITE(2,356)J,WI(J),X(J)
      WRITE(2,363)SUM1
  363 FORMAT(/4X,24HTOTAL RIGHT SET VARIANCE,F10.3)
      WRITE(2,364)SUM2
  364 FORMAT(/2X,26HTOTAL RIGHT SET REDUNDANCY,F10.3/)
      WRITE(2,999)
C
      CALL MINVIE(A,M1,DETERM)
      WL=1.0
      DO 39 I=1,M2
   39 WL=WL*(1.0-XL(I))
      WRITE(2,405)WL
      PREMCH=-(EN-(EM+1.0)/2.0)
      CHISQ=PREMCH*ALOG(WL)
      WRITE(2,406)CHISQ
      IDFCH=M1*M2
      WRITE(2,404)IDFCH
      IV=1
C
  500 ROOT=XL(IV)
      WRITE(2,501)IV
  501 FORMAT(//5X,43HTEST AFTER REMOVING CANONICAL CORRELATIO NO.I4)
      IF(IV-M2)511,71,71
  511 SUMR=IV
      DO 73 I=1,IV
   73 SUMR=SUMR-1.0/XL(I)
      PREMCH=PREMCH+SUMR
  510 WL=1.0
      MLOW=IV+1
      DO 70 I=MLOW,M2
   70 WL=WL*(1-XL(I))
      WRITE(2,405)WL
      CHISQ=PREMCH*ALOG(WL)
      WRITE(2,406)CHISQ
      IDFCH=(M1-IV)*(M2-IV)
      WRITE(2,404) IDFCH
      DFCH=IDFCH
      IF(DFCH-CHISQ)71,603,603
  603 WRITE(2,604)
  604 FORMAT(//5X,30HCHI-SQUARE VALUE LESS THAN D F//)
   71 CONTINUE
      DO 45 I=1,M2
   45 X(I)=T1(I,IV)
      WRITE(2,407)ROOT
      SROOT=SQRT(ROOT)
      WRITE(2,408)SROOT
      DO 46 I=1,M2
   46 Y(I)=X(I)
C
      DO 47 I=1,M1
      X(I)=0.0
      DO 47 J=1,M2
   47 X(I)=X(I)+C(I,J)*Y(J)
      DO 48 I=1,M1
      Z(I)=0.0
      DO 48 J=1,M1
   48 Z(I)=Z(I)+A(I,J)*X(J)
      DO 49 I=1,M1
   49 Y(I)=(1.0/ROOT)*Z(I)
C     Y(I)= LEFT-HAND WEIGHTS
```

```
C     NORMALIZE LEFT-HAND WEIGHTS
      SS=0.0
      DO 55 I=1,M1
   55 SS=SS+Y(I)*Y(I)
      VAREX=SS/EM1
   57 FORMAT(5X,I5,2F10.5,5X,(10F10.5))
      SS=SQRT(SS)
      DO 56 I=1,M1
   56 Y(I)=Y(I)/SS
C
      IV=IV+1
      IF(M2-IV)600,500,500
  600 WRITE(2,601)
  601 FORMAT(////5X,56HA POOR RELATION - IS THE MOST IRRELEVANT THING IN
     1 NATURE//)
 1000 WRITE(2,999)
  999 FORMAT(1H1)
      STOP
      END

