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# THE PROVISION OF HEALTH CARE IN REMOTE HOSTILE ENVIRONMENTS

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VOLUME II

C O N T E N T S

## ABSTRACT

The health care of those who work in remote places associated with hostile environments is reviewed concentrating on the offshore oil industry and Antarctic populations. An understanding of associated environmental hazards is essential for adequate health care and particular attention is paid to the hyperbaric environment and to environmental heat and cold.

The basic medical problems in remote health care are evaluated in three related studies. The first examines 2,162 personnel who required medical evacuations from the offshore structures of four North Sea operating companies, the second with 5,894 presentations from offshore at the Accident and Emergency department of Aberdeen Royal Infirmary, while the third examines 100 annual medical reports from British Antarctic Survey stations.

The pattern of illness and injury is similar in all three studies, while the definitive diagnoses available from the hospital study add credibility to the working diagnoses of the offshore medics. The limitation of evacuations requiring a dedicated helicopter to 7.7% of the total testifies to the adequacy of the health service and the training of the medics. Antarctic

personnel have many differences from the offshore personnel, but in both cases dental problems dominate the illness scene. The high number of injuries to bones and the frequency of hand injuries have implications for training.

Training, communications and environmental hazards were identified as key issues in remote health care and an aspect of each has been examined. The basic training course was assessed by examining about 1,000 trainee evaluations and it was found to meet the needs of the population, while the advances in communication technology - particularly digital slow scan television - were felt to constitute a major advance in remote health care. Useful advice can result even from a simple investigation of an environmental hazard like heat, but education of the workforce is needed for prevention.

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**VOLUME I**

## PREFACE

The studies from which this thesis was written, were undertaken while the author was employed as Assistant Director at the Centre for Offshore Health, RGIT.

The Centre for Offshore Health, was a self-funding academic unit, dependent for its existence on funds earned by the activities of its personnel. The author is thus grateful to the Director and personnel of the Centre for their support and help in allowing him the time to carry out the studies and to write this thesis. The Centre for Offshore Health amalgamated with the Offshore Survival Centre in RGIT to form RGIT Survival Centre Ltd in April 1989. The first year of the new company was very busy, but the author had the continuing support and encouragement of the Directors to complete the thesis.

The philosophy which has been used in these studies, and which has now been applied to other personnel in the Centre who are pursuing research work is that the subject chosen should be of general interest and importance to the Centre. This is intended to ensure the support of the other personnel and to maintain their interest and help in the prosecution of the research. It has also been deemed important that the studies should be sufficiently supported financially by outside resources to justify the author spending time investigating them. This philosophy has worked well. The results of this study have proved extremely important to the development of the Centre's teaching and research activities and the author has thus been greatly supported in his work by his colleagues.

A basic aim of the Survival Centre is the promotion and improvement of health care for those who work in remote places, associated with hostile environmental conditions. This thesis records the gradual establishment of a system of Health Care which has emerged for those who work in the North Sea and for those who work in British Antarctic territories. From the evolution of the concept it proceeds to study various fundamental aspects, which have been identified as of importance in the system. These include the definition of the actual problems which arose with a view to determining the adequacy of the health care system, together with the nature of the training work which was required and the areas of research which could best be followed. Other studies have been established, following those reported in this thesis. These have been commented upon within this thesis so that the continuing nature of the work can be appreciated.

The data collection in the retrospective study involved a team led by the author but the study was designed by the author in association with his Supervisor and Director of Studies. The other studies were carried out by the author on his own, aside from some technical help in typing entries into the computer and the haematological and biochemical analyses in the heat study were undertaken by the hospital laboratory on Das Island.

The thesis has been produced in two volumes, the first containing the text and the second the figures, tables and references. This is to facilitate reading so that the text can be read while the related illustration is seen.

CHAPTER I

## 1. INTRODUCTION TO REMOTE HEALTH CARE

Despite the enormous advances made in medicine during the second half of this century - the control of infection, transplantation, the surgery of the coronary arteries etc, there are still vast population groups for whom modern medicine is not available. While some of these groups live in places like Madagascar, Borneo and Central Africa, there are others associated with more advanced countries, for whom particular provision is now being made even although they live in remote and isolated situations. Such groups include the inhabitants of parts of Northern Canada, (House, 1981, 1985; Charbonneau, 1982), Central Australia, (Taylor and Biggs, 1987; Cummins, Biggs and Whiting, 1964) and certain parts of China, (Xinzhong, 1988).

During the second half of the 20th century the international oil industry began to explore a variety of remote and hazardous places for energy sources, and this exploratory business eventually led to the discovery of oil and gas reserves not only under inhospitable deserts, but also under the sea. A further environmental hazard was thus added to the recovery of the oil and gas and this required much investigation and thought in both human physiology and medicine, (Jones, 1983; Anderson, 1983; Sunde, 1983; Kummer, 1983; Golden, 1983;

Nome, 1983; Proctor, 1983; Bustin, 1983; Roythorne, 1983).

In the early days of exploration in isolated parts of the world, the growing oil industry had a requirement to provide reasonable standards of health care for its personnel. This was done by building, equipping and staffing such medical and hospital facilities as were required, (Norman, 1983). When the action shifted offshore new problems developed since there was an interval of time and distance, which separated the patient from these facilities and the health care of divers began to impinge on the medical support necessary, (Rawlins, 1972, 1977, 1980; Cox, 1974; Donald 1976; Cox and James, 1978).

The waters of the Gulfs of Arabia and Mexico are not particularly deep and the installations are relatively close to land. The situation was entirely different, however, when exploration began in the Northern North Sea, where the conditions were extremely hostile, where the time and distance separating the installations from hospital facilities were vast, and where the water was deep and cold. Also, there was an urgent requirement to use such techniques as saturation diving, which had until recently been largely experimental, (MacInnis, 1975; Vorosmarti, 1976; James and Cox, 1987).

Whereas previously such activities had taken place in obscure parts of the world this operation was in the centre of the civilised world, with highly developed countries all around the North Sea, each with strong and distinct medical views and systems, and the media observing what took place closely. There was thus a need rapidly to develop a system of health care for the increasing number of personnel working in the middle of the North Sea. It is the development of that system and its evaluation which forms a substantial part of this thesis.

It now seems clear that the system developed suits the need of the offshore industry well, and attempts have been made to introduce the concept developed in the North Sea into different areas one of which is British Antarctic territory, (Norman, 1981a). An occupational health scheme has now been devised for the British Antarctic Survey, which is roughly similar in concept to that developed for the North Sea offshore industry, (Norman and Brebner, 1988; Norman and Laws, 1988).

The examination of these two systems of health care together with an appraisal of the problems and provisions for remote health care in other parts of the world, such as the flying doctor service in Australia, the barefoot doctor concept in China, and the system developed in Memorial University, St Johns, Newfoundland for the remote populations of Labrador and Newfoundland will allow an appraisal to be made which will hopefully result in the description of a system of health care which can be adapted to suit the needs of any remote population group. The principles should be the same in a hot or cold environment, underwater or even in space, and the ultimate aim should be the provision of health care which approaches that which would be available if the patient lived in a city close to a modern teaching hospital.

In addition to isolation, most populations which have a need for some form of remote health care are associated with one type of environmental hazard or another. This may be heat, cold, high atmospheric pressure in divers or micro gravity for those men of the future who will staff the space stations.

## 2. REVIEW OF SYSTEMS OF REMOTE HEALTH CARE

This review will initially describe the main features of the systems which have emerged to provide health care for various remote population groups. It will then describe the development of the systems of health care which have emerged from the two main areas to be examined - the offshore oil and gas industry and British Antarctic territories. It will next examine the environmental hazards which are likely to be encountered in such remote situations, and which require to be taken into account in the development of health care for the populations at risk. Finally, there will be an appraisal of the areas which need particular attention, if a comprehensive system of remote health care is to emerge for such communities.

### a) REMOTE HEALTH CARE IN AUSTRALIA

Australia's economy has always been predominantly dependent on farming. It seems likely that it will continue in much the same way for many years with little change in the size of the country towns, which are widely separated and do not have the clinical work to justify full time specialists.

Australia's approach to the provision of health care for such remote and isolated areas was the establishment of the Royal Australian Flying Doctor service. This has been an extremely successful service but it still left unanswered the problem of specialist care, particularly that required urgently from surgeons and anaesthetists. The problem which had to be addressed was whether it was better to fly out specialist teams as and when required or to transport patients to the coastal cities for surgery, (Taylor and Biggs, 1987). The argument has common features with that which took place in the development of medical services for the Northern North Sea oil and gas industry, with particular respect to the problems of saturation divers who required surgical care.

In Australia, a flying surgeon service was set up in Queensland in 1959 and the personnel consisted of a pilot, an anaesthetist and a surgeon, (Cummins, Biggs and Whiting, 1964). This has proved an extremely satisfactory solution to the problem and further units have now been established. During the past 25 years, the flying surgical unit has flown more than 3.5 million kilometres and over 30,000 operations have been performed, (Taylor and Biggs, 1987).

### b) REMOTE HEALTH CARE IN CHINA

The approach used for health provision for the vast populations of remote China was rather different and has been described as the "barefoot doctor". This was essentially the training of people in the rudiments of medical care in an endeavour to bring at least some help to the large number of sick people who had no other means of care, (Xinzhong, 1988). Little has been written about this experiment, but it did not provide a good solution to the problems as far as can be determined. It is likely that a serious problem was lack of an effective system of communication so that advice from highly trained individuals could not be provided at the scene of the problem. Even if barefoot doctors had been provided with a reasonable education they would still have been seriously limited if they did not have access to the advice of their seniors, (Xinzhong, 1988).

In the provision of immediate care facilities in the more advanced, industrialised nations of the world it has become apparent that badly taught and practised first-aid is probably more dangerous than none at all, (Fisher, 1985). Serious consideration thus has to be given, not only to the whole system of health care needed to provide for the needs of remote communities, but also to the standards of training which are provided.

## c) REMOTE HEALTH CARE IN NEWFOUNDLAND AND LABRADOR

North American medicine is probably the most advanced in the world, but in the far North of Canada there are vast tracts of land which are still very sparsely populated, and which have an extremely hostile environment. The various Canadian States make provision for the health care of their own far Northern populations, but since the whole of Newfoundland and Labrador are sparsely populated, the problems of remote health care have probably been addressed most closely there, (Greenhill, 1979; Michaels, 1989). In this case, primary health care is most often administered by a specially trained nurse. The Department of Nursing at Memorial University, Newfoundland has elaborated degrees and diplomas for those nurses who wish to specialise in this particular form of service. This service works very well. Part of its success is probably due to the parallel development of systems of communication which allow access to medical and specialist advice by the nurse, (Charbonneau, 1982). Tele-medicine has, in fact, been pioneered in Newfoundland, and this allows case conferences to be held each day, from the Health

Sciences Centre in St John's with the nurses in the various remote outposts, (House, 1981).

Tele-medicine has continued its development in Canada, to allow for the transmission of ECG, EEG and even X-rays from various remote locations to the Health Sciences Centre. Until relatively recently there was, for example, only one neurologist in Newfoundland and Labrador and the availability of this system allows an EEG service to be provided throughout the State. This system of medicine requires continuing medical education, and the establishment of the tele-medicine network provides new dimensions in Newfoundland and Labrador, for this provision, (House, Roberts and Canning, 1981).

Despite these interesting developments in remote Canada and elsewhere, it must be admitted that the provision of high grade health care for those who live in remote places still has many deficiencies. In Asiatic communities, particularly in China and India, there are powerful family forces advocating traditional remedies. It is difficult for isolated health care workers, often not doctors to overcome these family superstitions. This must pose a major bar to development. Also, these isolated posts are often difficult to fill and aside from a dedicated few devoted practitioners the occupants are often young people endeavouring to gain experience before moving to a major city. It is also not possible for one person to cover the whole gamut of medicine. In a serious case the absence of readily obtainable specialist advice is a drawback to the solution of acute problems suddenly presented.

The practitioners who are most dedicated and who remain for many years in post often become set in their ways and refuse to keep up with the times and institute changes with advancing knowledge. Indeed, one does not need to look further than some remote areas of Scotland for examples of this even in the medical profession!

A further problem in remote areas is the extent of the area covered by a single practitioner. This means that immediate care for acute illness or injury may take a considerable time to arrive. This problem is currently recognised even in cities where universal first aid has been advocated. There is little evidence of universal first aid training in remote and backwards parts of the world.

A final problem in the quality of medical care delivery is the distance which the seriously ill or injured subject has to travel when more sophisticated facilities are required than can be provided locally. Under these circumstances the escorts are usually not versed in medical techniques at all. The patient is extremely vulnerable during the journey if he should deteriorate.

Many of these problems cannot be answered by improved systems of medical training. They can be improved by the introduction of rotational systems of highly trained people working in remote places for relatively short periods of time and, above all, by the provision of improved and more sophisticated forms of communication with co-ordinating centres where specialist advice is available. Universal training in immediate care and attempts to overcome the superstition in traditional medicine will take much time to achieve.

## 3. THE DEVELOPMENT OF OCCUPATIONAL HEALTH SERVICES IN REMOTE WORK-SITES

### OIL AND GAS INDUSTRY IN THE NORTH SEA

The discovery during the current century, of vast reservoirs of oil and gas in progressively more inaccessible parts of the world not only required considerable developments in technology and engineering, (Sa'd and Cox, 1987), but has also seen the need to develop a system of health care for the vast workforces which have been required. That system of health care has also made it necessary for there to be an improved understanding of the effects of a number of hostile physical environments on man, together with the measures needed to prevent illness from these extreme physical conditions, (Brit Med Assoc, 1975; Cox, 1970b; Sutherland and Cooper, 1986; Hellesøy, 1985).

In the Americas oil was originally sought in commercial quantities in Texas, while in the Netherlands an enormous natural gas field was discovered in the province of Gronegan in 1959. The main developments, however, were in the Middle East where vast deposits were discovered in Saudi Arabia, Iran, Qatar and Abu Dhabi, (Dent, 1974).

The problems of developing the Middle East oilfields were largely logistic, since there were few systems of transportation or communication available. From the medical point of view the problem was mainly one of the preparation, transportation and the establishment of considerable population groups in remote places associated mainly with environmental heat and in providing the necessary basis of primary and specialist medical care for those who were injured or became ill. There was also a requirement to provide for the families and dependents of the workforce. In order to cope with this, the major oil companies established their own medical departments, which usually also cared for the problems of the company's contractors and in many instances provided valuable health services for the local community. Where specialist services were required hospitals were built and specialists recruited, (Norman, 1982). Indeed, the oil company hospitals in Kuwait and in Iran for many years probably provided as high a standard of medical care as could be obtained in the Middle East.

When the Gronegan gas field was discovered in 1959, geological studies at that time indicated the possibility of similar prospects stretching westwards from the Dutch coast under the southern part of the North Sea, and towards the English coast, (Dent, 1974).

There were, however, many years of discussions and wranglings on the law of the sea, before agreement could be reached under the terms of mineral exploitation, and it took until 1964 before the terms of the convention became binding on the 22 nations which had begun discussions in Geneva in 1958. The first licence for exploration in the United Kingdom sector was granted in 1964, (Higginson, 1987).

At the beginning of the century offshore production wells had, in fact, been drilled in the Gulf of Mexico from piers which were built out from the shore. The first offshore well was drilled in Caddo Lake, Texas in 1904 and in the 1920's a rigid offshore drilling platform was constructed in Lake Maracaibo, and subsequently in the Gulf of Mexico 10 years later where oil was discovered in 8 metres of water, one mile offshore, (Dent, 1974). It was not until the 1930's and 1940's, however, that mobile platforms were used in the Gulf of Mexico, and it was in the 1950's that the first jack-up rigs were used to drill in depths up to 100 metres, (Dent, 1974). Following the use of the jack-up installations a submersible rig was designed to sit on the seabed during drilling operations and then to be floated from one location to another by a system of controlled water ballasting, (Cooper and Gaskell, 1966a; Parker, 1979).

Armed with this technology, the offshore petroleum industry moved jack-up rigs into the Southern North Sea and began exploratory drilling in the search for natural gas which was discovered first in late 1965, (Cooper and Gaskell, 1966b). By 1970 oil, in association with gas, had been discovered in commercial quantities and by 1974 most of the oilfields currently being developed in the Northern North Sea had been discovered. It was thus over a very short timescale that vast discoveries were made and industrial development off the East coast of Scotland begun. The industry grew to enormous proportions in a very short period of time - each new discovery being in deeper water and progressively more hostile environmental conditions.

Vast resources were ploughed into the engineering developments required and practically every oil company in the world was represented in the North East of Scotland very quickly. At that time there was no clearly defined system of health care which could support this vast influx. Many problems had to be faced hurriedly by the medical advisers to the oil companies on the one hand, and by the local and national medical authorities of Britain on the other, (Cox and Norman, 1987a,b; Elliott, 1985; Rawlins, 1977-1978, 1980; Shepherd, 1976; Cox, 1970a).

## a) THE IMMEDIATE PROBLEMS

There were five problems which had to be faced immediately (Norman, 1983). These can be summarised as follows:-

(i) There was a very large number of operators and contractors working from a chain of East coast bases and there was no co-ordination or communication between them and the various medical authorities available.

(ii) The National Health Service was in existence in Britain and highly developed. There were national systems of health care in the other seven nations which had their coast line on the North Sea and their systems were all different. This, in fact, was a disadvantage rather than an advantage. It would probably have been easier for the oil companies merely to have provided their own medical and specialist services as they had done in the Middle East.

(iii) A very considerable number of Government departments also claimed some form of responsibility for the work and they were all trying to produce legislation at the same time and with very little liaison between each other. In Britain, for example, it became known around this time that the National Health Service did not operate below the low water mark. This was a fact that had not previously been clearly stated either to the industry or to the profession, and it had considerable implications in the subsequent establishment of the services needed. Full time employees of the National Health Service, for example, could not function offshore with safety, unless they had private means of insurance, since they were working outwith their contract.

(iv) Of more immediate importance, there was now a very large workforce which soon numbered around 10,000 - working in an extremely hostile environment, with a whole range of new and virtually untried technology.

(v) A host of new and rather specialist problems, suddenly arose which the medical profession had not faced in that situation before. These problems included those of both bounce and saturation diving, the problems associated with survival in cold water, the precautions which had to be taken with potable water, food hygiene etc, if the workforce was to be kept healthy.

The early pioneers thus had serious problems which required urgent solution and it seemed clear that a format or system of health care to cope with this new problem in the North East of Scotland was required with some urgency. In order to achieve this, co-ordinating centres were set up in various parts of the country. In Aberdeen the Institute of Environmental and Offshore Medicine was established in 1976, (Norman, 1981b), while the North Sea Medical Centre was established in Great Yarmouth to care for the gas fields in the Southern Sector of the North Sea, (Cox, 1970a,b). Units emerged which took an interest in specific areas of the problem in other parts of the country such as the bone necrosis registry at Newcastle-upon-Tyne, (McCallum, 1975; Decompression Sickness Central Registry, 1981). The medical branch of the Royal Navy played a considerable part in advising both the units in the North and South part of the country and by pioneering such organisations as the Diving Medical Advisory Committee, (Rawlins, 1977-1978). The medical branches of the oil companies formed a Sub-Committee under the banner of the United Kingdom Offshore Operators Association, and the scene was thus set for the establishment of a means of providing good health care for the population at risk.

## 4. THE DEVELOPMENT OF A SYSTEM OF HEALTH CARE FOR THE OFFSHORE OIL AND GAS INDUSTRY

One of the big problems which the pioneers of the North Sea had to face was the strength and composition of the health care team which would be necessary and once again, many factors had to be considered in the different installations and the different situations which had to be catered for. The factors, (Norman, 1982) which were identified were:

(a) Time and distance from medical care.
(b) Size of the work force.
(c) Nature of work, eg diving, drilling, etc.
(d) Communications.
(e) Mode and type of evacuation.
(f) State of physical fitness of the work force.

The time and distance separating the doctor from his patient was a major consideration in this regard, together with the size of the workforce and the nature of the work. For example, if a considerable amount of diving or drilling was undertaken, then the risks were different from those of a production platform.

The communications system which was in operation, was of vital importance in the determination of medical support needed, as was the mode and time taken for the evacuation of the sick and injured. Equally important was the initial state of physical fitness of the work force, (Roythorne, 1983; Cox, 1987a). All these factors made it obvious that there was a paramount need for flexibility and versatility if the most appropriate form of health care was to be provided, and it meant that the possible components of the health care team were reasonably complex.

Whatever system was chosen, it had to revolve around the person of the company medical adviser who was normally located onshore and had at his disposal an offshore team directly under his charge, together with a selection of specialist services onshore behind him, to which he had access if he wished to use them, but which he shared with a number of companies, (Norman, 1976; Cox, 1970a,b; Proctor, 1976; Cox and Norman, 1987a; Rawlins, 1977-1978; Shepherd, 1976).

A variety of possible offshore medical personnel emerged and the distribution of these personnel depended upon the perception of the company of the factors mentioned above. There could thus be offshore:

(a) A doctor.
(b) A rig medic.
(c) A paramedic - first-aider, life support escort, diving paramedic.

Offshore medical responsibility may thus be primarily held by a doctor, but this would depend on the various factors which determine the extent of medical provision required, (Roythorne, 1979). It would be more usual for primary medical responsibility to be held by a rig medic, who is normally a nurse specially trained and either originating from the hospital services or from military areas. Most operating companies have now recognised a need for offshore personnel to be trained in appropriate forms of first aid, and these personnel form the first line of medical provision both for themselves and for their colleagues.

The number of paramedic classifications is not great in the North Sea and the second category is the life support escort. This implies a man of considerable intelligence who has another job, and has already completed a first aid course, but who is particularly interested in things medical. He has, therefore, undergone a further course of training to allow him to escort the seriously sick from the offshore installation to hospital and he is trained in such things as supporting the airway, taking blood pressure readings, looking after intravenous infusions and communicating medical information.

Each installation provides a sufficient number of escorts for its needs. This obviates the need for a second rig medic and also allows a certain amount of versatility to be built into the system, in order to provide the necessary support for the occasional disaster situation which may occur.

The third category of paramedics found offshore is the diving paramedic who is in a particular category since he has special knowledge to allow him to care for the highly specialised forms of medical problems which may arise in divers. He is usually a diver himself and has a fairly extensive knowledge of physiology to begin with and upon this the special requirement of both dysbaric and intercurrent illness in saturation systems can be taught, (Cox and James, 1978; Rawlins, 1972, 1977).
From this group of medical and paramedical personnel are drawn the offshore medical people who report directly and primarily to the company medical adviser.

Onshore, there gradually became available a series of specialist and other medical services to which the company medical adviser had access in addition to the medical advisers of other companies, (Proctor, 1976; Norman, 1983; Jones 1983). These services include:-

(a) Retained primary care physicians.
(b) Diving medical specialists.

(c) Surgical teams.
(d) Environmental health advisers.
(e) International specialists of various types.

These onshore services are available to the company medical adviser if he wishes to use them, but they are not normally part of the personnel of the company itself. They include retained primary care physicians which are usually present in those centres supporting a substantial degree of offshore activity. There is also a group of diving medical specialists, there are surgical teams, which include anaesthetists and which are available for extrication manoeuvres or for support in disaster situations. There are environmental health advisors and there are co-ordinating units to provide international specialist advice for unusual problems. It has already been noted that there is paramount need for flexibility if the best care is to be provided for the seriously sick offshore. In this regard medical co-ordination and a system of communications proved essential if the local medical man was to be brought in contact with the medical or specialist services which he may require urgently, (Morrison, 1976).

The occupational group which exercised most minds in the early days was the saturation divers, (McCallum, 1975; Rawlins, 1972; Norman, Childs, Jones, Smith, Ross, Riddle, MacKintosh, McKie, MacAulay, Fructus, 1979;

Hendry, Childs, Proctor, 1979; Cox, 1974). These personnel were practising a virtually new technology and there were large numbers of problems which were difficult to solve or even to identify and understand properly at that time (Caldwell, 1976; Warner, 1976; Childs and Norman, 1978). They also had a very high profile as far as the media was concerned. On the other hand, since the problems of saturation divers seemed most difficult to solve, it was felt by many that the elaboration of a system of health care which would suit the needs of saturation divers could be readily adapted for the remaining population since the most difficult case would already have been solved.

Following several long and hard discussions with the aid of various international symposia, (The UK Offshore Safety Conference, 1982; Safety and Health in the Oil and Gas Extractive Industries, 1983), the Diving Medical Advisory Committee, recommended a series of priorities for the management of illness and injury in saturation divers. In many ways that series of priorities has formed the basis of current systems of health care for the whole industry and for other population groups under consideration.

The priorities, set out in order of importance, are:-

(i) Appropriate training in first aid.
(ii) Clear and precise communications.
(iii) Trained doctors willing to go offshore.
(iv) Mobile specialist teams.
(v) Some form of transfer under pressure facilities.

These aspects are discussed below on the section on diving, but they are mentioned at this point since they appear to form the basic foundation of the system which emerged.

a) PERSONNEL SELECTION

Probably the most important item in providing for ideal health care in remote worksites is the recognition of the physical and mental requirements for optimal human performance in these situations, so that the personnel can be carefully selected both physically and mentally, (Palinkas, 1986). Different attributes are necessary for different situations, (Bennet, 1987). For example, any tendency to pulmonary air trapping in divers would be a serious risk to survival, while mental health is as important as physical health in the confines of an Antarctic base in winter, (Taylor, 1987; De Monchaux, Davis and Edholm, 1979).

The system of health care which has emerged has 5 main areas which warrant discussion. These areas are:-

(i) Universal basic life support training.

(ii) Existence of effective and precise systems of communication.

(iii) The existence of a medical co-ordinating centre or base.

(iv) The existence of appropriately familiarised doctors and specialists.

(v) Ongoing research and evaluation.

## b) TRAINING

The extent of the immediate care training depends upon the remoteness and degree of isolation of the personnel at risk. All, of course, must be taught the basic management of unconsciousness, bleeding and the technique of resuscitation, but the amount of instruction on the continuing management of conditions like burns and fractures, depends upon the degree of isolation. A major part of the instruction, however, must be directed towards the marshalling of clinical information and the formating of that information for delivery back to a centre, where a medical man can assist to make a diagnosis and advise on management. The quality of the doctor's advice is related directly to the quality of information with which he is provided. This is an essential part of the training, (Norman and Brebner, 1987; Anderson and Cox, 1987; Norman, 1985).

It is clear that a basic knowledge of life support in the entire work force reduces the incidence of accidents and it also instils a greater sense of confidence in the workforce, (Steggles, 1984; Fisher, 1985).

## c) COMMUNICATIONS

There are certain important aspects of communications which need to be addressed. In the first instance, both written and oral communication is desirable. It is probably best unless the emergency is acute that the information should be provided in the first instance, in the written form. It may be that following advice from other specialists at the co-ordinating centre that the answer may be provided in writing, without the need for voice communication. In certain cases, voice communication is most helpful, but this should always be set up by a written message, in the first instance. Following the discussion there should be a confirmatory exchange of telexes to confirm the nature of the information and the agreement on the treatment to be provided.

Voice communication is now feasible, with the advent of satellite communications, in the most obscure parts of the world, and that type of communication, has probably done more to improve the quality of care, which can be provided in remote situations than anything else, (House, 1985; Shamaskin and Caldwell, 1974).

Diagnostic capability can, however, be improved if it is possible to transmit a series of clinical measurements from the remote situation to the specialist at the co-ordinating centre. Nowadays, such monitoring of pulse, ECG, EEG, etc, is quite straight forward and simple, and this can be of great value, (House, 1981; House, Roberts, Canning, 1981).

The most recent innovation is the use of slow scan television, to transmit X-ray images, (Webber, Wilk, Pirruccello and Aiken, 1973). The analogue systems have been in operation for some time, but the recent advent of the digital systems has made the resolution sufficiently good to be of real diagnostic value in difficult cases. There is a portable X-ray machine with which it is possible to train non-radiographers to take high quality X-ray pictures in a few days. With the use of slow scan television, to transmit the images over considerable distances, to a co-ordinating centre, diagnostic ability is now greatly improved, (Norman and Laws 1988).

d) TRAINING OF DOCTORS AND SPECIALISTS

It is important that the doctors who are at the communication centre should be thoroughly familiar with the levels of expertise of the personnel with whom they are communicating at the remote site and also with the equipment there, (Cox, 1970a,b). If doctors are to be based at the remote site, then they will need particular training programmes before they leave in such subjects as dentistry, radiography, laboratory techniques, etc. They also need to learn the technique of communications with their seniors at a distance, (Norman and Laws, 1988).

Much of this information is now available and is routinely presented in the training courses of various centres and there are diplomas in immediate care and remote health care being provided by certain educational institutions, (Norman, 1985).

e) CONTINUING RESEARCH

There is obviously also a need for continuing research if the system is to be upgraded and improved with the passage of time. The main first point in any medical procedure is the establishment of the diagnosis. When it comes to advice on management, there may be doubts

about the competence and experience of the person at the remote site. In general the actual manoeuvres of acute medicine are standard and can be readily taught. The problem is the authority to use dangerous manoeuvres, which could result in loss of life if wrongly used.
This is why the communications system is so important. The senior man at the base can decide on the use of manoeuvres and take the authority and responsibility for employing them upon himself, (Johnson, 1985; Norman and Brebner, 1987; Cox, 1987).

The person at the remote site does not have to choose or know why he is undertaking the manoeuvres since the judgement of when to use them could be well beyond his competence and authority.

Although the techniques are straight forward, they must be constantly practised. If this does not happen it can be very stressful for a layman to attempt such procedures as the establishment of an intravenous line, the passing of a naso-gastric tube or the intubation of the chest if he has only seen it done once. One way around this problem is to create very detailed videos of these manoeuvres and when they appear to be indicated, to suggest to the man at the remote situation that he examines the video several times and then discusses the question once again. The technique for constructing such distance learning packages are now being developed, (Fraser, 1985).

Over the years a system of health care for remotely sited personnel has thus gradually emerged, which has resulted in making it possible to provide an extremely high level of health care for those who work in such situations. It needs constant review and evaluation, however, until the final aim is realised - that the man at the remote work site will receive as good attention if he is injured or ill as his colleague working in a shore based factory close to a large hospital.

## 5. THE DEVELOPMENT OF HEALTH CARE FOR BRITISH ANTARCTIC TERRITORIES

In the early 1970's the academic group which set out to tackle the health care problems of the offshore oil and gas industry quite fortuitously became involved also in the development of health care provision for the British Antarctic Survey. This has allowed health care provision for 2 very different groups of personnel, but with some close similarities also, to develop side by side. In many cases the principles adopted for one group were thus rapidly transferred to the other.

The offshore oil and gas industry consists of a very large population working in fairly hostile conditions at some distance from specialist facilities. The Antarctic Survey, on the other hand, consists of relatively small population groups, working over a wide geographical area in the Antarctic. They are, however, separated from their medical base by many thousand miles, from hospital facilities for several months at certain times of the year and they function in the most hostile climate on earth. From both an academic and practical point of view there is much to learn by observing the relationship between both developing systems, (Norman, 1981a; Norman and Brebner, 1988).

Aberdeen has a long association with the exploration and exploitation of the Southern Oceans and the Antarctic Continent. This was partly due to the whaling industry, based in South Georgia, which was supported medically by both Norwegians and Scots, (Headland, 1984). The late Dr Maklin, who was Shackleton's medical officer, was an Aberdonian, as was the late Major General R A Smart, RAMC, who was an early base commander in Britain's most Southerly Antarctic base, at Halley. It had always been policy for a doctor to accompany Antarctic expeditions, but the doctor usually had some other function and was often a biologist. Edward Wilson was Scott's medical officer and he made a marked contribution to biology and achieved great fame as a painter of Antarctic scenes, (Seaver, 1933).

The technique of medical support, which persisted right up until the 1970's, was merely to find a medical officer, give him a fairly substantial package of drugs and instruments and hope for the best. There were no clearly defined medical criteria for selection and there was not a great deal that could be done if anything serious happened. Despite this, there are some remarkable accounts in the literature of medical feats in the South. Probably the most remarkable is the removal of an eye, which took place on the Norwegian base in 1956 when the medical officer - Ove Wilson, a final year medical student - diagnosed the possibility of developing sympathetic ophthalmitis and was talked or instructed through the difficult and specialised operation by radio from Norway.

The organisation of health care services and research for the British Antarctic Survey has undergone progressive and rapid development during the last decade and in 1986 an Occupational Health Unit was established by the British Antarctic Survey (BAS). It is named the British Antarctic Survey Medical Unit, and it functions within the Centre for Offshore Health at RGIT in Aberdeen, (Norman and Laws, 1988).

The current medical unit consists of a number of medical officers whose contracts, including one and a half years overseas, usually lasts about two and a half years. They are professionally responsible to a Senior Medical Officer, a Senior Research Officer and a Chief Medical Adviser, who are responsible in turn to the Director of the British Antarctic Survey for the establishment and implementation of BAS medical policy, for medical training and the direction of medical and physiological research.

The commitment of these latter 3 individuals to the unit is part time from a main employment base in the Centre for Offshore Health. This allows the unit to be run in a most cost effective manner. Other part time personnel include a training officer together with an administrator. The number of medical officers in post at any time varies between 8 and 12 depending on the time of year, because in addition to work on a base, the medical officer may be travelling to and from the Antarctic, where he acts as medical officer on one of the ships, undergoing his preliminary training course, or taking part in the evaluation of the research programmes with which he has been involved in the field.

The main functions of the medical unit are three fold: the practice of remote medicine, training and research. The philosophy of remote health care is encompassed by various aspects of these elements.

## a) THE PRACTICE OF REMOTE MEDICINE

A basic tenent of the medical philosophy which has been established during the evolution of the BAS medical unit is that of universal training of all personnel proceeding South, in appropriate areas of immediate and continuing health care. This training includes instruction in the techniques of medical communication, because the system depends, as in the North Sea, on the existence of clear and precise communications. The aim is for the specialist to obtain sufficient information from his juniors in the field to arrive at a diagnosis and for the juniors to be able to carry out the therapeutic manoeuvres advised by the consultant.

The system is not unlike that practiced in British hospitals, except that the senior house officer may be separated from his consultant by 14,000km! Four consultants in Aberdeen ensure immediate consultant availability for the field medical officers and the duty consultant will normally take advice from an appropriate specialist so that, through the field medical officer, the remote patient has access to the best and most appropriate advice available, (Norman and Laws, 1988).

The success of the system, depends entirely upon:-

(a) the state of communications available;
(b) the nature of the training programme.

Each base and ship is equipped with telex and most of the medical communications with the unit in Aberdeen are carried out satisfactorily by that medium. Occasionally, there is a real need to discuss a point directly or urgently and this has been achieved by the installation of a satallite communications system, which provides excellent quality conversation facilities. Such conversations are always followed by a confirmatory telex exchange, (Norman and Brebner, 1988).

There are still problems however in the interpretation of difficult X-rays, or the adequate description of clinical lesions such as rashes and this has led to an investigation of the use of slow scan television for the transfer of information. Communication discussions are still underway to determine the best and most cost effective way of upgrading communications with the Antarctic to include a medical facility for the transmission of X-rays and clinical material.

b) MEDICAL TRAINING

Specially prepared first aid courses are provided for all personnel prior to embarkation. This 4 day course, not only fulfils the criteria of the Health and Safety Executive of Great Britain, (Cox, 1987c), but it also provides the personnel with information of special relevance to their working situation and includes instruction in medical communication techniques. This course is conducted by the professional teachers from the Centre for Offshore Health and is augmented by further teaching sessions conducted by the medical officers on the ships and bases. A book has now been written to accompany the course, (Milne, 1988).

The medical officers in turn are provided with a course on instructional techniques as part of their basic training programme so that they can fulfil this important part of their duty effectively. In addition to this, the medical officers are provided with a series of training modules which include courses on First Aid, Diving Medicine, Radiography and Radiology, Medical Communication Techniques, Anaesthetics and Analgesics for Remote Places, Plastering Techniques, Dental First Aid, Environmental Health and Introductory Research Methods, (Horsley, 1985). This course is currently being prepared as a dedicated text, also.

## c) MEDICAL RESEARCH

The medical research work has taken 2 main directions:

(a) Medical research designed to improve the health care of the population at risk. This is achieved by epidemiological studies and environmental health investigations, together with the specified areas of concern identified by the base commanders and serving medical officers, eg skidoo drivers thumb, seal finger, (Candolin, 1953) and gastro-enteritis, (Harker, 1989).

(b) Scientific research using the personnel as a captive population of humans, living in the same environment, of the same age and fitness, doing the same things and eating the same food. This has proved extremely valuable for certain aspects of bacteriological, (Bell, 1985; Krikler, 1986) and hormonal (Arendt and Broadway, 1987) research. This research may be of value to Antarctic personnel, but is designed more to provide for general scientific advances in the associated scientific areas, (Edholm and Gunderson, 1973).

In addition to these areas, preparations are being made for the further evaluation of human performance in response to physical effects such as cold, dehydration, light and darkness. This requires some development of psychological testing before further work can be done in that area. Finally, short term experiments are carried out when appropriate ideas or needs present and one such area at the moment is the investigation of the possible effects which the ozone hole may have on man in the Antarctic, (Norman, 1989).