      SUBROUTINE MINNIE(A,N,DET)
      DIMENSION A(30,30),IPIV(30),IND(30,2),PIV(30)
      DET=1.0
      DO 2 J=1,N
    2 IPIV(J)=0
      DO 55 I=1,N
      AMAX=0.0
      DO 105 J=1,N
      IF(IPIV(J)-1)6,105,6
    6 DO 10 K=1,N
      IF(IPIV(K)-1)8,10,74
    8 IF(ABS(AMAX)-ABS(A(J,K)))9,10,10
    9 IROW=J
      ICOL=K
      AMAX=A(J,K)
   10 CONTINUE
  105 CONTINUE
      IPIV(ICOL)=IPIV(ICOL)+1
      IF(IROW-ICOL)14,26,14
   14 DET=-DET
      DO 20 L=1,N
      AID=A(IROW,L)
      A(IROW,L)=A(ICOL,L)
   20 A(ICOL,L)=AID
   26 IND(I,1)=IROW
      IND(I,2)=ICOL
      PIV(I)=A(ICOL,ICOL)
      DET=DET*PIV(I)
      A(ICOL,ICOL)=1.0
      DO 35 L=1,N
   35 A(ICOL,L)=A(ICOL,L)/PIV(I)
   38 DO 55 L1=1,N
      IF(L1-ICOL)40,55,40
   40 T=A(L1,ICOL)
      A(L1,ICOL)=0.0
      DO 45 L=1,N
   45 A(L1,L)=A(L1,L)-A(ICOL,L)*T
   55 CONTINUE
   60 DO 71 I=1,N
```

```
      L=N+1-I
      IF(IND(L,1)-IND(L,2))63,71,63
   63 JROW=IND(L,1)
      JCOL=IND(L,2)
      DO 70 K=1,N
      AID=A(K,JROW)
      A(K,JROW)=A(K,JCOL)
      A(K,JCOL)=AID
   70 CONTINUE
   71 CONTINUE
   74 RETURN
      END

      SUBROUTINE DIRNM(M)
      DIMENSION A(30,30),B(30,30),X(30,30),XL(30)
      COMMON A,B,X,XL
C     DIAGONALIZE B-INVERSE*A
C     A,B ARE M BY M INPUT MATRICES
C     XL CONTAINS EIGENVALUES,X CONTAINS EIGEN VECTORS IN COLUMNS
      EPS=1.0E-16
      DO 135 I=1,20
      DO 135 J=1,20
  135 X(I,J)=0.0
      DO 32 I=1,M
   32 XL(I)=B(I,I)
      CALL JACK(M,B,XL,X,EPS)
      DO 1 I=1,M
    1 XL(I)=1.0/SQRT(ABS(XL(I)))
      DO 2 I=1,M
      DO 2 J=1,M
    2 B(I,J)=X(I,J)*XL(J)
      DO 3 I=1,M
      DO 3 J=1,M
      X(I,J)=0.0
      DO 3 K=1,M
    3 X(I,J)=X(I,J)+B(K,I)*A(K,J)
      DO 4 I=1,M
      DO 4 J=1,M
      A(I,J)=0.0
      DO 4 K=1,M
    4 A(I,J)=A(I,J)+X(I,K)*B(K,J)
C     A NOW CONTAINS B-1/2PRIME*A*B-1/2
      TRACE=0.0
      DO 10 I=1,M
   10 TRACE=TRACE+A(I,I)
      WRITE(2,11)TRACE
   11 FORMAT(9X/29H TRACE OF B-1/2PRIME*A*B-1/2=,F14.7//)
      DO 33 I=1,M
   33 XL(I)=A(I,I)
      CALL JACK(M,A,XL,X,EPS)
      SUMR=0.0
      WRITE(2,15)
   15 FORMAT(/20X,15HEIGENVALUES ARE/)
      DO 12 I=1,M
      SUMR=SUMR+XL(I)
   12 WRITE(2,13)I,XL(I)
   13 FORMAT(20X,I4,F15.7)
      WRITE(2,14)SUMR
   14 FORMAT(9X/20HSUM OF EIGENVALUES= ,F14.7//)
```

```
      DO 6 I=1,M
      DO 6 J=1,M
      A(I,J)=0.0
      DO 6 K=1,M
    6 A(I,J)=A(I,J)+B(I,K)*X(K,J)
  100 FORMAT(3X,12F10.5)
      DO 9 J=1,M
      SUMV=0.0
      DO 7 I=1,M
    7 SUMV=SUMV+(A(I,J)**2)
      DEN=SQRT(SUMV)
      DO 8 I=1,M
    8 X(I,J)=A(I,J)/DEN
      EM=M
      VAREX=SUMV/EM
    9 CONTINUE
C     COLUMNS OF X(I,J) ARE NOW NORMALIZED
      RETURN
      END