## 6. ASSOCIATED ENVIRONMENTAL HAZARDS

In this overpopulated planet it is reasonable to suppose that the reason why remote and isolated work sites are remote and isolated is because they are associated with some kind of environmental hazard or danger which discourages human habitation. It thus seems clear that any system of health care for such work sites requires a knowledge and close understanding of the main environmental hazards which are likely to be met.

Until the recent past the two main environmental problems recognised were intense heat and intense cold. In more recent years, however, high atmospheric pressure has been added to this group as undersea activities have mushroomed in the search for sources of food and energy below the waves. At the same time the micro-gravity problems of space have also received much study since attention has turned towards the exploration of space for similar reasons. This has chiefly been pursued by the Americans and the Russians so far, but the European community are now committed to the establishment of a space station by 1995 with personnel travelling backwards and forwards for work cycles of 3 month's duration, by shuttle, (Yardley, 1986). It seems clear that this area of development must now be taken into account in proposing a system of health care for remote and isolated work sites.

a) ENVIRONMENTAL COLD

The effect of environmental cold on human performance and efficiency has not yet been fully clarified although a number of workers have investigated both the physical and psychological effects of cold on performance over the years, (Vaughan and Mavor, 1972; Davis, Baddeley and Hancock, 1975).

The effects of cold on man in the literature have been investigated from several specialised points of view. It seems unwise to extrapolate the results of the fairly extensive animal literature directly to man in a cold work site. The animals have normally been exposed to extreme low temperatures for prolonged periods of time in a naked condition, whereas man modifies his behaviour with the climate, and has the advantage of clothing and shelter if the climate is severe, (Norman 1961). In addition, the extensive bio-chemical and physiological work carried out in the 1950's on the consequences of reducing the body temperature cannot be directly applied to man on the side of a mountain or in a cold work site, since these experiments and observations were normally carried out in the controlled situation of a laboratory or operating theatre, where bio-chemistry and ventilation could be readily observed and controlled.

The start point in the appreciation of the problems of man working in the cold seems to be the acceptance of the knowledge that for optimal function, the body temperature of man needs to be maintained within 1/2$^{o}$C of 37$^{o}$C, (Clark and Edholm, 1985e).

Comparative physiological studies, (Irving and Krog, 1954, 1955; Irving, 1951; Wetmore, 1921) tell us that there is very little mammalian species variation in body temperature, but an important fact which emerges from such comparative studies is that the critical temperature (the environmental temperature below which metabolism rises in order to maintain the body temperature) varies greatly between species and between environments. It is usually found to be around the coldest temperature to which the animal is expected to be exposed during winter. It was found to be +20$^{o}$C to +30$^{o}$C for tropical animals, 0$^{o}$C for the polar bear cub and -40$^{o}$C for the Arctic Fox, (Scholander, Hock, Walters, Johnson and Irving, 1950). Thus, the metabolic economy is reasonably adapted to the particular environment to which the animal is normally exposed. The problem, however, with man at work in a remote place and particularly those associated with the oil industry, is that the environment to which he is exposed may change greatly from one work site to another and often his home is in one part of the world and his worksite is in an entirely different environment, (Norman, 1986).

When studies were carried out in man to determine his critical temperature (Erikson, Krog and Scholander, 1956), they were difficult to interpret since man had been extensively modified in a physiological sense by the influences of civilisation, but Erikson et al (1956) concluded that his critical temperature lay in the region of 26°C. The subject was subsequently reviewed extensively by MacLean and Emslie-Smith, (1977), and they concluded that the value for man was around 27°C. It must thus be concluded that since the critical temperature of tropical animals is 27°C that man responds as a tropical animal, (Clarke and Edholm, 1985b).

Acclimatisation to temperature change is an important determinant of efficiency and physical performance, (Edholm, 1978), but although there are well recognised physiological changes when man moves from a temperate zone to a hot area, (Burton and Edholm, 1955), there are no well recognised indices of cold acclimatisation when he moves from a temperate zone to a cold climate, (Norman, 1961; Bridgman, 1986). MacPherson (1958) argues that since man is physiologically best suited to the environment of a tropical forest, it is useless to attempt to demonstrate profound physiological changes in temperate man on exposure to severe cold since the greater part of the possible change in that direction has already been made by his movement from a tropical to a temperate climate and any further possible change in that direction must be very small.

Localised adaptation to environmental change is also of great importance to working safely and efficiently in extreme environments and to training schedules. Nelms and Soper (1962) showed that fish filleters in Britain were able to maintain a functional hand at temperatures lower than controls. This type of response could be important for survival in emergencies in cold climates. Massey (1959) and Hampton (1969) had investigated the phenomenon in Antarctic personnel with inconclusive results, but Johnson (1981), working at Halley, noted an increased functional ability of the hand as the year of his subjects' exposure to the polar environment advanced. He did not observe any physiological changes, however, and concluded that the increased functional ability was more a matter of training - and thus of intelligence (eg repeatedly putting hands in warm pockets, standing with back to the wind, etc) than to any physiological change.

The only unequivocally functional change in man caused by a cold environment is the 'warm' hand of the Eskimo, which remains functionally useful at low temperatures and maintains an incrased blood flow compared to controls, (Brown, Hatcher and Page, 1953). This is important for his survival. It seems likely, however, that this has taken centuries of adaptation and is very different from temperate zone man expecting change in time scales measured in years - or even life-times!

There are, of course, well recognised local adaptive changes recorded in animals exposed to extreme changes of environment, (Irving and Krog, 1954; Scholander and Schevill, 1955; Bazett, Love, Newton, Eisenberg, Day and Foster, 1948) but it would appear that the further we move from the case of the naked animal exposed to prolonged cold in the experimental chamber to the clothed, sheltered man leading a fairly normal life at a polar station, the less obvious does it become that adaptive changes to a colder environment occur.

Norman (1961) stated that the measurement of the effects of cold on man were neither simple nor do they consist entirely of the measurement of the climatic variables of the district in which he lives or works. Man uses his intelligence to protect himself from unnecessary exposure to the extremes of temperature by providing himself with clothing, artificial heating and shelter. This is an important concept for those who are responsible for providing health care for those who work in the extremes of temperature because it does not alter their basic vulnerability - it only emphasises man's use of his intelligence to take the narrow ranges of environmental variations which he needs with him - offshore, to the Antarctic, to the deserts of Arabia or to the depths of the sea.

The maintenance of health in isolated communities associated with environmental cold thus demands considerable forethought in the provision of an adequate diet, together with the essentials of clothing, heating and housing. Little or nothing has been recorded of the patterns of injury or illness of the personnel at risk, nor the extent to which the problems could be associated with the environment - nor even the individual's exposure to the environment. It seems esential that there should be a clear understanding of the effects which the extremes of environmental temperature may have on both performance and the occurence of life threatening emergencies and their management if the work force is to be effectively cared for and the confidence of the personnel is to be maintained, (Roythorne, 1981; Keatinge, Hayward and McIver, 1980; Cox, McIver, King and Calder, 1980; Rawlins and Tauber, 1981; Rawlins, 1972, 1981).

Bigelow in the 1950's, showed that there was an exponential drop in oxygen requirements as the body temperature was reduced. Thus, when the body temperature reached 28°C, the oxygen requirements were about a third of those needed at 37°C, (Bigelow, Lindsay, Harrison, Gordon and Greenwood, 1950). This fundamental observation, which has been widely applied to the surgery of the heart and brain certainly holds good in the operating theatre when bio-chemistry is controlled, when an abundant supply of oxygen is ensured by ventilation and when shivering is controlled by muscle relaxation. Auld, Light and Norman (1979, 1980), reproduced the condition of accidental hypothermia in dogs and compared it to that of the controlled reduction in body temperature practised in the operating theatre. They found that when the temperature fell to between $28^o$ and $30^oC$, the tissue oxygen requirements, in fact, doubled compared to control values, due to the vastly increased oxygen needs of the shivering muscles.

The increased oxygen was provided for partly by removing increasing quantities of oxygen from the haemoglobin and partly by maintaining an increased level of cardiac output. The heart rate, however, fell with the decline in body temperature due to the direct effect of cold on nerve transmission. This required the stroke volume to increase considerably and indicated the stressful effect which accidental cooling had on the heart. It seems clear that a competent myocardium is of great importance for work with safety in the cold, (Norman, 1985a; Emslie-Smith, Sladden and Stirling, 1959).

Such experiments as these, underline the vulnerability of the heart to environmental cold, and this has also been pointed out by other authors, (Golden and Hervey, 1981; Clark and Edholm, 1985d; Norman, 1985a, 1986). It suggests one of the criteria necessary for the establishment of physical fitness standards for work in cold climates. Where the work site is not only cold but wet, as in the fishing or offshore industry. Where helicopters are used over seas in transportation this fact is further underlined by the demonstration of the increased likelihood of fatality from cold shock if the myocardium is compromised by age or atherosclerosis, (Keatinge and Nadel, 1965; Keatinge, McIlroy and Goldfien, 1964).

The management of hypothermia in the intensive care units of hospitals has been relatively clearly documented, (Emslie-Smith, Lightbody and MacLean, 1981; Ledingham and Mone, 1980; Ledingham, 1981), but there is still some doubt where the occurrence takes place in a situation far from standard hospital care. Golden and Hervey (1981) made a very convincing case for the management of immersion hypothermia by immediate re-immersion since the rapid rate of cooling would result in a low temperature being reached before any circulatory or bio-chemical adjustments had time to take place, (Keatinge, 1969). Unless urgent action was taken to reverse the meteoric fall in body temperature it would continue into the afterdrop and could result in a critically low temperature being reached to cause the heart to fibrillate. This is Golden and Hervey's explanation of the phenomenon of post-rescue death.

Since the critically low temperature will have been reached before there has been time for metabolic and circulatory changes to take place, it seems clear that re-immersion in hot water provides the most effective management for immersion hypothermia, and it must be instituted with urgency.

Norman and Brebner, (1987), point out that the condition is much more complex when body cooling takes place in dry cold. The poor conduction of air compared to water means that cooling is much slower and there will be time for both bio-chemical and circulatory changes to take place before the subject collapses - an event which depends upon the interaction of the state of physical fitness, the environment, the clothing assembly worn, the state of nutrition and the motivation of the subject. In the field it seems that more gradual re-warming is safer and there is, of course, much less chance of severe 'after-drop' in temperature taking place in this type of hypothermia.

Of great importance to the safety of operations in cold climates is an understanding of the individual physiological variations which can take place in apparently normal, healthy individuals in their responses to environmental cold, (Burton and Edholm, 1955). Of equal importance is the effect which minor degrees of body cooling may have on the efficiency and mental performance of people exposed to severe cold. Ellis, Wilcock and Zaman (1985) have shown wide variations in the shivering response to cold among a homogeneous population exposed for 2 hours in a cold chamber and Light, White, Allen and Norman (1980) have confirmed this finding in a population of Antarctic divers. These workers have suggested that in the absence of shivering it is difficult for man to determine whether he is cold or not from subjective sensation. These views are also held by Keatinge et al (1980). A poor shivering response means that an important protective mechanism to a cold climate is lost. The body temperature will fall more rapidly than in normal controls and could lead to a dangerous level of temperature without discomfort, (Norman, 1985a; Hayward and Keatinge, 1979).

Whether or not minor degrees of cooling do effect cognitive function and thus compromise safety has not quite been resolved yet. Ellis, Wilcock and Zaman (1985), have shown a clear reduction in cognitive function in a group of men exposed for 2 hours in a cold chamber and they have shown also that the increased number of errors made were made with greater confidence. They noted, however, that it was related to change in skin temperature rather than to change in core temperature. This view is consistent with Baddeley's findings in divers exposed to cold, (Baddeley, Cuccaro, Egstrom, Weltman and Willis, 1975; Davis et al, 1975). He concluded that the changes in cognitive functions which he observed were due to the distracting effects of cold, from the discomfort it produces rather than to a change in central nervous function from a falling core temperature. These arguments have not been finally resolved but are clearly of great importance to both the comfort and safety of men working in cold climates.

Since this is a developing area of some complexity, it is important that both those responsible for the health of work forces operating in environmental cold and also the personnel themselves should have ready access to the most up to date information on the effect of cold on performance, on the safe limits of exposure for man, on any individual variations which may place a worker at undue risk and on both preventive measures and on the actions which should be taken in the remote worksite. It was with thoughts such as these in mind, that the chapter on environmental hazards was written in the 'Offshore Health HandBook' by Norman and Brebner, (1987).

## b) ENVIRONMENTAL HEAT

Although man has been shown to be fundamentally a tropical animal, who probably began his existence in Central Africa, (Edholm, 1978), survival time, when lost and wandering in the Arabian Desert in the height of summer, is not greatly extended beyond that which takes place if he falls into the North Sea in winter. This emphasises his vulnerability to the extremes of temperature and adds weight to the argument that for survival in such extremes he must take precautions to provide himself with a safe thermal environment. The most important aspect of the protection against extreme heat is a well developed sweating reflex. Since the evaporisation of sweat draws its necessary latent heat from the body, 0.58 Kcal of heat are drawn from the body for every gram of sweat evaporated, (Clark and Edholm, 1985a) This is a powerful and important mechanism and provided that there is an abundance of fluid available to provide sweat the body temperature can be maintained within reasonable limits in high environmental temperatures, (Heins, 1983).

The extent to which man is able to sweat probably has similar degrees of individual variation as shivering. Indeed, there are well recognised cases of people who have severe difficulty in sweating at times and who are extremely vulnerable to environmental heat, (Ladell, 1960). Their situation can be compared to the demise of Cleopatra's black slaves when she had them painted gold! As with shivering in the cold it is likely that the man who sweats most easily will be able to maintain his body temperature within reasonable levels.

The phenomenon of acclimatisation to heat is of some importance since considerable numbers of the workforce in extreme heat are likely to be expatriates, who move from temperate to hot zones at the beginning and end of their work cycles. Acclimatisation to heat is not achieved by exposure to heat alone, but requires regular physical work in the heat for its production, (Hellon, Jones, MacPherson and Weiner, 1956; MacPherson, 1960). It normally requires something like 2 weeks to produce full acclimatisation, following life in a temperate zone. During this time the ability to sweat increases progressively, the salt content of the sweat is reduced and the vascular arrangement in the subcutaneous tissues become more attuned to rapid and sustained vasodilation, (Clark and Edholm, 1985d,e). Equally, acclimatisation is lost rather readily on leaving the hot zone. Following 2 to 3 days in a cool area, acclimatisation is unaffected but a week away from the hot zone requires 2 or 3 days to regain full acclimatisation, while it is totally lost following an absence of a month, (Edholm, Adam, Cannon, Fox, Goldsmith, Shepherd and Underwood, 1961).

It is important to recognise that it does not seem to matter whether the man's origin was in a hot area or a cold area; his responses to excessive heat are the same. It can lead to serious mistakes in judgement if Negroes or Arabs are expected always to be fully acclimatised to their own climate. Particularly in wealthy areas, like the Arabian Gulf, senior Arab personnel often live in air-conditioned houses, go to work in air-conditioned motor cars and remain in air-conditioned offices. They may well be less able to function effectively in the heat than their temperate zone colleagues who are used to working physically in the open. This can lead to dangerous situations if it is not appreciated and the author can testify to this from his early days of teaching casualty handling techniques in the desert!

These considerations are of importance to the safety of hot work sites, since the features of heat exhaustion are vague and difficult to recognise unless the supervisor or physician is very familiar with them. Unrecognised heat exhaustion will proceed to the life threatening condition of heat stroke just as rapidly and unexpectedly as the collapse of hypothermia takes place in the cold, (Norman and Brebner, 1987).

From the practical point of view the problem areas which need resolution and dissemination amongst the personnel working in these conditions are not greatly different from those identified for cold climates. The nature of heat stroke is understood and has been widely documented (Leithead and Lind, 1964), together with its management in hospital conditions, but there still seems to be some doubt about its best management in remote places. The other area which requires ultimate definition is the effect of high temperature on human performance, with some kind of definition of the upper thermal tolerance limits for unimpaired mental performance. In this latter area, the investigations which have taken place so far have resulted in rather equivocal results (Bell and Provins, 1962; Fraser and Jackson, 1955; Pepler, 1963; Wing, 1965). This situation is not dissimilar to that currently found in cold climates.

The role of dehydration in heat stress and the role of dehydration on mental performance have most recently been questioned by Sharma, Sridharan, Pichan and Panwar, (1986) and by Gopinathan, Pichan and Sharma, (1988). These workers selected a group of acclimatised Indian soldiers and exercised them in the heat until they became dehydrated to 1%, 2%, 3%, and 4% of their body weight. Following recovery from the heat and exercise, they were given cognitive function tests and it was noted that the deterioration in mental performance which took place became highly significant when dehydration reached the 2% level. The authors concluded that it may be the dehydration rather than the heat itself which was responsible for the decline in cognitive function with heat. This is similar to Baddeley's conclusion that the distracting effects of the cold may be more responsible for the decline in cognitive function than the absolute fall in core temperature, (Baddeley et al, 1975).

## THE HEAT ILLNESSES

In the 1940's much attention was placed upon the relative requirements of salt and water in the prevention of heat illness and in its management, (Lee, 1964). In the 1960's it was recognised that less salt was probably required than had been thought in the past (Ladell, 1964). Norman and Brebner (1987) have concluded that salt is dangerous in the emergency management of heat stroke in the field and should only be used on advice from a physician.

In the preventive aspects of heat stroke salt tablets are now considered less important than the addition of a small quantity of salt to the drinking water. This is acceptable and probably the best means of allowing for the increased salt requirements of work in hot climates. Edholm (1978) suggested a teaspoonful of salt to a litre of water for work in the heat and that concentration has been recommended also by Norman and Brebner (1987).

Both efficiency and comfort at work in environmental heat is largely dependent upon environmental humidity, (Heins, 1983). This is because the evaporation of sweat which is an essential of thermo-regulation in the heat can only take place adequately if the air is not already fully saturated with water. If there is some wind movement to remove the saturated air from the surface of the body that helps. Efficiency and effective thermo-regulation is thus more likely to be found in hot, dry conditions than hot, wet conditions, (Clark and Edholm, 1985c,e). It seems possible that the heat illnesses which take place in a humid situation may be different from those in a hot, dry work-site and the management of the conditions could be different also. An investigation has thus been undertaken, conducted in a Middle East worksite to examine the problem in an area of high humidity and the results will be described later in the thesis.

Finally, it seems to be important in considering safe working in environmental heat, that the personnel at risk in remote, hot climates should be fully conversant with the nature of the risk, with the preventive measures needed and with the immediate management of the illnesses when they occur, if they are to function with maximum safety, confidence and freedom from accidents, (Norman and Brebner, 1987).

## c) THE HYPERBARIC ENVIRONMENT

Nowadays increased atmospheric pressure is almost entirely considered to relate to divers. Increased atmospheric pressure had provided occupational problems, however, for many years before those produced by the offshore oil and gas industry, (Aldrich, 1900; McWhorter, 1910; Paton and Walder, 1954). This is because the technique was used in the construction of tunnels and bridges. Caissons, usually not exceeding 4 atmospheres absolute pressure, were used fairly commonly, (Lanphier, 1964). The use of high atmospheric pressure in therapeutics goes back even further. The first record of a hyperbaric chamber for use in a variety of chronic disease processes was that of a Dr Henshaw (1644) who considered the 'salutary effect of change of climate to be due, in great measure, to change of barometric pressure'. Exercised by the waste of time and energy spent travelling to other climates and the problems associated with the taking of long and hazardous journeys he constructed a chamber by means of which patients could be subjected to air at raised or lowered barometric pressure. The chamber was made of wood and a huge set of organ bellows, furnished with a suitable arrangement of valves, allowed the pressure within the chamber to be raised or lowered as desired.

Since then there have been a great number of pressure chambers constructed for industrial and therapeutic purposes and even Robert Boyle, who was first to write that air was essential for life, had his own pressure vessel, (Norman, 1964). He used it to observe the effects of high atmospheric pressure on small animals and it may be that the glint he observed in a viper's eye, following rapid decompression, was the first nitrogen bubble to be observed in Caisson Disease, (Dugan, 1960).

The father of modern hyperbaric biology was, however, Paul Bert (1878), who explained the aetiology of Caisson Disease and suggested slow decompression to prevent decompression sickness. He also practised recompression when it occured. The safety of divers and Caisson workers has provided the main stimulus to research in high pressure physiology and those pressure chambers which were built in the fifties, were used largely for the treatment of patients suffering from Caisson Disease. Rather later the condition of barotrauma was recognised, (Kidd, 1974; Kidd and Elliott, 1975; Hendry, Childs and Proctor, 1979). Most expertise and knowledge of the dysbaric conditions was held in the Navies of the world until about 20 years ago when saturation diving became a recognised technique, (Bond, 1964; Cousteau, J-Y, 1966; Earle and Giddings, 1980) and the way was open for the exploitation of the continental shelves for sources of energy, (Bachrach, 1975).

The Naval chambers were largely used for the management of decompression sickness and pulmonary barotrauma (Liebow, Starg, Vogel and Schaefer, 1959). In view of the dangers of oxygen toxicity in deep diving, the investigation of hyperbaric oxygen as an aid to the therapy of a variety of hypoxic conditions largely took place in the civilian sector, (Churchill-Davidson, Sanger, Thomlinson, 1955, 1957; Smith, Ledingham, Sharp, Norman and Bates, 1962; Smith, Sillar, Norman, Ledingham, Bates and Scott, 1962; Jacobson, Bloor, McDowall and Norman, 1963; Hutchison, Kerr, McPhail, Douglas, Smith, Norman and Bates, 1962; Barclay, Ledingham and Norman, 1964; Cameron, Gibb, Ledingham, McGuinness, Norman and Sharif, 1964; Norman and Smith, 1966; Skene, Norman and Smith, 1966; Smith, Irvin and Norman, 1966; Irvin, Norman, Suwanagul and Smith, 1966; Norman, Irvin and Smith, 1966; Norman, Simpson and Diomi, 1974b; Norman, Napper, Davidson, Robertson and Smith, 1974a), and although it is generally regarded as having its origins in Glasgow, in the 1950's, (Illingworth, 1963) and in Amsterdam, (Boerema, 1961), it is interesting to note that the first use of hyperbaric oxygen was by a Spanish physician named Valenzuela (1887) who used it in a case of pneumonia with apparently good results!

From the point of view of remote work sites, the personnel involved in caring for divers and the divers themselves need to have a clear view of the nature of decompression sickness, (Strauss, 1976), barotrauma, (Kidd and Elliott, 1975), and oxgyen toxicity, (Donald, 1947, a,b). They need to have an understanding of the methods of preventing these conditions and the actions which need to be taken when they occur.

There are similar problems, which still need clarification to those which occur with thermal extremes such as the possibility of changes in cognitive function due to either nitrogen narcosis, the more subtle effects of oxygen or even barometric pressure, itself, (Behnke Thomson and Motley, 1935; Poulton, Carpenter and Catton, 1963; Poulton, Catton and Carpenter, 1964; Baddeley, De Figuered, Hawkswell-Curtis and Williams, 1968). These are important implications, not only for those functioning in hyperbaric environments, but also for those who may be called upon to look after them for some form of dysbaric problem or intercurrent illness. There is also current concern about possible long term consequences of deep diving, (James and Cox, 1987). The possibility of genetic damage has been investigated, (Fox, Robertson, Brown, Whitehead and Douglas, 1984) and found not to be a serious problem. One long term problem which has been identified and investigated is that of bone necrosis and this has been extensively investigated and documented, (McCallum, 1975; Davidson, 1964; Davidson and Griffith, 1970; Elliott and Harrison, 1970; Harrison, 1971; MRC Decompression Sickness Panel MRC, 1981; Decompression Sickness Central Registry, 1981). It has been related to decompression sickness, but with strict adherence to decompression schedules has been shown to be a less serious problem in numerical terms than was originally anticipated.

d) MICROGRAVITY

The problems of providing health care for those who are to service the space stations of the future are very similar to those of more easily recognised remote communities, since the main problem which they will face is the time and distance, which will separate them from medical help. So far, the astronauts of the States and Russia have been extremely healthy, fit, young people, very carefully selected and with precisely kept medical records, (Simons, 1964). Work in the microgravity situation is hard just as work underwater is hard and a very high degree of physical fitness is required for it to be carried out with a margin of safety, (Berry, 1973, 1986).

The main problems which have emerged from observation of early space travellers relates to muscle wasting and bony decalcification, (Kerwin, 1975). This has been assumed to be due to disuse atrophy and has been compared to the condition of orthopaedic patients. Efforts have been made to combat it by introducing techniques for exercising the various muscles in mini gym's during space travel and dietary considerations, with a view to limiting calcium loss. It is not yet clear, however, whether the increase in activity and the exercise will reverse this process or whether it is due to some fundamental effect on bone or muscle associated with the microgravity state, (Cheston and Winter, 1980; Gibson, 1975; Griswold and Truch, 1981).

There is thus a theoretical increased risk of urinary calculi under these circumstances, but urinary calculi have not been reported in increased incidence in space travellers to date. These problems need to be resolved before interplanetary flights can take place. There is still considerable work to be done before the full effects of microgravity become apparent. There appear, for example, to be functional changes in certain bacterial groups which could possibly increase their virulence in much the same way as in gram negative organisms, such as the Pseudomonas pyocyaneus, which became a serious problem in the 1970's with saturation divers, (Alcock, 1977).

There is also some evidence that lymphocytes in vitro have a reduced protective action in tissue immunity in the microgravity situation, and this has obvious implications for closed, over-crowded communities from the environmental health viewpoint, (Fischer, Daniels, Levin, Kimzey, Cobb and Ritsmann, 1972; Kimzey, Johnson, Ritzman and Mengel, 1976). It will probably be some time before these various aspects are fully understood but once again there needs to be a clear statement of the problems which may arise, the method of their prevention and the action which needs to be taken for their management.

The growth of work in remote places has been associated with an increasing number of people exposed to hostile and dangerous physical environmental conditions. It seems possible that a common system of health care can be produced for all the personnel involved. From the environmental point of view the problems which need to be solved and the statements which need to be made follow roughly similar lines of enquiry.

## 7. RECENT DEVELOPMENTS IN OCCUPATIONAL HEALTH SERVICES FOR THE OFFSHORE OIL AND GAS INDUSTRY IN THE NORTH SEA AND THE BRITISH ANTARCTIC SURVEY

By the beginning of the last decade the systems of health care described above had been more or less established for both the North Sea industry and the British Antarctic Survey and the principles governing the various components accepted. As far as the North Sea was concerned, however, developments in other areas were just as rapid. The industry had become much more experienced in offshore work and the workforces had become more stable. The end of the 1970's had seen the establishment and growth of large and sophisticated safety and training departments in the operating companies and following the Burgoyne Report, (Burgoyne, 1980), the Department of Energy had emerged as the responsible Government department for health and safety offshore. The rig medics had become very experienced and the onshore doctors were required to attend offshore less and less frequently.

Despite these advances there remain fundamental problems for the provision of remote health care for both the offshore industry and the Antarctic Survey which have much in common with those found in more primitive population groups. Communication systems are still in a developing state and should help to improve the situation ultimately and the offshore industry has taken the question of health care training more seriously than most other industries. On the other hand, we are still left with the single-handed remote practitioner, often without a medical qualification. Medical qualifications probably matter less than the general feeling of boredom which apparently envelops the practitioner if he has not enough to do and if there no real requirement for him to keep abreast of developments. Inevitably, under these circumstances when a serious situation arises he is less able to cope with it than he should be. On the other hand, the absence of professional colleagues inclines him psychologically to feel that his competence is greater than it is. It is not easy to see an answer to this very real problem.

Another area which causes continuing worry is that of evacuation and care during a long journey. In remote places the medical man is not always in a sufficiently senior position to influence the logistics of evacuation in the face of his managers. Non-medically qualified managers have an almost universal desire to evacuate the sick with the greatest speed, no matter what their condition or what the environmental conditions at the worksite are. It is often difficult for the medic or even the doctor to resist such pressures. In the more serious cases where stabilisation before transportation is required he may allow the marginal case to slip too readily through his fingers into the waiting helicopter or aeroplane. The real solutions to these problems are based, once again, on training and on improved communications and co-ordination between the sharp end of the worksite and senior medical opinion and support.

It began to be stated that the pattern of illness and injury occurring in offshore installations was changing. There was no real proof, but it was felt that this was a reasonable assumption in view of the improvements which had taken place in safety and training. The question of the ageing of the workforce and its implications was also discussed.

These considerations were of some importance in the elaboration of appropriate training courses for the lay, nursing and medical personnel involved and also for the planning of future health care provision, both onshore and offshore, together with the supply of equipment, materials and drugs. If the offshore population was indeed ageing, then marked changes may be required in the system, and personnel planning decisions could be foreseen for the future. There appeared to be a fairly urgent requirement to try to determine the nature of the problem which had to be catered for in terms of the occurrence of illness and injury currently and in terms of whether the pattern was changing. It also seemed reasonable to consider the development of some system of ongoing surveillance at this stage of development of the occupational health services. It could be argued that this should have been the start point of the development of an occupational health service for the offshore industry, but until that time the developments had to be so rapid and the situation was so complex and confused that such studies had not been undertaken.

By the beginning of the last decade also, the various components of the system used for the North Sea were being established for the British Antarctic Survey. Until that time, the equipment provided had been that of a battle cruiser in the hope that that would be sufficient to meet most eventualities. Well-found training courses were now being provided, however, for all the personnel who were venturing South and for their doctors. It seemed reasonable, therefore, to try to determine the pattern of injury and illness which took place in these communities, and a similar study was begun from the records of the Antarctic Survey. It was hoped also that it would be possible to establish an ongoing system of surveillance to determine the nature of the training courses which were required, both for the lay personnel and for their medical attendants. It was also hoped that it would be possible to arrive at some more rational means of determining the requirements of drugs, materials and equipment so that the operation could be carried out in both a more efficient and a more cost-effective manner.

Training was still regarded as the first priority in remote medical systems, and thus it seemed important that some form of evaluation should take place to determine whether the training courses elaborated so far were appropriate to the needs of the personnel themselves and to those who employed them. It seemed sensible to carry out such an evaluation at the same time as the ongoing pattern of illness and injury was being assessed so that if changes were required, all the necessary information would be available when these decisions had to be made.

In the determination of priorities the existence of clear and precise communications had always been regarded as of equal importance to the training work which was undertaken. The sophistication of communications in the North Sea had increased enormously over the years, and by the 1980's it was normally possible to have a clear discussion by telephone with an offshore medic and telex communications were well established.

In addition, helicopter provision was also such that it was becoming more and more possible for the injured and sick rapidly to be transferred to the medical or hospital facilities which they required. Although the cost of a dedicated helicopter was considerable the more sophisticated means of communicating medical information such as slow scan televisions etc, only seemed justifiable if it could be shown that there was considerable and expensive use of dedicated helicopters for medical emergencies and so it seemed important that the extent of use of such services should be established. It was already known that the meteorological condition of the North Sea made helicopter transfer of the sick impossible on only very rare occasions throughout the year, (Leese, 1984).

The situation was, however, different in the emerging oilfields off Newfoundland and Labrador where fog made it impossible for a helicopter to land on an offshore structure for about a third of the year. Under these circumstances it seemed clear that in order to provide the same health care provision for the workforce in the Grand Banks as was available in the North Sea it would require rather more sophisticated forms of training and communications. Equally, the communication technology was becoming less expensive and with the emergence of space satellites more effective, (Shamaskin and Caldwell, 1974; Schwarz and Johnson, 1977).

This was probably of greater importance when the condition of the very remote populations in the Antarctic were considered and attention was, therefore, turned to the British Antarctic Survey and to Eastern Canada in order to investigate further the possibility of using more sophisticated communication devices to improve health care in these places.

An important area of enquiry which was followed in the Antarctic and other overseas locations by the Centre for Offshore Health was the determination of the effect of various environmental stressors on human performance. The initial ones identified were heat, cold, dehydration and the effect of light and darkness, (Norman 1989).

By 1982 it seemed of greatest importance to endeavour to determine the actual pattern of illness and injury which was taking place offshore and whether that pattern was changing with the changing nature of the industry and to identify whether adequate training programmes were being provided and how effectively the problems which arose were managed. From the British Antarctic Survey point of view it seemed important to determine the pattern of illness and injury which had taken place in the past and to set up some means of ongoing surveillance. It seemed of equal moment in that situation to determine the feasibility of introducing more sophisticated means of medical communications. In all these areas it was important to bear in mind constantly the hostile environmental conditions which remote health care workers had to endure, and to study their problems against a background of environmental hostility. These are the areas which form the basis of the studies which are now to be presented.

# CHAPTER II

## THE PATTERN OF INJURY AND ILLNESS IN THE OFFSHORE OIL AND GAS INDUSTRIES

A decade after the establishment of the offshore oil and gas industry in the North Sea there was still no clear and authoritative statement on the pattern of injuries and illnesses which took place in that heavy industry working in an isolated and hostile environment. There were several individual studies of aspects of the problem or the experience of individual doctors or companies (Leese, 1977; Cox, 1970a; Roythorne, 1983) and the Department of Energy had a requirement for returns to be made of the illnesses and injuries which took place. Aside from the returns made from diving accidents, (Warner, 1976,) these returns do not appear to have been specially analysed and no publications have resulted from them, (Linning, 1980). Initially, there was only a requirement to report an episode of illness if it persisted for more than 3 days. Since an illness of that severity usually resulted in evacuation there was often no need for it to be reported. This meant that for many years it appeared that no one ever became ill in the North Sea!

It thus seemed reasonable that an attempt should be made to determine the global pattern of injury and illness in the offshore industry, particularly since such information is necessary if appropriate training programmes are to be set up for the health-care team and if appropriate provisions are to be made for the management of those people who become injured or ill with particular regard to equipment, facilities and personnel.

In addition to these considerations there was much speculation that the pattern of injury and illness was changing as the years passed, due to the increasing stability of the workforce with time, to the increasing experience of the industry and to the emergence of strong safety, training and medical departments. There was also speculation that the pattern of illness was changing and its incidence increasing as the traumatic episodes of the early days of construction declined. This was said to be due to the ageing of the population and future personnel problems could readily be envisaged. It seemed clear that if provision was to be made to answer these problems that a clear statement was required of the actual incidence of illness and injury and of any change in the pattern which was taking place with time. The training organisations would also require to take any change in the pattern of illness and injury into account in preparing rig medics and associated personnel for their health-care function offshore.

It was with these considerations in mind that it was decided to set up this study and agreement was reached with 4 major operating companies to study their records for a retrospective period of 9 years. It was also hoped to determine from this study the appropriateness of the records currently being kept from the viewpoint of advising on ongoing surveillance of offshore morbidity and also to determine the adequacy of the medical policies currently in use. A final aim of the study was the recognition of the need to be in a position to recommend an appropriate format for future data collection, since prospective surveillance seems almost certain to be indicated and desirable, if answers were to be obtained rapidly to the health-related problems already on the horizon.

## METHODS

The first task in the study was to gain access to the medical records of a group of operating companies in the North Sea, and eventually this was achieved through the medical departments of 4 major operating companies. Medical confidentiality was assured since the records were only handled by doctors or nurses. The approval of an ethical committee was obtained and the provisions of the Data Protection Act carefully adhered to. A small study team consisting of doctors, nurses and scientists was set up to advise on progress and twice yearly liaison with the company medical advisers was practised.

The next stage of the study involved the construction of a questionnaire designed to extract consistent data from reports which had been compiled in a variety of styles and to varying degrees of completeness. Advice was taken from the 4 operating company medical departments and a workable document eventually emerged, such that requests for information which was largely unobtainable were omitted as far as possible from the final version of the questionnaire. The questionnaire can be seen in Figure 1.

The medical departments of two of the operating companies were based in Aberdeen and the other two in London. Since permission was not granted from the companies for the medical records to be removed from their parent departments considerable travel was necessary in order to extract appropriate information from the reports in the various company offices. The medical records of the four operating companies were examined for a period of nine years - from 1976 to 1984 inclusive and a considerable number of records had to be examined in order to extract the 2,162 evacuations which had taken place for medical reasons.

The different reporting and record keeping procedures of the four companies resulted in data being extracted from different sources for different companies. For example, rig medic logs and referral letter copies were made available and used as a data source for one company whilst for another accident report forms and personnel records had to be used. It was also recognised during the data collection phase that some companies had changed their reporting and/or record keeping procedures during the period of the study.

All information was entered onto a mainframe computer, Honeywell 66, and registered in accordance with the Data Protection Act, 1984. Information such as dates and times was entered in uncoded form, but other and text information was coded before entry. Each medical evacuation incident was identifiable by a record code.

Each individual casualty was allocated a patient code so that individuals who had been evacuated more than once could be easily identified. No attempt was made to identify a person who had been evacuated whilst working for one operator and who had been evacuated at a later time, whilst working for another operator.

In this sense the evacuees were considered as having been made up of 4 mutually exclusive populations. Whilst it is recognised that there is likely to be some transfer of working personnel between the operating companies it was felt that identification tags from the records available were insufficient to identify such individuals positively.