      SUBROUTINE JACK(N,A,SUM,COV,EPS)
      DIMENSION A(30,30), SUM(30), COV(30,30)
  999 DO 58 J=1,N
      DO 59 I=1,N
   59 COV(I,J)=0.0
   58 COV(J,J)=1.0
   60 AMAX=0.0
      DO 61 I=2,N
      JUP=I-1
      DO 61 J=1,JUP
      AII=SUM(I)
      AJJ=SUM(J)
      AOD=A(I,J)
      ASQ=AOD*AOD
   76 IF(ASQ-AMAX)73,73,77
   77 AMAX=ASQ
   73 IF(ASQ-EPS)61,61,62
   62 DIFFR=AII-AJJ
      IF(DIFFR)63,65,65
   63 SIGN=-2.0
      DIFFR=-DIFFR
      GO TO 66
   65 SIGN=2.0
   66 TDEN=DIFFR+SQRT(DIFFR*DIFFR+4.0*ASQ)
      TANK=SIGN*AOD/TDEN
      C=1.0/(SQRT(1.0+TANK*TANK))
      S=C*TANK
      DO 74 K=1,N
      XJ=C*COV(K,J)-S*COV(K,I)
      COV(K,I)=S*COV(K,J)+C*COV(K,I)
      COV(K,J)=XJ
      IF(K-J)67,74,68
   67 XJ=C*A(J,K)-S*A(I,K)
      A(I,K)=S* A(J,K)+C* A(I,K)
      A(J,K)=XJ
      GO TO 74
   68 IF(K-I)69,74,71
   69 XJ=C*A(K,J)-S*A(I,K)
      A(I,K)=S*A(K,J)+C*A(I,K)
```

```
          A(K,J)=XJ
          GO TO 74
       71 XJ=C*A(K,J)-S*A(K,I)
          A(K,I)=S*A(K,J)+C*A(K,I)
          A(K,J)=XJ
       74 CONTINUE
          SUM(I)=C*C*AII+S*S*AJJ+2.0*S*C*AOD
          SUM(J)=C*C*AJJ+S*S*AII-2.0*S*C*AOD
          A(I,J)=0.0
       61 CONTINUE
          IF(AMAX-EPS)70,70,60
       70 RETURN
          END
```

APPENDIX 3 : TWO STAGE LEAST SQUARES REGRESSION

LIST

```
      DIMENSION TIT(10),FM1( 9),SS(30,30),R(30,30),Y(30),X(30),XMAT(30,3
     10),A(30730),B(30,30),C(30,30),D(30,2),COF(30,2),S(30,30),
     2E(2,30)7F(2,30),SG(30),SUM(30),VAR(30),NS(30),V(30)
   89 FORMAT(//)
   90 FORMAT(5I5)
   91 FORMAT(9A8)
   92 FORMAT(1X,12F10.4)
   93 FORMAT(5X,9A8)
   94 FORMAT(20I3)
   95 FORMAT(1H1)
      READ(7,90)IMO
      DO 5000 IM=1,IMO
      READ(7,91)(TIT(K),K=1,9)
      WRITE(2793)(TIT(K),K=1,9)
      READ(7,90) N,NY,NX,INP,NORG
      WRITE (2,90)N,NY,NX,INP,NORG
      READ(7,91)FM1
      NV=NY+NX
      DO 207 J=1,NV
      SUM(J)=0.0
      DO 207 K=1,NV
  207 SS(J,K)=0.0
      DO 208 L=1,N
      READ(INP,FM1)(VAR(J),J=1,NV)
      DO 208 J=1,NV
      SUM(J)=SUM(J)+VAR(J)
      DO 208 K=1,NV
  208 SS(J,K)=SS(J,K)+VAR(J)*VAR(K)
      EN=N
      DO 210 J=1,NV
      DO 210 K=1,NV
  210 R(J,K) = (SS(J,K)-SUM(J)*SUM(K)/EN)/EN
      DO 211 J=1,NV
      Y(J) = SUM(J)/EN
  211 X(J)=SQRT(R(J,J))
      WRITE(27212)
  212 FORMAT(/5X,24HVAR        MEAN        S D/)
      DO 213 J=1,NV
  213 WRITE(27214)J,Y(J),X(J)
  214 FORMAT(4X,I3,4X,F10.4,1X,F10.4)
      WRITE(27215)
  215 FORMAT(/5X,20HCROSS-PRODUCT MATRIX/)
      DO 216 J=1,NV
      DO 206 K=1,NV
  206 SS(J,K) = R(J,K)*EN
```