Standard coding procedures were used where possible. Working diagnoses of illness and injury and of symptoms of illness and injury observed on examination were coded using the International Classification of Diseases, (1978). A maximum of 4 diagnostic codes could be entered per evacuation. This allowed multiple injuries to be accurately encoded; it also meant that the observation of ill-defined symptoms might be recorded either accompanying a working diagnosis or without any form of diagnosis. The total frequency of disorders and symptoms reported, therefore, can amount to greater than the number of evacuations. In addition, a random alpha-numeric code was allocated to the observations of symptoms of illness and injury since it was uncertain how well the use of International Classification of Diseases (ICD) codes would perform using only working diagnosis, with no confirmation or follow-up in the majority of cases. For such information, eg the manner of onshore reception or the eventual medical disposal of the evacuees, it should be realised that some of the categories used to encode the information are not mutually exclusive. It is not unreasonable for instance, that both an ambulance and a representative of the operating company were at the heliport to meet an evacuee. The total of the frequencies contained in these categories will often therefore be greater than the total frequency of evacuees.

Random alpha-numeric codes were also used for other text details which could be categorised, such as the description of the incident, the form of treatment, the equipment used to manage the casualty and the consultation. A distinction was made whether information of a specific category was simply not present or not applicable to a specific evacuation incident. Where the casualty's age was missing from the information available the age was computed where possible, using the date of birth and date of report of the incident to the medic.

After entry of all data onto the computer, and the usual debugging procedures, the data was analysed using SPSSX Statistics Package for Social Sciences Update. Only specified comparisons have been made rather than across the board comparisons of one variable against another to reduce meaningless yield.

## RESULTS

During the 8 years of the study from 1976 to 1984 inclusive there were 2,162 evacuations for medical reasons from the offshore installations of the 4 companies. Figure 2 shows annual figures for all evacuations which took place from 1976 to 1984. Of these it was possible to determine from the records whether the evacuee was an operator's or a contractor's employee in 1900 (87.9%) cases. The ratio of contractors' to operators' men evacuated is shown for each year of the study. During the whole nine years of the study the operators' employees evacuated amounted to 178 (9.4%) of the 1900 cases and the contractors' employees to 1722 (90.6%) of the cases.

The absolute number of evacuations actually increased as the years passed, there being for example, 37 and 110 in 1976 and 1977 respectively as compared with 287 and 674 in 1983 and 1984 respectively. This does not, however, imply an increased incidence of medical evacuation necessarily; it is almost certainly due to the increasing offshore population available for study as the years passed, coupled with the varying time for which medical records were available from each company in the study and the fact that all 4 companies were operating offshore only from 1983.

Figure 3 shows the average total offshore population of the 4 companies during the period of the study. The increases in the population are related to the times when the various operators began work offshore. One company's records go back to 1977, a further two began offshore work in 1980 and the final company in the latter part of 1983. These figures are necessary to allow interpretation of the data presented in Figure 2, which shows a rising rate of evacuations for medical reasons as the years pass, but the rising rate of evacuations is consistent with the rising rate of the offshore population.

Further light can be thrown on the interpretation of the rising absolute rate of evacuation per annum by considering the number of man days worked offshore for each evacuation which took place. When the data are set out in that way the picture obtained can be seen in Figure 4. Aside from a peak, which is difficult to explain, in 1980 there is little difference in the incidence of evacuation when it is considered as a function of the number of man days worked in each year of the study.

There were 319 (14.7%) evacuations which were repeat episodes for the same men. Of those 156 were for the second time, 21 for the third, 6 for the fourth, and 2 for the fifth time.

Of the 2,162 evacuations which took place 1314 (60.8%) were for injury and 848 (39.2%) were for illness. There can be seen in Figure 5 a bar chart which gives the relative incidence of injury compared to illness each year from 1976 to 1984. Prior to 1980 most attention was paid to the recording of injury. The Department of Energy only required notification of illness if it persisted offshore for more than 3 days and considering space constraints it is likely that episodes of significant illness would have been evacuated ashore by that time.

During 1980 and 1981 there was considerable imbalance between the incidence of illness and injury, but there was evidence that the incidence of injury was falling and that of illness was rising (illness:injury was 25%:75% in 1980 and 40%:60% in 1981). During the subsequent years of the study, however, injury and illness have each accounted for about 50% of the medical evacuations.

From the records available it was possible to determine whether the evacuations were undertaken in the emergency or the routine mode in 1777 (82.2%) cases, while in 385 (17.8%) this distinction could not be made. Of the 1777 cases where the evacuation modality was specified 137 (7.7%) cases were evacuated by use of the emergency system while 1640 (92.3%) were evacuated by routine means. The incidence of emergency evacuation is in fact surprisingly low. Emergency evacuations have been identified as a main area for concern. Before examining these episodes in detail, however, it seems reasonable to consider the whole spectrum of medical evacuation in the first instance.

A breakdown is set out in Table 1 of the numbers which were evacuated for illness. They are classified into appropriate body systems. It should be emphasised that the ultimate or definitive diagnosis was not often available to the study team and the diagnosis from which this record is established is likely to be that of the medic acting on his own or in consultation with an onshore doctor.

It can be seen that the group of cases in which there is no working diagnosis is high accounting for 30.9% of the cases of illness evacuated. The disorders recorded have been analysed according to their rates of incidence, regardless of whether they are linked to other disorders or symptoms in the same casualty or not. It is therefore to be expected that the frequency of ill-defined conditions and symptoms should be high, since often such observations will accompany a working diagnosis. The content of some of the larger groups in the above series are dissected further below.

The gastro-intestinal tract accounted for a high number of evacuations for illness (20.9%) and of the 239 cases evacuated about half (112 cases) were for a dental problem. The next most common problem was in fact haemorrhoids and anal fissure which accounted for 36 (15%) cases. Of the remainder there were 22 evacuated on the presumptive diagnosis of peptic ulcer, 10 for strangulated hernia, 13 for appendicitis, 10 for gastro-intestinal bleeding, and 1 for cholecystitis. Since only 1 case of strangulated hernia was evacuated by the emergency mode it is presumed that these herniae must often have been incarcerated rather than strangulated.

The respiratory system was responsible for a high level of evacuation and of the 117 cases evacuated just under half (45 cases) were suffering from influenza and there were 32 (27.3%) cases of bronchitis. Of the remainder there were 12 (10%) cases of tonsillitis, 12 (10%) of pneumonia, and 11 (9.4%) upper respiratory infections. 7 cases were, however, diagnosed as suffering from pneumothorax but only 3 were evacuated by the emergency mode.

It is not surprising that the musculo-skeletal system accounted for a fairly large number of the evacuations and of the 156 cases evacuated no less than 81 (52%)

were suffering from acute back complaints while 53 (34%) had a problem associated with one or more joints and there were 11 (7%) acute neck problems.

Disorders of the eyes and ears were included in the nervous system and the bulk of the problems of the nervous system requiring evacuation were in fact related to eyes and ears. There were 23 (24%) ear problems and 43 (44.8%) eye problems of which 29 (30%) were labelled conjunctivitis. The only real problems of the central nervous system were in fact 5 (5.2%) cases of migraine.

Disorders of the cardio-vascular system did not figure as prominently as might have been expected and of the 41 cases evacuated, 10 (24%) were suffering from some form of myocardial ischaemia or infarction. There were 3 cases of thrombophlebitis and 1 case of heart failure but there were also 7 (17%) cases of hypertension evacuated on the presumptive diagnosis of hypertensive heart disease. 5 other cases were evacuated for cerebral ischaemia and 2 because of varicose veins. Mental disorders requiring evacuation in fact equalled cardio-vascular disorders at 42 (3.7%) cases of which the bulk (52%) were neurosis, accounting for 22 of the cases. There were, however, 5 alcoholic psychoses and 4 cases of organic psychosis.

Of the evacuations which took place because of injury a break down of the causes may be seen in Table 2.

Suspected fractures were responsible for by far the largest number of evacuations for injury accounting for 442 (30%) cases. Since diagnosis is the problem in these cases it would be reasonable to add dislocations, strains, and sprains to this type of injury and this would bring the total to 647 (43.8%) cases. The highest incidence of fractures was in the upper limb and of these 191 (81.6%) cases involved the hand. Of the lower limb fractures 99 (70.7%) involved the feet.

The group of 45 fractures of spine and trunk contained 31 cases of rib fracture and 5 of pelvis. There were 9 dislocations of shoulder and of the 192 cases of strains and sprains, 40 were of the back, 83 were of the ankle and 12 were of the wrist. Of the 62 crush injuries, 5 were of the trunk, 9 of the lower limb, and 45 of the upper limb. Of the 65 open wounds of head, neck, and trunk, 5 were of the eye ball and ocular adnexa. 83 (69%) of the open wounds of the upper and lower limb were in fact wounds involving fingers. This brings the total evacuations for injuries of the hand to 319 which is 24.3% of all evacuations for injury or 14.8% of all the evacuations studied. Foreign bodies of the eye accounted for 149 which is 95.5% of the evacuations for foreign body but if all the evacuations for diseases or injury of the eye are extracted the total comes to 215 cases accounting for 10% of all evacuations.

In order to assess the fundamental reasons for these evacuations with a view to reducing the number of them a series of factors has been considered. This was designed to establish a pattern with the available hard information. These factors include:-

the site on the installation where the incident took place,
the relative distribution between injury and illness,
whether the subject was on duty or off duty when the incident took place,
the time when the report was made to the medic,
the time lapse between reporting to the medic and evacuation,
the existence of consultation between the offshore medic and the onshore doctor,
the age of the patient,
whether the patient was provided with an escort,
the qualifications of the escort,
the destination of the helicopter,
the reception of the patient ashore,
the disposal of the patient for ultimate treatment.

The extent to which the above facts were available from the records will be included with each category.

There can be seen in Table 3 an analysis of the location of the subject at the time of the injury. The location was not specified in 105 (15.3%) cases. The installation deck and the drill floor account for 38.7% of the injuries between them and are still the places where accidents are most likely to occur on offshore installations. A surprising incidence took place in cabins: the percentage of 5.0% is small but the absolute number is 34 episodes. Nearly all of those episodes (30) took place during the night or in the early morning and were associated with confusion or disorientation on suddenly being wakened from sleep. They either consisted of head injuries from sitting up suddenly and bumping the head, on the surrounding structures or stepping out of the top bunk and landing on a limb with some force on the deck. The remaining 4 were associated with tripping over a sill on the way into a bathroom.

The information which was provided in the case of both illness and injury as to whether the evacuee was on duty at the time of occurrence of the injury or when he became ill was also noted. The point was made in 136 (16%) of the cases of illness studied and 958 (72.9%) of the cases of injury studied. It is hardly surprising that over 95% of the cases of injury were sustained while the subject was on duty, though it must be remembered that the injury location was not noted in 356

(27.1%) cases. Nevertheless, a total of 41 (4.3%) accidents requiring evacuation took place when the subject was off duty. In the case of illness the distribution is of course different and 73% of those who were evacuated because of illness became ill while on duty and the remaining 27% were in fact off duty when they became ill.

There may be seen in Figure 6 the distribution of the time of day when the report of the incident which resulted in evacuation was made to the medic. The information was available in the records of 990 (45.7%) cases. It can be seen that although the largest number of these reports was made between the hours of 0600 and 1200 there was a considerable frequency of reporting throughout the 24 hour period. The lowest frequency was during the night and 13.4% of cases were reported from midnight to 0600 hours.

Figure 7 shows the lapse of time between reporting the incident and the institution of evacuation. By far the largest number of evacuations took place in the first twelve hours after the incident was reported and this accounts for 642 (44.9%) cases. There is still a residue which was finally evacuated after 72 hours of offshore management - and there were four cases which were evacuated within 15 minutes of the incident being reported to the medic. It was possible to obtain this figure from the records in 65.4% of cases.

In the matter of the existence of consultation with a medical adviser before evacuation took place this was not recorded in the records of 177 (8.2%) cases. Consultation was recorded as having taken place, however, in 870 (43.8%) cases and there was no record of consultation having taken place in 115 (56.2%) cases.

In Figure 8 can be seen the frequency distribution between injury and illness which resulted from taking account of the age of the evacuee. The mean age of the 1314 cases evacuated because of injury was 28.3 years and the mean age of the 848 cases evacuated because of illness was 34.4 years. From the records the age was, however, only available in 40% of cases.

In considering the pattern of incidence of illness and injury it can be seen that there is an abrupt change in the decade between 46 and 55 years of age. Before the 46 years point the incidence of illness accounts for 25% of the evacuations and the level does not vary much during each preceding decade. After 45 years, however, the incidence of illness accounts for about 50% of the evacuations and remains at that level in the next decade. The corollary of course applies to the incidence of injuries - namely that prior to the decade ending at 45 years about 75% of evacuations which take place are due to injury and in the decade beginning at 46 years the number of evacuations due to injury is reduced to around 50%.

In Figure 9 can be seen the age distribution of the evacuees. It can be seen that the peak age for evacuation is in the decade 26 - 35 years. It would however be necessary to relate these data to the age distribution of the whole population at risk to produce meaningful conclusions on age and incidence of evacuation.

In seeking information from the records on whether the presence of an escort for the evacuee was considered there was sufficient information in 1341 (62.0%) cases to suggest that the matter had been discussed. This question was not referred to in 821 (38.0%) cases. In considering the 1341 cases where the question of the need to provide an escort was raised, the number of cases considered to be sufficient to warrant this was 121 (9%) while the provision of an escort was considered to be unnecessary in the remaining 1220 (91%).

Of further interest in the matter of escorting the 121 patients ashore is the qualification of the escorting personnel. In the 121 patients escorted ashore the status of the escort was specified in 77 (63.6%) and not specified in 44 (36.4%). Where the status was specified, the distribution is as set out below:-

| | | |
|---|---|---|
| No qualification | 1 | (1.3%) |
| First Aider | 6 | (7.8%) |
| Qualified Escort | 7 | (9.1%) |
| Rig Medic | 51 | (66.2%) |
| Doctor | 12 | (15.6%) |

All the evacuations took place by air except for 2 which were by sea and the destination was specified in 2011 (93%) cases and unspecified in 151 (7%). In those cases where the destination was specified the distribution was as set out below:-

| | | |
|---|---|---|
| Heliport | 1190 | (98.90%) |
| Hospital Helipad | 20 | (1.00%) |
| Medical Barge | 1 | (0.05%) |

There can be seen in Figure 10 an analysis of the arrangements made to meet the evacuees on arrival ashore. It can be seen that 1254 (74.5%) were met by a company representative and 281 (16.7%) were not met at all. Of the remainder, 99 (5.8%) were met by an ambulance which had been arranged before arrival and the final 50 (3%) were met by a doctor. The information was provided in the records of 1684 (77.9%) cases.

Figure 11 shows the disposal of evacuees for treatment. The disposal was specified in the records of 1997 (92.4%) cases. 80 (3.7%) were admitted directly to hospital and 973 (46.1%) were seen at a casualty or out-patient department of a hospital. Of the remainder, 536 (25.4%) were treated initially by a general practitioner and 520 (24.6%) by a company medical officer. It is of course possible that subsequent referral to hospital services may have been arranged, but the problem was not considered such as to warrant immediate hospital attention in 50% of cases evacuated and dealt with directly by the general practitioner or company doctor.

Since a main area of concern is the incidence of emergency evacuations this area deserves separate consideration. There were 137 cases evacuated as emergencies and of those 48 (35%) were evacuated because of illness and 89 (65%) because of injury. Evacuations requiring a dedicated helicopter thus amounted to 7.7% of the total.

The number of emergency evacuations which took place each year may be seen in Figure 12. The rising trend is very similar to the pattern found for the total evacuation figures shown in Figure 2 and is also likely to be related to the rising offshore population figures over the years of the study. The same small number of operators' employees compared to contractors' men is found in the case of emergency evacuation as was found in the total evacuation picture.

The diagnoses available to the study were the working diagnoses made by the medic on his own or in consultation with an onshore doctor. In most instances the definitive diagnosis was not available to the study. The incidence of illness associated with emergency evacuation is, however, set out in Table 4.

In considering these conditions it is clear that by far the largest group is that of undiagnosed illness which accounted for 46.7% of the cases of illness evacuated as an emergency. These cases consisted of a group of vague symptoms referrable to all the body systems.

Cardio-vascular disturbances were the cause of the greatest number of emergency evacuations for illness and of those half (7 cases) were diagnosed as suffering from acute myocardial ischaemia or infarction, 5 patients had some form of heart failure and 1 showed an arrhythmia.

Of the remaining two cases 1 was suffering from thrombophlebitis and 1 had hypertension. Equal in responsibility for emergency evacuations with the cardio-vascular system was the disorders of the gastro-intestinal system which were responsible for 13 emergency evacuations. 5 of these were on the presumptive diagnosis of appendicitis, 5 were for peptic ulcer, and the remaining 3 for cholecystitis, gastro-intestinal bleeding and strangulated hernia.

The next most common cause of emergency evacuation was diseases of the nervous system and special senses. Of the diseases of the central nervous system, epilepsy accounted for 2 and migraine for a further 2. The remaining 5 cases were due to eye problems of one type or another (excluding foreign bodies) and of these two had conjunctivitis and one had suffered a sudden loss of vision.

Of the 6 psychiatric disturbances, 4 emergency evacuations were for some form of neurosis, 1 for psychosis, and the remaining one for problems associated with alcohol dependence. Considering the high incidence of routine evacuation for respiratory complaints it is perhaps surprising that the emergency evacuations for respiratory disorders number only 4, 3 of which were on a diagnosis of pneumothorax. There was also a very large incidence of routine evacuation for musculo-skeletal problems but only 1 - an acute neck - was evacuated as an emergency.

Of the emergency evacuations, 84 were undertaken for injury and the distribution of these is set out in Table 5.

Fractures maintain high frequency in considering emergency evacuation and account for 35.2% of such evacuations though in this case lower limb fractures are more prevalent than upper limb. If dislocations, strains and contusions are added to the fractures the whole group accounts for 45.6% of the cases evacuated by the emergency mode. Of the 9 fractures of spine and trunk, 3 were cases of fractured ribs and 3 were pelvic fractures. Of the fractures of the upper limb, 4 were of hands and both dislocations were of shoulder. The sprain was a back injury. Burns accounted for 9.6% of emergency evacuations and assumed a more prominent position here than in the picture painted for total evacuations.

Of the 137 emergency evacuations studied the presence or absence of an escort was not specified in 46 (33.5%) of cases. Of the remaining 91 emergency evacuations 76 (84%) were escorted and 15 (16%) were not escorted. It may be considered useful in this context to compare these figures with those of the specified routine evacuations. Of 1192 incidents followed by routine evacuation 34 (3%) were escorted and 1158 (97%) were not. In this case virtually all the evacuations took place within 12 hours, though once again, there was one which took place within 15 minutes of the report to the medic. The evacuations falling outside the first 12 hours which still required the emergency mode were few and far between. 5% took place, however, between 12 and 24 hours following the report to the medic and 1 more than 72 hours following the initial report.

In 7 (5.1%) cases it was not possible to determine whether consultation had taken place between the offshore medic and an onshore doctor, but in the remaining 130 (94.9%) cases requiring emergency evacuation, consultation was claimed with an onshore doctor in 74 (57%) cases. In the remaining 56 (43%) emergency evacuation took place without such consultation.

There may be seen in Figure 13 the arrangements made to meet the emergency evacuation cases at the heliport. This was specified in the records of 115 (83.9%) of the 137 cases where emergency evacuation took place. It can be seen that 39 (27.6%) of the cases were met by a company representative and 2 (1.4%) were not met at all. Of the remainder in this category 68 (48.2%) were met by an ambulance which had been arranged before arrival and 32 (22.6%) were met by a doctor.

In Figure 14 can be seen the ultimate disposal for treatment of the emergency evacuation cases. 47 (34.3%) were admitted directly to hospital and 74 (54%) were seen at a casualty or out-patient department of a hospital. Of the remainder, 4 (2.9%) were treated initially by a general practitioner, and 12 (8.7%) were treated by a company doctor. The 88.3% immediately treated by the hospital services presents a different picture from the 52.7% of all evacuations so managed.

The pattern of disposal of the evacuees found when treatment was considered in terms of whether the evacuations took place because of injury or because of illness may be seen in Figure 15. Virtually all the injuries were managed by the hospital services, though 69% were contained by the casualty department and only 27% required formal admission to hospital. Of the illnesses, one quarter evacuated by the emergency mode were managed by a general practitioner or company doctor. Where the hospital services were required, however, about 50% required formal admission.

## DISCUSSION

This study suffers from some of the problems of all retrospective studies in that a certain proportion of the desirable information was not available. It has, however, produced some very useful information, particularly when consideration is given to the fact that it was drawn from the records of 4 different source companies. It has not been possible to obtain values for the annual total offshore population of the installations under study nor the ratio of contractors' to operators' personnel, and the data has thus been treated in terms of absolute values and percentages.

An early decision had to be made in determining the level of severity of the condition which it was considered worthwhile including, and it was decided to limit the study to those conditions which required evacuation, either by the routine or the emergency mode. This decision was made in the knowledge that there is little space on an offshore installation to nurse a patient. Thus, inability to work normally means evacuation, even although the condition may be well within the capacity of the rig medic to manage. This view seems to have been justified on the basis that an escort was considered to be unnecessary in 91% of the patients evacuated, that no special medical provision was required at the heliport for 91% of the evacuees who were either met by a company representative or not met at all, and that about half (52.9%) were dealt with initially at least by a general practitioner or company doctor without reference to the hospital services.

It was also decided to consider evacuation made by means of a routine helicopter separately from that where it was considered necessary to use a dedicated helicopter. This was on the basis of the very high cost of a dedicated helicopter and also to provide an opportunity to compare the pattern of those conditions considered to be urgent emergencies with the more general picture of illness and injury offshore. The main difference in the pattern was that cardio-vascular disturbances rose to the position of greatest prominence in the emergency evacuations of illness (at 16.7%) from its insignificant position of 3.6% when evacuations for illness are considered as a whole. On the other hand, fractures, dislocations and sprains account for nearly 50% of the evacuations for injury, whether the evacuation was undertaken in the routine or the emergency mode, and the decision of evacuation made was presumably made on the grounds of the severity of the trauma and other related factors.

In any event, the economic consequences of emergency evacuation are much less severe than popular opinion holds, since of all the evacuations considered only 137 (7.7%) of the 2162 evacuations required a dedicated helicopter. This relatively low figure suggests the adequacy of the medical provision provided offshore, the state of training of the medics and the position of communications between offshore medics and onshore doctors. It probably also reflects the relatively non-urgent status of a large number of patients evacuated, and it provides a base-line against which to assess future developments in the provision of offshore health care.

When the distribution of illnesses and injuries which took place is considered, the pattern was surprising in some aspects and very much as expected in others. In the case of the evacuations for illness, the very high proportion of evacuations for conditions relating to the digestive tract was surprising as was the very low rate of evacuation for disorders of the cardio-vascular system or mental disturbances. The high rate of musculo-skeletal disorders in the illness groups is probably to be expected in heavy work. The respiratory system also accounts for a reasonably high rate of evacuation, but 68.2% of these cases were due to transient infections such as influenza, tonsillitis, etc.

The cardio-vascular system is concentrated upon very much in the pre-employment medical examination which normally requires an electro-cardiograph over the age of 40, together with a careful history and the measurement of various cardiac parameters. This is probably why the incidence of cardio-vascular disease which required evacuation is so low. The incidence of evacuation for mental disturbances is also low, (3.7%). This system is not normally rated highly as a reason for evacuation, yet it accounts for as many evacuations as were required for cardio-vascular complaints.

The low incidence of acute psychological disturbance as a cause of evacuation is at variance with the view expressed by Anderson, when he reviewed the reasons for evacuation of offshore workers from the records of the North Sea Medical Centre in 1970 (Cox, 1987). He stated that acute psychological disturbance was second only to trauma as a cause of evacuation. It must be remembered, however, that natural gas was discovered first in the Southern North Sea only in late 1965 and it was 1970 before oil, in association with gas, was discovered in commercial quantities, (Cooper and Gaskell, 1966b). Anderson was thus commenting on an industry which is very different from that in existence today. Indeed, the industry only became established in the Northern North Sea between 1972 and 1974 and there were only incomplete returns made of the incidence of illness as opposed to injury before 1980, due to the reporting instructions to industry from the Department of Energy, (Bell, personal communication).

The low incidence of evacuation for psychiatric reasons noted in this study was discussed with the Medical Officers of the companies involved, and also with those of the 10 companies involved in the prospective studies which followed, and all were in agreement that the figures quoted in this study were in sympathy with the general impression and with their individual company figures.

In the first annual prospective study of evacuations from the offshore installations of operating companies reported in November 1988, the incidence of psychiatric evacuation was further reduced to 2.3% of illnesses requiring evacuation and, once again, it was closely related to the figure obtained for diseases of the cardio-vascular system (2.5%).

In the second year studied prospectively and reported on in November 1989, psychiatric disturbances accounted for 18 of the 399 cases evacuated or 4.5%. There can be little doubt that the impression recorded from the 1970 study does not reflect the true incidence of evacuations for psychiatric reasons in the offshore industry.

The reason for the prominence of the digestive system was largely due to teeth and the next reason was lesions around the anal canal labelled piles or fissures. Teeth are examined carefully in the pre-employment medical examination, but it is possible that part of the problem is in the fact that doctors are not skilled at examining the teeth. Whatever the reason for the high incidence of dental lesions this is surely one area where the number of evacuations could be reduced by preventive measures. Pyper (1987) has recognised this problem and advised on it for several years and Hahn (1987) surveyed the offshore workforce and found a high incidence of dental disease with poor standards of oral hygiene. About half the population questioned did not receive regular dental care. Another possible area lies in the high incidence of evacuations for conditions around the anal canal. These could possibly also be reduced by more careful examination of the area and promulgation of the importance of this area to examining doctors.

The pattern of illness is, however, different when we consider the emergency evacuation pattern and in this case the cardio-vascular system became the most important system and responsible for 16.7% of the emergency evacuations. The digestive tract maintained its important position also in the emergency evacuation pattern: it was responsible for nearly as many evacuations as the cardio-vascular system. In other ways the pattern is very different from the total evacuation pattern since emergency evacuations for cardio-vascular disorders are now 3 times as frequent as those for mental disturbances, and since musculo-skeletal disorders fall to the bottom of the list.

In considering the injuries which required evacuation the clear front runner is fractures which account for 37.6% of the evacuations for injury. Diagnosis of a fracture is something of a problem without X-ray facilities, and if dislocations and strains are added to the group it rises to a proportion of 59.1% of evacuations for injury. The same pattern holds true for emergency evacuations where indeed fractures were responsible for over 35.2% of the evacuations. The addition of dislocations and strains to this group raises the proportion to 37.5%. These figures are clear indications for the directions of first aid and rig medic training, and also for the provision of equipment.

A further indication for training of medics and first aiders is the incidence of hand injuries. When fractures and soft tissue injuries of the hand are taken together they account for 24.3% of the evacuations for injury and 14.8% of all evacuations. The foreign body in the eye also assumes significant numbers, but when all eye conditions are taken together they account for 10% of all evacuations. Burns, poisoning and other environmental factors, on the other hand, account for a very small number of evacuations.

A distinction has been maintained throughout between injury and illness. The reason for this is because the condition is not only different, but preventive measures are entirely different. In addition, the resources needed for management are also different in terms of training and equipment. Preventive measures designed to reduce the number of injuries are largely a matter of safety and training departments. Preventive measures designed to reduce the incidence of illness offshore are more properly the business of the Medical Department since they are concerned with the setting of medical standards of fitness to work offshore, and the determination that these standards are applied.

The occurrence of inter-current illness in a workforce is also associated with less easily defined parameters such as age, the incidence of psychological stress, the environment of the workplace and these factors are subject to wide individual biological variation. The situation is recognised as being far from simple and clear cut, and there are also more nebulous factors such as the recognition that good and universal first aid training reduces the incidence of accidents by enhancing safety awareness, (Steggles, 1984).. It still seems worthwhile, however, to maintain a clear distinction between illness and injury for the basic reasons mentioned above in a study such as this, (Norman, Ballantine, Brebner, Brown, Gauld, Mawdsley, Roythorne, Valentine and Wilcock, 1988).

While it is not possible to determine the accuracy of the working diagnosis from the current study the available diagnoses provide a picture of the general pattern of illness and injury offshore. It is significant to note that a diagnosis could not be attempted in up to 30.9% of the cases of illness evacuated, but some form of working diagnosis was usually present in the injuries. It is difficult to determine the best form of management for a patient in the absence of a working diagnosis. Since this undiagnosed category assumes a proportion of some significance perhaps measures taken to improve offshore diagnoses would not only improve management, but also reduce the number of emergency evacuations which take place. Such measures could include:

(a) Training of medics in diagnostic techniques.
(b) Provision of and insistence of usage of medical consultation before evacuation.

(c) Review of diagnostic equipment and further aids held offshore.

(d) Training of medics in clinical information transfer.

(a) Offshore medics are normally nurses trained either in the National Health Service or in military organisations and they are now well used to functioning on their own with a minimum of direct supervision from onshore doctors. The main difference in the training of the nurse and the doctor is in the area of the techniques used in diagnosis. Offshore nurses have had to develop their own diagnostic method and it is not always the best method. Also, they are not trained to recognise the classical presentation of the various disease states. A firm recommendation from this study has been to concentrate on this subject in rig medic training programmes. The opening session in the courses now presented in Aberdeen is on diagnosis, history taking and documentation and as much time as possible is spent in teaching the correct form of formal patient interviewing and system examination, with a logical sequence of steps taken towards diagnosis.

During the second week of these 2 week courses at least 3 days are now spent on attachment in a hospital where they are given access to patients following which they produce written case records. Such a change in training should result in an improved standard of offshore diagnosis.

(b) The usual diagnostic procedures undertaken by the nurse can only be regarded as a first step. The second phase of the process is the discussion which takes place between the nurse and the onshore doctor, so that a working diagnosis at least can be arrived at. Satisfactory results can only be achieved by this technique if the medic is, in the first instance, able to extract the relevant information and communicate it effectively to the onshore doctor. It is recommended that the number of such consultations should be increased.

In this retrospective study consultation with an onshore doctor was recorded as having taken place in less than half the episodes reported, (43.8%). Following that study and recommendations made to the Medical Directors of the offshore companies, attempts were made to improve the situation and in the first annual prospective study reported at the end of 1988, the rate of consultation with an onshore doctor had risen to 68.2% and in the second annual prospective study reported in 1989 the figure was 72%.

(c) In the provision of additional diagnostic equipment there is some controversy on the use of such aids as X-rays, ECGs and laboratory techniques, such as the plating and staining of bacteriological slides. In some cases ECG machines are held offshore and the companies have trained their medics to take acceptable ECGs and to interpret the most salient features. In other instances short courses in bacteriology have been undertaken and some medics produce quite acceptable material in a diagnostic form. Few in the North Sea have so far invested in X-ray equipment to date.

One of the dangers of introducing such techniques is that an early manifestation of a serious illness may be missed if tests are poorly conducted or if interpretation of the results is left to an inexperienced person. The time and distance situation in the North Sea is such that this risk is hardly justified. On the other hand, it seems worthwhile to determine whether acceptable additional information can be obtained and used in the consultation between the medic and the onshore doctor or specialist.

This has proved to be particularly useful in the matter of ECGs, and by the use of a modem the tracing can be transmitted directly to the desk of the onshore doctor or the cardiologist.

In the case of X-rays the use of slow-scan television is still in its infancy. Some such system would be required in this case as in the evaluation of bacteriological material if these techniques were to be of real value. A case could be made for the limited use of radiology, however, under strict onshore control if the films were sent ashore for proper radiological evaluation. The same would hold true of bacteriological material until the techniques of telemedicine become more advanced.

These more elaborate techniques are, of course, valuable when the time and distance factors become greater than those found at the present time in the North Sea. The occupational groups in the extremely remote and isolated parts of the world are usually relatively small and the economics of such techniques have to be borne in mind. They are, however, under current review in such situations as the Antarctic and in the preparations which are being made by the European Space Agency for long-term space travel.

(d) Nurses are not any better than trainee doctors in transmitting a concise case description with the relevant information which can assist the doctor or the specialist in arriving at a diagnosis at a distance. It has to be remembered that it takes a medical student 6 years to be able to describe a medical problem effectively and probably several post-graduate years before he can do it well. This limitation has to be borne in mind when the position of a medic is considered who is released for relatively short periods of time for ongoing training. Nevertheless, it must be regarded as an important element in improved diagnosis and it is recommended that time should be set aside in developing offshore medic courses for planning the format which messages should take and the type of information which they must contain.

This type of training is also given in the Antarctic to those who act as paramedics on Polar travelling expeditions and fairly elaborate exercises are set up on some of the stations, during the winter months. This has resulted in greatly improved management of the accidents which take place in the Polar wilds and in the confidence which those who undertake these journeys have in the medical backup available to them.

The age distribution of illness and injury with time needs constant monitoring since it may have wide-reaching implications as time passes, particularly in such areas as safety, training, medical and personnel policies. The peak in the incidence of evacuation for injury at 28.3 years of age agrees with previous studies, (Linning 1980), but the peak of evacuations for illness at 34.4 years is perhaps younger than was expected.

More firm conclusions could be drawn from these figures if the age distribution of the population at risk was known. The peak in evacuations for all reasons, however, was in the decade of age from 26-35 years. The absolute number of evacuations required over the age of 45 was extremely small, and it is thus possible that advancing years may pose less of a problem than has been anticipated, provided an effective system of medical screening is maintained. It is even possible that the older workers who are more experienced and are inclined to take fewer risks, may have a lower incidence of accidents from breaches of safety procedures.

The distribution of injuries is fairly evenly spread over the 24 hour period in this study. The figure shows that of those who are evacuated, the likelihood of the evacuation being because of illness increases as they become older, but the likelihood of evacuation because of injury decreases. Considering the pattern of evacuations as a whole over the period of the study it has been seen that the number of evacuations required for injury gradually reduced towards 1980, while those required for illness gradually increased, and in the last few years of the study evacuations for illness and injury ran at about 50% each. There are a number of possible explanations as to why the evacuation rate for illness in the early years was low in comparison to injury.

It is possible in the early years that more risks were taken by an inexperienced workforce working in extremely hazardous conditions. As time went on, however, and experience was gained, together with the growth of training departments and safety departments it is possible that the injury numbers dropped in relation to the lessening amount of dangerous activity and the appearance of a more stable occupational population. Another possible explanation is that reporting systems for illness were not as stringent as for injury in the early days and thus a percentage of the illness related incidents were simply not reported. For example, the Department of Energy only required notification of illness if the situation persisted for more than 3 days. These cases would, of course, be evacuated before this time for operational reasons and hence no particular report was necessary. While advancing years could pose less of a problem than has been anticipated, the paramount value of an effective system of medical screening seems of fundamental importance.

In considering the location in the offshore structure of the incident leading to evacuation, the finding that one third of the accidents took place on deck or on the drill floor is hardly surprising and would fit with previous studies (Linning, 1980; Sutherland and Cooper, 1986; Hellesøy, 1985). Of greater interest and possibly worthy of investigation was the fact that 34 injuries requiring evacuation took place in cabins. This has possible implications for the design of cabins and the design of both living accommodation and sick bays on offshore structures has received recent attention, (Cox, 1987b; Anderson and Cox, 1987b; Elliot, 1987; Chalk, 1987). Alcohol can certainly not be implicated in the cause of these accidents since it does not exist on offshore structures and it is unlikely that drugs would be involved either. Hypnotics are not normally prescribed since it is necessary for a man to become instantly awake and reactive in the event of an emergency. The design features which need to be borne in mind in these instances are the surroundings of the bunk and the possibility of using restraining bars, particularly in the top bunk. Equally, the presence of sills at the entrance to bathrooms is a recognised part of marine architecture but hardly seems necessary on a fixed or even semi-submersible offshore installation. The subject has, however, been addressed in considerable depth by Elliot, (1987).

A further fact which comes from the investigation is that 41 (4.3%) accidents requiring subsequent evacuation actually took place when the man was off duty. The location of the man at the time of injury was noted in 958 (72.9%) cases. In noting this point, however, it must be remembered that for the offshore worker the installation is both home and workplace (Linning, 1982) and in onshore workers the incidence of accidents in the home is much higher (Ernst, 1986; Lowry, 1990).

The time when the report was made to the medic has possibly more implications for the work and efficiency of the medic than the management of the incident.

Although the bulk of the consultations took place between 0600 and 1200 hours there is a substantial incidence throughout the 24 hour period, since there is only normally one medic on duty. This could have implications for his efficiency if the consultation rate was high.

In considering the factors which were collected and which relate to the management of the incident there is some value in looking at the total picture and the emergency evacuations together. 44.9% of all evacuations took place within the first 12 hours after the report to the medic, and this seems reasonable, particularly since illness may take some time to develop. In the case of emergency evacuations practically all took place within the first 12 hours and this is how it should be. 5%, however, took place between 12 and 24 hours and one more 72 hours after the report to the medic. Though very small in number, this picture represents 8 cases (6.7%) of emergency evacuations, which presumably could have been made by the routine mode if the seriousness of the situation had been realised earlier. This is a good reason for encouraging more frequent communication between the offshore medic and the onshore medical adviser.