```
TIME =  0000  00.055

TIME =  0000  00.113

TIME =  0000  00.745
```

```
  216 WRITE(2,217)(SS(J,K),K=1,NV)
  217 FORMAT(2X,10F13.3)
      WRITE(2,218)
  218 FORMAT(/5X,18HCORRELATION MATRIX/)
      DO 219 J=1,NV
      DO 220 K=1,NV
      R(J,K) = R(J,K)/(X(J)*X(K))
  220 SS(J,K) = R(J,K)
  219 WRITE(2,92)(R(J,K),K=1,NV)
C
      DO 500 IRUN=1,NORG
      WRITE(2,95)
      WRITE(2,89)
      WRITE(2,205)IRUN
  205 FORMAT(5X,6HREG NO,I5/)
      READ(7,90)NPY,NPX
      NOP=NPY+NX+1
      NOSEC = NPY + NPX + 1
      READ(7,94)(NS(J),J=1,NOSEC)
      NEXTJ = NOSEC + 1
      JMIN = NPY + 2
      DO 305 I=1,NX
      JTRY = NY +I
      DO 306 J=JMIN,NOSEC
      IF (JTRY.NE.NS(J)) GO TO 306
      GO TO 305
  306 NS(NEXTJ) = JTRY
      NEXTJ = NEXTJ + 1
  305 CONTINUE
      WRITE(2,94)(NS(J),J=1,NOP)
      DO 309 K=1,NOP
       NC = NS(1)
      KSUB = NS(K)
  309 S(1,K) = SS(NC,KSUB)
      MSUB = 2
      DO 243 J=1,NV
      IF(J.NE.NS(MSUB))GO TO 243
  245 DO 251 K=1,NOP
      KSUB=NS(K)
  251 S(MSUB,K)=SS(J,KSUB)
      MSUB = MSUB+1
  310 FORMAT(5X,2I5)
      IF (MSUB.EQ.NOSEC) GO TO 247
  243 CONTINUE
      JMIN = NOSEC + 1
  247 DO 307 J=JMIN,NOP
      DO 308 K=1,NOP
      KSUB = NS(K)
      JF = NS(J)
  308 S(J,K) = SS(JF,KSUB)
  307 CONTINUE
      DO 300 I=1,NOP
  300 WRITE(2,217)(S(I,J),J=1,NOP)
      WRITE(2,89)
      IUP = NPY + NPX
      DO 235 I=1,IUP
      INOM = I+1
  235 V(I) = S(INOM,1)
      WRITE (2,217)(V(I),I=1,IUP)
      WRITE(2,89)
```