In considering both total and emergency evacuation groups there was a small incidence which amounted to less than 1% in both groups where evacuation took place within 15 minutes of the initial report being made to the medic. Presumably, in these cases, there would have been some delay and disadvantage if consultation with an onshore doctor before evacuation took place was absolutely mandatory, since the opportunity of a helicopter present at the time would have been missed. Consultations seem to be a very important factor, however, in determining whether an evacuation should take place and should be encouraged wherever possible. Yet there was only evidence of consultations having taken place with an onshore doctor in 43.8% of cases evacuated. In the case of the emergency evacuations the consultation rate prior to evacuation rose to 57%, but 56 (43%) of the emergency evacuations took place without evidence of prior medical consultation. A higher rate of consultation - and these are usually very readily available - must surely improve the situation of management in most cases.

Consultation would presumably reduce the incidence of vague and undiagnosed symptoms so that decisions regarding routine or emergency evacuations would be made with more fact and logicality. It is quite possible, however, that a higher rate of consultation could result in an increasing emergency evacuation rate in some cases, but hopefully it would result in better overall management. There were, for example, 10 cases diagnosed as strangulated hernia, and 7 cases diagnosed as pneumothorax, yet only one case of supposed strangulated hernia and 3 cases of penumothorax were evacuated by the emergency route.

When the matter of the provision of an escort was addressed the overall picture of management of the incident was further elucidated. The overall usage of an escort was in 9% of cases evacuated and this low figure lent support to the contention that the consideration of evacuations provides a reasonable picture of significant offshore injury and illness. In emergency evacuations, the usage of escorts rose dramatically to 84% of cases and this is right and proper for the type of case where emergency evacuation is fully justified. There was, however, no evidence of an escort being provided for 16% of emergency evacuations. Escorts have been trained specifically for this task for some years and are intelligent and motivated offshore personnel who have an interest in and have shown aptitude in basic first aid. They are designed not only to act as escorts, but also to provide back up for the medics in a serious incident. Less than 10% of the escorts employed were, however, drawn from this category of personnel, and around 50% were the medics themselves. While the decision may have been made that the case was sufficiently serious to require the attention of the medic, his presence meant that the installation was left without medical cover. Under these circumstances it would be preferable for an onshore doctor to act as escort and indeed this took place in around 16% of cases.

The arrangements made to meet the evacuees and the ultimate medical disposal of the patients evacuated provides further information on the level of the problem and its management. The reception of the total number of patients evacuated provides a picture which seems reasonable and consistent with the nature of the conditions being evacuated overall. The fact that 74.5% were met by a non-medical company representative indicates the level of seriousness of many of the cases evacuated and this is further emphasised by the fact that about half (52.9%) were dealt with medically by a general practitioner or a company doctor and without reference to the hospital services. Of the remainder, 5.8% were met by an ambulance and 3% by a doctor. This suggests a small but reasonable number of fairly serious problems evacuated by this means. On the other hand, 59% of those evacuated by the emergency mode were met by ambulance and 28% by a doctor. Though the numbers are substantially greater than for the total evacuation group they seem low for emergency evacuations and it could be assumed that the ambulance reception could reach at least 90 or even 100%. A small number (2%) of cases evacuated as emergencies were not met at all. Of the emergency evacuations, 96% required immediate attention by the hospital services and this is a reasonable figure, though it should be noted that only one third (34.3%) were actually admitted directly to hospital.

This is the first composite study of the pattern of injury and illness found in the offshore oil and gas industry which shows the change in the pattern with time. This presumably was influenced by the increasing size of safety, medical and training departments and also with the increasing experience of the workforce. There was a preponderance of injury as opposed to illness in the early part of the study and it gradually declined over the years as the incidence of illness increased. At the end of the study illness accounted for nearly as many evacuations as injury. This emphasises the need to maintain an ongoing database of these events if adequate health and safety provision is to be provided for the workforce, to suit the situation in existence at any moment in time.

This study indicated a need, for example, to change the emphasis in the training courses provided for medics and in the experience sought during the selection procedures. Most attention was originally paid to the consequences of serious accidents and medics with a background in intensive care and accident in and work were sought. It seems now that there is a gradual change of emphasis towards the conditions that ageing flesh is heir to and thus much more emphasis needs to be placed on the early recognition and management of malignant disease, hypertension, gallstones etc. On the other hand, the pattern of injuries shows that nearly 50% are fractures and large numbers involve both hand injuries and foreign bodies in eyes. The first aid courses certainly do not place such considerable emphasis on the management of fractures and casualty handling and these courses now need to be modified to take this into account. It seems clear that such information as has emerged from this study should also be used in designing courses provided in other parts of the country. Equally, particular attention needs to be paid in medic training to the problems of the removal of foreign bodies from the eyes and the management of hand injuries.

The need for improved communications between the offshore medic and the onshore medical advisers has been pointed out by this study, and in particular the requirement to insist upon consultation between the medic and his onshore adviser before a complicated case is managed or before evacuation takes place. In order to achieve this, however, an increased amount of training in communication techniques and in the use of such equipment together with an understanding by the medics of the principles of diagnosis is essential.

The whole pattern of illness and indeed the lower requirement for a dedicated helicopter for evacuation than anticipated suggests that the pre-employment medical examination is adequate. The study also emphasises the need for concentrated effort on two particular areas in the pre-employment medical, namely the teeth and the anal canal, if further unnecessary evacuations and interruption of work are to be avoided.

The study, of course, demonstrates the usual problems of all retrospective studies in that there is a variable quality of information presented in varying forms and it was limited to 4 operating companies. The study has, in fact, been presented to the Medical Directors of the oil companies operating in the North Sea and together with the Department of Energy support has now been provided for a series of prospective studies involving 10 operating companies, extending over 5 years and reported upon annually. The first 2 studies have now been carried out and it is gratifying to note that the pattern of both injury and illness has been remarkably similar to that which emerged in the retrospective study. In the study reported in 1988 the incidence of illness requiring evacuation as opposed to injury was 49.5% while in the study reported in 1989 the incidence of illness slightly exceeded that of injury and the figure found was 54%.

The same pattern of evacuations which required a dedicated helicopter as opposed to the routine mode was also maintained. In the study year reported during 1988 the proportion of evacuations which required a dedicated helicopter was 8% and during the study reported in 1989 it was 6%, while the figure in the retrospective study was 7.7%. It thus appears that the first two years of the prospective study have confirmed the trends and patterns noted during the retrospective study. Improvements in the situation resulting from the points made in the retrospective study have also been referred to in this section with regard to the increasing incidence of medical consultation with the medic. Following the advice designed to improve the standards of offshore diagnosis there has also been a falling number of illness evacuations with no real working diagnosis. The figure quoted in the present study where vague and undefined symptoms only were available was 30.9% of cases evacuated for illness while in the prospective study reported in 1989 it had fallen to 16.1% and the 1989 figures indicated that they had fallen even further to 8.3%.

The pattern of distribution of the conditions requiring evacuation noted in the prospective studies was virtually the same as those in the retrospective study with the digestive tract leading the field and for the same reasons. Disease of the cardio-vascular system and mental disturbances requiring evacuation remained at the same low level during both prospective study years.

It was hoped that one of the problems which was highlighted by the current study would be overcome in the prospective study, and that is the ability to compare the working diagnosis with the definitive diagnosis. In addition, in the current study there were a large number of cases labelled as vague and undiagnosed conditions in either the illness or the injury category. In order to throw further light on this area a second study was undertaken using the records of admissions to Aberdeen Royal Infirmary over roughly the same period of time as the current study and this experiment is reported in the next section.

## CHAPTER III

## THE INCIDENCE OF ACCIDENTS FROM THE OFFSHORE INDUSTRY ADMITTED TO ABERDEEN ROYAL INFIRMARY FROM 1978 TO 1986

As the oil industry and its associated service companies rapidly expanded during the 1970s there was a growing concern that their requirements for health care might overwhelm the resources available from the National Health Service in Aberdeen and in the Grampian area. In 1979, Nimmo and Innes carried out an extensive study on the use which was made of the National Health Service hospitals and outpatient facilities by the personnel of the offshore oil industry and their families. They found that although the numbers requiring attention were considerable it was well within the capacity of the existing resources of the National Health Service. Excluded from Nimmo and Innes' study was the impact which the oil industry had on the Accident and Emergency Department at Aberdeen Royal Infirmary.

It thus seemed reasonable that that aspect should now be studied both to complete the picture and also as a means of providing comparison for the figures obtained in the previous section from the epidemiological data provided by the studies conducted with 4 major offshore operating companies. There have been few studies published previously on the incidence and nature of accidents associated with the offshore industry. The United Kingdom Offshore Operators Association commissioned a report from Heriot-Watt University. This report was, however, aimed more at accident causation, safety implications and the numbers of lost time accidents which took place, rather than registering the nature of the incidents in terms which were of medical relevance. A previous study had also been carried out by Linning (1980) on behalf of the Department of Energy and following the Burgoyne Report (1980) on offshore safety. This was a useful study and it provided some epidemiological data on the nature of the incidents which took place, but the main thrust of the Report was directed towards the occupational groups who had become injured and also it attempted to determine whether a better system of reporting was required. One of its conclusions was that there already existed a vast amount of uncorrelated information in the Department and aside from that relating to diving accidents very little of value had been done with it.

The pattern of injury which emerged from the study reported in the previous section was based largely upon the working diagnoses of the offshore medics, albeit in consultation with an offshore doctor in approximately

50% of cases, (Norman et al 1988). This present study was carried out as a means of obtaining more definitive diagnostic data on the subject of offshore accidents and it was hoped that the pattern of injury which emerged from this study would help to validate the diagnoses of the previous study.

Aberdeen Royal Infirmary serves a vast geographical area since it is the only major teaching hospital in the North East of Scotland, North of Dundee. It serves a vast onshore and offshore area, passing inwards as far as the Grampian Mountains and Tomintoul and northwards to include the Elgin area, together with Orkney and Shetland. The Accident and Emergency Department is thus well placed as the catchment area for almost the entire population of offshore workers requiring immediate emergency hospital attention for injury from the Northern UK sector of the North Sea. It was for this reason that it was decided to attempt to review the admissions from the offshore industry to that Department for a period and it was possible for this to be done over a period amounting to almost a decade from 1978 to 1986. The study began in 1978 because it was at the beginning of that year that the Department started to record which of the patients had been referred from offshore by marking the top of the treatment card. This has made it possible to retrieve all offshore referrals and thus their definitive diagnoses from 1978 onwards. The study was concluded in 1986 and it thus overlaps the period of the study reported in the previous section.

## METHODS

The first task was to retrieve all the referral cards which originated from the offshore industry, that is those which were marked with an '0'. This proved to be a mammoth task since the Department saw around 40,000 new cases each year and it was from this mass that the relevant cards had to be extracted. The layout of the card is shown in Figure 16 and it was fortunate that the standard of record keeping was of a consistently high standard.

The next task was the choice of the fields of information which were to be recorded. Those eventually chosen were as follows:-

Patient Number
Date
Age
Operator/Contractor
Marital Status
Method of Disposal
State of Consciousness
Occupation
Type of Injury
Body Part Affected
Sex

The data was coded using simple random numeric codes apart from the information referring to the injuries themselves which were coded using the International Classification of Diseases (1978) for the purpose of standardisation. Once coded the data on the cards was transferred to a database (Datagem) on the BBC microprocessor. This proved very convenient for entering the patient records, using patient numbers rather than names, but it unfortunately did not have sufficient power or speed for adequate data analysis. It was, therefore, necessary to transfer the whole database to a mainframe computer. Unfortunately, this had to be done twice, since it was initially transferred to a Dec 20 mainframe computer. This computer was then replaced by a Honeywell mainframe computer which was finally the computer used. The data was analysed using the Bio-Medical Data Package. The study was registered under the Data-Protection Act and was approved by the Joint Aberdeen University/Grampian Health Board Ethical Committee.

## RESULTS

During the years of the study around 650 cases were referred to the Accident and Emergency Department each year from an average total of 40,000 new cases per year. The total number of injury referrals during the period 1978 to 1986 was 5,894 and the annual distribution of these is set out in Figure 17, where it can be seen that there are no particular upward or downward trends in volume during that period.

In order to determine whether a particular time of the year was more associated with accidents than others the monthly distribution for the whole period of the study is set out in Figure 18. It is not possible to identify clearly any month which is consistently high or low over the 9 year period. March, in fact, produced the highest absolute number of incidents and July and September tied for the lowest number. The values may be seen in Table 6.

Figure 19 is a pie chart which sets out the distribution of the types of injury which took place. There were 1575 (26.7%) fractures confirmed and there were 1007 (17.1%) sprains. This compares with the 30.7% working diagnosis of fractures reported by the offshore medics in the previous study which also reported 13.3% strains.

If the fractures and sprains are added together a figure of 2582 (39%) results and this compares with the figure of 44% from the working diagnoses of the offshore medics in the previous study. When fractures, sprains and crush injuries are summated it can be seen that these 3 problems account for 50% of the injuries reported. This, once again, compares very closely with the figure given in the offshore study of 48.3%.

The distribution of each type of injury is shown for each year of the study in Table 7. It can be seen that the number of each type of injury is remarkably consistent throughout the years of the study. This seems to establish the pattern of injury which can be expected.

Figure 20 is a pie chart which sets out the body part involved in the various injuries. It can be seen that over the period of the study 2302 (39%) of the injuries involved the hand, and 271 (4.6%) involved the eyes. Once again, this can be compared with the 24.3% of hand injuries noted in the offshore study, but in this case when eye injuries and hand injuries are added together the total is 41%, whereas the figure quoted by the offshore medics working diagnoses was 34% and the percentage of eye injuries was 10% in that study. The lower incidence of eye injuries noted in this study is almost certainly due to the fact that there is a separate eye out-patient department to which serious eye injuries would be automatically referred and sometimes before admission registration details were taken.

The highest incidence of injury is to the hands in both studies with 2302 (39.1%) in the Accident and Emergency Study. In this study also, feet came in second place with 1082 (18.4%). There were 542 (9%) head injuries and this can be compared with the 7.5% head injuries noted in the offshore study. In this case, the injuries to the eyes assumed fourth place with 271 (4.6%) of the cases. This is of course much lower than the figure quoted from the medics' working diagnoses for reasons already stated.

The distribution of the injuries noted in this study which took place each year for the 4 main body parts - hands, feet, head and eyes - can be seen in Table 8. Once again, it can be seen that the pattern is very similar from year to year. Chi-squared analysis shows that there is no significant difference from one year to another ($P > 0.1$).

The question of consciousness was raised specifically as a means of determining the severity of the injury and also as a means of determining the types of condition first aiders and escorts. The results can be seen in Table 9 for each year of the study. The vast majority of casualties - 98% were received conscious in the Accident and Emergency Department, but it can be seen that the annual distribution of patients who had been unconscious at any time from the time of the accident to the time of receiving treatment in the Accident and Emergency Department varied between 6 and 26 or from 1% - 2%.

In Figure 21 can be seen the occupational frequency of the casualties presenting during the period of the study at the Accident and Emergency Department. The six occupations shown account for 41% of all injuries and the remaining occupations for 59%. The 59% were distributed over 91 different occupations. The occupation of roustabout produces the highest number of accidents consistently and the 6 occupations quoted as the top injury producers are basically outdoor, manual occupations. Table 10 shows the distribution of these 6 occupations each year, and once again, there appears to be a consistent pattern with roustabout remaining well ahead of the others, and with the others following fairly homogenous groups which do not vary much from year to year.

88% of all injuries involved contractors' personnel and only 12% operators' personnel. Once again, this is a consistent pattern as can be seen from the annual distribution throughout the study which is set out in Table 11.

Figure 22 shows the age distribution of the casualties for the total 9 year period from 1978 to 1986. The group with the highest incidence of evacuations is the 26-30 year group (46%) and this compares with the distribution found in the offshore study where the figure for the 26-35 age group was in the region of 45%. As in that study also the incidence of casualties resulting from the over 45 age group is very small. The distribution around 30 years is shown for each year in Table 12.

Figure 23 shows the disposal of the casualties after referral to the Accident and Emergency Department. The largest number of casualties were discharged after treatment. That accounts for 1,817 (30.8%). 728 (12.4%) were, however, admitted to hospital and that is a rather larger percentage than noted for the injuries considered in the offshore study where 3% were admitted. If illness and injury are added together in that study, however, a total of 8% were in fact admitted to hospital. In this study, 1,377 (23.4%) were treated initially in the Accident and Emergency Department and asked to return to the outpatient clinic at a later date, while 232 (4%) were referred to other hospital departments. One patient was recorded as dead on arrival and there were no records of any patient having died in the Accident and Emergency Department. The distribution of the various disposal categories is shown in Table 13. Changes in the number of hospital admissions from 1981 onwards are apparent and there is a continuing increase in the number who were admitted with a downward trend in the number of patients who were asked to return either to the outpatient clinic or to their own general practitioner. Otherwise the numbers appear relatively constant with time.

## DISCUSSION

Over the 9 years of the study, there were 5,894 cases referred from the offshore industry to the Accident and Emergency Department and this averaged out at around 650 cases per annum. This is a relatively small number when compared to the 40,000 new cases seen each year in the department and it represents only a 1.6% increase of new patients seen during the period of the study. The numbers seen were fairly unchanging each year throughout the study so there is little evidence of an increasing or decreasing workload in the Department due to the offshore industry's presence. The study, therefore, has produced rather similar results to the conclusions of Nimmo and Innes (1979) in that there is little evidence that the industry as a whole had much effect on the overall workload of the departments of the National Health Service.

This study was carried out over roughly the same period of time as the previous study involving the 4 offshore operating companies. There were 5,894 cases studied in the Accident and Emergency study as compared to 2,162 in the offshore study. The pattern of injury described in both cases is remarkably similar and that says much for the accuracy of the working diagnoses provided by the rig medics in association with their onshore medical supporters. 24% of fractures compared to the 30%

working diagnosis of fractures by the medics is very close and the medics have certainly erred on the right side. When fractures, strains and crush injuries are taken together the incidence in both studies is almost identical. This not only helps to validate the first study, but also adds considerable weight to the point made with regard to training, since casualty handlers and first aiders are given courses which contain much less than 50% weighting towards the immobilisation techniques and casualty handling, including stretchers and lifting. Once again, hand injuries were shown to be consistently frequent over the whole 9 years of the study and they were responsible for 37% of the cases admitted. In the offshore study the value produced was 24.3%. This figures justifies the considerable emphasis which is placed in rig medic training courses on hand injuries.