```
C
      DO 230 I=1,NX
      IUP = NPY + I + 1
      DO 230 J=1,NX
      JUP = NPY + J + 1
  230 XMAT(I,J)= S(IUP,JUP)
      CALL GAUJOA(XMAT,NX,COF,0,DETX,30,2)
      WRITE(27231)DETX
  231 FORMAT(/5X,16HX DETERMINANT = ,F16,5/)
      DO 260 I=1,NPY
      IUP = I + 1
      DO 260 J=1,NX
      JUP = J + NPY + 1
      A(I,J) = S(IUP,JUP)
  260 B(J,I) = S(IUP,JUP)
      CALL MATMUL (A,NPY,NX,XMAT,NX,C)
      CALL MATMUL (C,NPY,NX,B,NPY,A)
      DO 261 I=1,NPY
      IUP=I+1
      JMIN=NPY+1
      JMAX=NPY+NPX
      DO 261 J=JMIN,JMAX
      JUP=J+1
      A(I,J)=S(IUP,JUP)
  261 A(J,I)=S(JUP,IUP)
      ILOW=NPY+1
      IUP=NPY+NPX
      DO 262 I=ILOW,IUP
      IMIN=I+1
      DO 262 J=ILOW,IUP
      JMIN=J+1
  262 A(I,J)=S(IMIN,JMIN)
      DO 263 I=1,NX
      IUP=I+NPY+1
  263 D(I,1)=S(IUP,1)
      CALL MATMUL(C,NPY,NX,D,1,B)
      ILOW=NPY+1
      IUP=NPY+NPX
      DO 264 I=ILOW,IUP
      IMIN=I+1
  264 B(I,1)=S(IMIN,1)
      WRITE(27357)
  357 FORMAT(/5X,8HA MATRIX/)
      DO 265 I=1,IUP
  265 WRITE(27217)(A(I,J),J=1,IUP)
C
C A MATRIX HAS NOW BEEN FORMED
      WRITE(2789)
      WRITE(27358)
  358 FORMAT(5X,8HB VECTOR/)
      WRITE(27217)(B(I,1),I=1,IUP)
      WRITE(2789)
      CALL GAUJOA(A,IUP,COF,D,DETA,30,2)
      WRITE(27266)DETA
  266 FORMAT(/5X,16HA DETERMINANT = ,F16,5/)
      CALL MATMUL (A,IUP,IUP,B,1,COF)
      JUP=NPY+1
      DO 270 J=2,JUP
      I=J-1
      E(1,J)=-COF(I,1)
```

```
  270 D(J,1)=-COF(I,1)
      D(1,1) = 1.0
      E(1,1) = 1.0
      DO 271 I=1,JUP
      DO 271 J=1,JUP
  271 C(I,J)= S(I,J)
      DO 360 I=1,JUP
      F(1,I) = 0.0
      DO 361 J=1,JUP
  361 F(1,I) = F(1,I) + E(1,J)*C(J,I)
  360 CONTINUE
      C(1,1) = 0.0
      DO 362 J=1,JUP
  362 C(1,1) = C(1,1) + F(1,J)*D(J,1)
      FIRS=C(1,1)
      DO 272 J=1,NPX
      I=NPY+J
      E(1,J)=COF(I,1)
  272 D(J,1)=COF(I,1)
      DO 273 I=1,NPX
      ICO = I+NPY+1
      DO 273 J=1,NPX
      JCO = J+NPY+1
  273 C(I,J)=S(ICO,JCO)
      DO 363 I=1,NPX
      F(1,I) = 0.0
      DO 364 J=1,NPX
  364 F(1,I) = F(1,I) + E(1,J)*C(J,I)
  363 CONTINUE
      C(1,1) = 0.0
      DO 365 J=1,NPX
  365 C(1,1) = C(1,1) + F(1,J)*D(J,1)
      SEC = C(1,1)
      EX = NPX
      EY = NPY
      DEN = EN - EX - EY
      SIG = (FIRS-SEC)/DEN
      DO 275 I=1,IUP
      SIN = ABS(A(I,I)*SIG)
  275 SG(I) = SQRT(SIN)
      WRITE(2?275)SIG
  276 FORMAT(/5X,20HVARIANCE ESTIMATE = ,F15.5/)
      WRITE(2?280)NS(1)
  280 FORMAT(/5X,22HDEPENDENT VARIABLE IS ,I5/)
      DO 268 I=1,IUP
      L=I+1
  268 WRITE(2?269)I,NS(L),COF(I,1),SG(I)
  269 FORMAT(5X,2I6,5X,F12.5,5X,F12.5)
      RSQ = 0.0
      DO 236 I=1,IUP
  236 RSQ = RSQ + COF(I,1)*V(I)
      WRITE (2,290)RSQ
  290 FORMAT(//5X,20HMULTIPLE R SQUARED =,F15.5/)
C
  500 CONTINUE
      WRITE(2?95)
      REWIND 60
 5000 CONTINUE
      STOP
      END
```

```
      SUBROUTINE MATMUL (A,NA1,NA2,B,NB2,C)
      DIMENSION A(30,30),B(30,30),C(30,30)
      DO 10 I=1,NA1
      DO 10 J=1,NB2
      C(I,J)=0.0
      DO 11 K=1,NA2
   11 C(I,J)=C(I,J)+A(I,K)*B(K,J)
   10 CONTINUE
   12 RETURN
      END
```

TIME = 0000 22.089

## APPENDIX 4 : LIST OF VARIABLES USED IN THE ANALYSIS

### Performance Indices

Pe1 No. of in-patients per 1000 Catchment Population.

Pe2 No. of Annual Admissions per 1000 Catchment Population.

Pe3 Patient Turnover Rate.

Pe4 Patient Death Rate.

Pe5a Overall Discharge Rate.
Pe5b Young Patients Discharge Rate
Pe5c Short Term Patient Discharge Rate.

Pe6 No. of new out-patients per annum per 1000 Catchment Population.

Pe7 No. of new day-patients per annum per 1000 Catchment Population.

Pe8 Total no. of out-patient attendances per annum per 1000 Catchment Population.

Pe9 Total no. of day-patient attendances per annum per 1000 Catchment Population.

Pe10 No. of out-patient attendances per 100 in-patient days.

Pe11 No. of day-patient attendances per 100 in-patient days.

## EXPLAINER VARIABLES

### Environmental Indices

E1a Index of hospital accessibility.

E1b Index of hospital inaccessibility.

E1c Distance from hospital to the nearest large town.

E2a No. of Welfare Service Social Workers per 1000 Catchment Population.

E2b No. of Mental Health Social Workers per 1000 Catchment Population.

E2c No. of places for the Mentally Ill provided by the Local Authority in workshops or day centres per 1000 Catchment Population.

E3a Official Contact between Local Authority and Hospital.

E3b Actual Contact between Local Authority and Hospital.

E4 Involvement of Voluntary Organisations.

Professional Indices (Number per 100 In-patients in each case).

Pr1a Consultant Psychiatrists.

Pr1b Other Psychiatric Medical Staff.

Pr2a Trained Nurses.

Pr2b Other Nurses.

Pr3a Psychologists.

Pr3b Psychiatric Social Workers.

Pr3c Therapists.

Pr3d Instructors/Teaching Staff.

Pr4 Domestic Assistants and Ward Orderlies.

Institutional Indices

In1a % of resident patients working in domestic and hospital service departments.

In1b % of resident patients working elsewhere i.e. handicrafts etc.

In2 % of patients in wards of 50 or more.

In3 Average % bed occupancy.

In4 Number of years elapsed since qualification of Medical Superintendent.

In5a % of beds with a space of less than 50 sq.ft.

In5b % of beds with a space of more than 60 sq.ft.

In6 No. of visiting hours per week.

In-patient Costing (£ per in-patient per week)

IC1 Cost of Drugs.

IC2 Total Ward Cost.

IC3a Cost of Pathology.

IC3b Cost of Pharmacy.

IC3c Cost of Ancilliary medicine.

IC4 Medical Service Departments cost.

IC5 Total In-patient cost.

Out-patient Costing (£ per 100 out-patient attendances)

ICO1 Cost of Drugs (Equivalent to IC1).

ICO2 Total Out-patient Departments cost (Equivalent to IC2).

ICO3 Cost of Treatment Departments only (Equivalent to IC4).

ICO4 Net total cost (Equivalent to IC5).

ICO5 $\frac{\text{Net Total Out-patient Cost (ICO4)}}{\text{Total In-patient Cost per in-patient per week (IC5)}}$

Socio-Medical Indices

S1 % of Catchment Population who are male.

S2a % of Male Catchment Population, over 15, who are married.

S2b % of Female Catchment Population, over 15, who are married.

S3a % of Male Catchment Population in Executive and Professional Classes.

S3b % of Male Catchment Population in other Non-manual and Skilled manual Classes.

S3c % of Male Catchment Population in Unskilled and Semi-skilled Classes.

S4 % of Admitted Patients who are informal admissions.

S5 % of Admitted Patients who are aged 65 or over.

S6 % of Admitted Patients who are Male.

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