In the offshore study the other area which had a high incidence of injury requiring evacuation was the eye. This is probably the only area where there is a different value shown since only 4% of cases were admitted to the Accident and Emergency study with eye injuries. This is, however, probably due to a local reason in that there is a specific eye out-patient department in Aberdeen to which these patients would probably be referred directly in many instances. Only

2% of all the casualties admitted to the Accident and Emergency study had been unconscious at some time before reaching there. This is a relatively small number, but it is relatively constant over the 9 years of the study and it is important to recognise, particularly in terms of the training which is necessary for offshore escorts.

In terms of occupation it appeared that the roustabouts suffered consistently more injuries than any other occupational group. Linning (1980) on the other hand, noted a 5-fold increase in accidents to drillers over all other occupational groups and this was followed by diving accidents. Diving accidents do not come into the province of either study reported here, since rig medics normally are not responsible for divers and diving accidents do not reach the Accident and Emergency Department in Aberdeen. The general patterns of injury which have emerged overall from these studies are not inconsistent with the reports of others on individual company statistics (Roythorne 1983; Leese 1977) nor is it inconsistent with reports from other areas of the North Sea (Hielem 1976; Hellesøy 1985; Cox 1970b). It should also be pointed out that not only does the pattern of injury appear very similar in both of these studies, but particularly in the Accident and Emergency study it is unchanging over the 9 years of the study.

In terms of related factors, there is a preponderance of contractors' employees over operators' employees. This is probably due to the fact that there are many more contractors on offshore installations and their jobs tend to be more hazardous than those of the operators' employees who are mainly present in a supervisory and administrative capacity. Age distribution was very similar in both studies, and the average age for accident frequency was the same decade in both studies and this is also in keeping with the study carried out by Linning (1980). In both studies, once again, the over 45s were responsible for very few accidents or evacuations and in the Accident and Emergency study there was a continuing decrease in injury after age 30. This must suggest an effect of training and experience on the incidence of injury. The number of injuries which took place each year was unchanged over the whole 9 years of the study and there was little to be noted when monthly or even seasonal distribution was taken into account. There was, however, a higher injury rate in winter and spring and the increase amounted to just under 5%. This could be expected, since the population at risk is largely the group working outside and since there is an increase environmental hazard from both the cold and increasing periods of darkness at that time of the year. The figures, however, do not reach significance, though it might be reasonable to analyse them more carefully in terms of looking only at those people who have outside occupations, and where the accident took place outside, in order to determine whether the work of Wilcock (Ellis, Wilcock and Zaman 1985) and Arendt (Arendt and Broadway, 1986, 1987) is applicable to offshore accidents. This is in terms of the effect which the physical environment may have - cold and light/darkness respectively - on human performance and cognitive function.

There was only a slight increase in the average age over the 9 years of the study. This suggests either a transient workforce which is either continually being replaced by younger workers, or that in spite of the stable and ageing workforce this continues to be the group at risk. There is an indirectly proportional relationship between single and married men with the number of married men increasing towards the end of the period of the study. This may be because there is a significant decline in the 21 year of age group with the passage of time.

The general pattern of disposal of the patients when they reach Aberdeen is rather similar in both studies and gives some indication of the level of severity of the casualties evacuated from offshore. One third of the patients referred to the Accident and Emergency

Department were seen only once, whereas a quarter have return visits. The main group, however, are apparently dealt with on their original visit. Other departments in the hospital have a limited involvement since the referral rate there is only 4% and a quarter of the patients seen in the Department were referred to their own general practitioner after treatment. The pattern is roughly the same in both studies. In the Accident and Emergency study, however, there was a fairly sharp increase in the number of admissions over the years. If the distribution of injury type is quite stable this indicates either an increase in the severity of injury or a change in the admission policy of the department.

The Department of Energy produce offshore accident statistics annually, but they are of a very general nature. These two studies were attempts to arrive at a more general pattern of illness and injury and their management across the industry. They have shown a gratifyingly similar distribution at least as far as injury goes. They have the advantage now of establishing a base line upon which prospective studies can be built more clearly to define the existing pattern of illness and injury and the trends which take place from time to time as changes in personnel and working policies take place, and the improvements to the system of health care provided by the medical, training and safety departments involved. Much emphasis has been placed on the importance of training in the whole philosophy of health care in remote places and the observation that no death from offshore took place in casualties who arrived alive at the Accident and Emergency Department underlines the importance of management prior to admission.

It is a relatively short time since large numbers of industrial workers were first required to function in such a remote and hostile environment as the North Sea, and these studies show that those responsible for health care have, in fact, introduced an effective system which has already been used as a model for other parts of the world such as the Middle East and the polar regions.

## CHAPTER IV

## THE INCIDENCE OF ILLNESS AND INJURY IN BRITISH ANTARCTIC TERRITORIES OVER 25 YEARS (1944-1979)

Health care for British Antarctic Survey personnel was originally provided by recruiting doctors to accompany the various expeditions on a one off basis, providing them with a massive array of medical equipment and consumables and hoping for the best, (Norman and Laws, 1988). In the mid-1970s the British Antarctic Survey made arrangements to receive medical advice from the Institute of Environmental and Offshore Medicine in Aberdeen which was closely involved with the evolution of the system of health care for the offshore oil and gas industry. The main problems in providing health care for the Antarctic community were very similar to the fundamental problems of offshore medicine. There was a clear need for careful personnel selection and the identification of means for overcoming the time and distance which separated the Antarctic community from hospital facilities, together with the identification of the particular occupational and environmental hazards associated with life in the Antarctic. It is not, therefore, surprising that the elements of the occupational health unit which was finally established for the British Antarctic Survey in 1986 bore a very close resemblance to the elements of the occupational health services required for the North Sea oil and gas industry, (Norman and Brebner, 1987).

The population in the Antarctic is, of course, very much smaller than that in the North Sea, but it is separated from its senior medical advisory system by 14,000 km and associated with the most hostile environment on earth. In endeavouring to arrive at the best system of health care for remote communities associated with hostile environmental conditions it thus seems reasonable to compare the problems of this community with the much larger industrial community in the North Sea, (Norman, 1981a). It takes considerable time and effort to initiate a change in the general principles of health care for the North Sea community, and it takes even longer to determine its effect. In the Antarctic community, however, changes can be made much more readily. New ideas can be introduced for a trial period without too much of a problem and the effects of such innovations can be readily assessed. A good example of this lies in the determination of the value of the more sophisticated and newer forms of tele-medicine communication described in a succeeding chapter.

Thus in some cases, the occupational health care of the British Antarctic community has followed that which was established and tried for the North Sea population and in other areas the Antarctic community has led in certain areas which have subsequently proved of importance in the North Sea. An example of this is the recognition of the existence of minor thermal problems in Antarctic divers. Their effect on the subjective sensation of comfort (Light, White, Allen and Norman, 1980) led to an investigation (Keatinge, Hayward and McIvor, 1980) in the North Sea and the demonstration of the effects on cognitive function of minor degrees of hypothermia in saturation divers which ultimately helped to pinpoint many of the problems which had arisen in the 1970s and their solution in the 1980s, (Warner, 1976; Rawlins, 1981; Rawlins and Tauber, 1981).

The establishment of a prospective database of injuries and illnesses occurring on these Antarctic bases is an important step towards the evaluation of the occupational health service in place. While arrangements were being made for this to be done, (Horsley, 1986), it seemed reasonable that a retrospective study should be carried out on those episodes of illness and injury which had occurred in the past 25 years, in order to establish the existing pattern and to compare it with the pattern which emerged in the North Sea studies. The population at risk is very different in that the upper age limit for Antarctic service is 35 years and the vast majority of both scientific and support staff are younger than 25 years.

## METHODS

The information required was obtained from the medical reports submitted to the British Antarctic Survey by the various Medical Officers since its inception. The quality of the medical reports over the years varied greatly, and in some instances the information available was extremely sketchy. It was hoped, however, that a pattern would emerge in view of the vast number of reports which were analysed even although in certain instances their quality was dubious. In all around 100 medical reports were available for analysis and the results of the extraction of the information were once again placed upon computer for analysis and registered in accordance with the Data Protection Act, 1984. In this instance a BBC micro-processor was used.

## RESULTS

The British Antarctic Survey currently operate 5 bases in the Antarctic. During winter they are entirely populated by males, there being no females or families. There is an establishment for a doctor on each of the 4 main bases, Halley, Signy, Rothera, Faraday and and although these posts are all currently occupied they were not occupied completely in the past. The fifth station at Bird Island, off South Georgia, winters only 3 people and medical care is provided by one of the scientists who undergoes paramedic training at Aberdeen.

The locations of the 4 main stations can be seen in Figure 24 and are as follows:-

(a) Signy Island (60°South; 45°West), in the South Orkney islands.

(b) Halley (76°South; 26°West), on the Brunt Ice Shelf in the Weddel Sea.

(c) Rothera (67°South; 68°West), on the West Coast of the Antarctic peninsula.

(d) Faraday (65°South; 64°West), also on the West Coast of the Antarctic peninsula.

In Table 14 can be seen the average winter and summer populations of these bases. Nowadays most of the field work is, in fact, carried out during the summer season in view of the greatly improved systems of transport by the use of skidoos and aeroplanes. The winter population is almost entirely support personnel though there are a few scientists involved largely in making repetitive measurements on the geophysical bases.

In addition to the 5 bases the Survey operates 2 ships, RRS Bransfield (4816 tonnes) which is the main logistics ship and the RRS John Biscoe (1548 tonnes) which carries out an extensive marine biological and geographical programme in addition to its more limited logistic duties. The ships are part of the Survey and the personnel are employees of the British Antarctic Survey. They come under the medical supervision of the BAS Medical Unit and the Medical Officers act as ships' doctors, particularly when the ships are in Antarctic waters. Medical problems arising onboard ship are thus contained in the prospective medical database though they were not often recorded in much detail in the past. There is thus limited information about the problems which arose in the ships in the past.

There can be seen in Table 15 a distribution of accidents and illnesses which took place during the year 1987/1988. As can be seen the problems of the digestive tract, of the skin and trauma account for 65% of problems which arose. The prominence of the digestive tract is due, once again, to the inclusion of the dental problems within it according to the system of the International Classification of Diseases, (1978). The dental problems, in fact, accounted for 13.5% of the gastro-intestinal conditions and other problems of that system for the remaining 10%. The large incidence of skin problems is principally from one base (Rothera) which was undergoing a re-build during that period, had problems with the water supply and consequently with hygiene.

The general distribution of the problems which arose during the 25 years of the Survey's development can be seen in the pie chart set out in Figure 25. General medical problems and trauma account for about a third each, while environmental and psychological problems account for only a small portion. The great prominence of dental troubles can be seen clearly in this figure and indeed when it is added to the smaller surgical area these 2 parts account together for almost the remaining third.

There were 2379 cases of injury or illness reported during the 25 years of the study and of these, 887 (37%) were classified as injury while 1492 (63%) were classified as illness.

The distribution of illnesses is set out in Figure 26 in the form of a bar chart. The great preponderance of gastro-intestinal problems (including teeth) is very similar to the pattern found in the offshore study, and there is an absence of cardio-vascular disease which could be expected in this very young population. Dental disturbances occupy a similar position to the offshore study and it should be noted that the problems of the special senses incorporate the problems of eyes. The respiratory tract produces much fewer problems possibly due to the absence of infection in the Antarctic, while the skin shows an increased incidence over the more industrial North Sea study.

In order to compare these patterns more easily there may be seen in Figure 27, a double bar chart which sets out the pattern of illness in the Antarctic alongside the pattern of illness in the offshore North Sea study and they are set out together for ready comparison.

In Figure 28 may be seen the distribution of injuries over the 25 years in the Antarctic and once again the results are set out in the form of a bar chart. The overall preponderance of musculo-skeletal problems largely including fractures is very similar to both the Accident and Emergency study shown in Chapter 3 and the offshore study shown in Chapter 2 of this thesis.

Foreign bodies in the eye, account for only 8% in this overview picture, though in recent years the incidence has risen due to the inclusion of the figures for the ships. The chipping of rust is an occupation which the personnel are encouraged to take part in during the long voyage South.

Burns occupy a rather more prominent position than they do in the offshore study and this is probably due to the cramped and rather primitive cooking conditions and heating stoves which were used in the past.

For more ready comparison with the other studies there may be seen in Figure 29, a treble bar chart setting out the distribution of injury in the Antarctic study, in the offshore study and in the Accident and Emergency study of injuries sustained offshore. Once again, these are set out in the same terms for ready comparison.

## DISCUSSION

The vast majority of personnel employed by the British Antarctic Survey for service in the South are relatively young. Some of the scientists are recent graduates and most of the support personnel are around the same age which on average is between 20 and 25 years. 35 years is regarded as the upper limit for Antarctic Service. This is possibly why there is an absence of cardio-vascular disease in the figures which emerged from the Survey over the 25 year period of the study. They also partially account for the low level of respiratory disease reported, though this may have some bearing on the character of the micro-biological environment of Antarctic stations, (Hadley, 1980). The relative humidity of an Antarctic base runs around 20%, however, and it is in some ways surprising that this very low humidity is not associated with a higher degree of respiratory disorder, (Norman, 1961).

It is noteworthy that the high level of disease of the digestive tract noted in the offshore industry was almost precisely mirrored by that found in this rather different population in the Antarctic. The reason is not obvious in this case, however, since the dental selection and examination of Antarctic personnel is extremely rigorous. Not only is a certificate of dental fitness required from the applicant's dental practitioner, but a thorough examination and treatment schedule is undertaken by the consultant dentists to the Royal Air Force before embarkation. In addition to this, lectures are given on dental hygiene throughout the year and a dentist is employed who ensures that each man is dentally perfect when he enters his base and also attends to the second year men when the ship calls, (Norman, 1989). Despite this the incidence of dental problems is at least as great as it is in the North Sea offshore industry. This presumably requires further consideration and investigation.

An outstanding feature of the illness figures in the offshore study was the extremely low level of illness associated with environmental pollutants and industrial chemicals together with the very low incidence of burns. Equally, in the Antarctic figures there is an extremely low incidence of hypothermia and serious cold injury. It thus appears, that in both of these situations the vast majority of the problems which arise are those which flesh is heir to rather than specific problems which might be expected more frequently and due to the particular working or environmental situations in which the industries function.

On the industrial side this is probably largely due to the professionalism of the industry and to the care taken by the training and safety departments. In the Antarctic it once again reflects the professionalism of the personnel and the high standard of training and of the equipment with which they are provided. A very much higher incidence of cold injury and hypothermia is found in almost any town in Britain during winter and certainly in those who use the hills for recreation in the United Kingdom and who have not had the same degree of training or equipment provision, (Fox, Woodward, Fry, Collins and McDonald, 1971; Harper, 1981).

When consideration is given to the comparison of the pattern of injuries sustained in the 3 studies which have been undertaken the striking factor is the similarity in the incidence of fractures which amount to around 50% in all cases, and also the involvement of hands and eyes as particular problem areas. This carries an important message in the preparation and training of those who are to function either in the offshore industry or in the Antarctic.

Since this study was conducted the British Antarctic Survey doctors are given a full first aid course before leaving, are taught how to instruct the subject and they are encouarged to carry out casualty handling courses and exercises in the Antarctic. This has greatly improved the confidence of those who work in the field and in recent years there have been outstandingly good examples of complex casualty handling in the field.

As far as the offshore industry is concerned the training courses for rig medics and first aiders have been altered since the first study was undertaken to include considerably more work on fractures and their immediate management, together with the transportation and casualty handling of the injured subject with a fracture. It is now proposed to set up a prospective database for British Antarctic territories and to endeavour to create an international database from the figures of other nations also. This includes France, the United States of America and Australia. When this database is completed it will provide an important form of comparison with the prospective database which has been established for the offshore industry and hopefully it will then be possible to monitor the ongoing efficiency of the health care services for 2 very different population groups both of whom work in remote places with severe environmental hazards.

The importance of training and the equal importance of communications have been repeatedly emphasised in the descriptions given of the system of health care which has emerged for remote communities working in hazardous conditions from these Aberdeen studies. The training which was required to ensure an immediate response in the field and also to ensure that the equipment provided could be used effectively are equally important. An important part of the training has also been to ensure that appropriate information could be passed between a man in the field and the medical co-ordinating centre back home. The importance of this for the offshore industry is accepted, but its greater importance for Antarctic personnel is even more obvious since the immediate care practitioners are separated from consultant advice by half the surface of the globe.

The next two sections therefore deal with the evaluation of the training systems which have been used over the years and also with the development and testing of more recent forms of improved communication devices.

## CHAPTER V

## EVALUATION OF IMMEDIATE CARE TRAINING

In providing an effective system of health care for people working in remote places with hostile environments it has already been stated that the 2 most important priorities are the provision of training courses for the population at risk, and the provision of a precise and effective system of communication.

This section deals with the evaluation of the system of training which was developed at the Centre for Offshore Health in Aberdeen to fulfil that need for the main occupational population with which the Centre was associated, namely the offshore industry in the North Sea. A subsequent section will deal with the development of communication systems, mainly for the other occupational population with which the Centre was associated, the British Antarctic Survey.

In the early 1970s there was no requirement for training of personnel in health care matters in the North Sea or elsewhere. This was only slightly modified in 1976 with the "Offshore Installations (Operational Safety Health and Welfare) Regulations" known as Statutory Instrument 1019, (HMSO, 1976). This instrument stated that on every offshore installation which is normally manned there should be at least one medically trained person and whenever there were 40 or more persons thereon at least 2 of them should be medically trained persons. The problem was that the regulations defined medically trained persons as either State Registered or Enrolled Nurses or the holder of a Certificate of Competency to Practise First Aid, including the use of a mechanical resuscitator. The regulations were in effect setting the minimum qualifications and they were very widely interpreted when the companies appointed their rig medics. The vast majority of companies, particularly the major operating companies, employed State Registered Nurses as their medics, but some companies still employ only first aiders.

In 1981, the Health and Safety Executive introduced first aid regulations which were specifically geared to onshore work. Many of the companies, however, adopted these standards and introduced first aid training for their offshore personnel. This improved the situation greatly and in the main operating companies there was a policy developed of almost universal training in first aid for offshore personnel. It was stated that the length of the course should be around 4 days and they provided an indication of what the syllabus should contain, (Cox, 1987c). It also indicated that refresher training should take place for not less than one day every 3 years.

In 1982 the Health and Safety Executive produced guidance notes for offshore installations (Cox, 1987c). These regulations as of August 1989 have still to be introduced, but during this time the Centre for Offshore Health has refined its own courses in consultation with the industry and they go beyond the requirements currently suggested by the Health and Safety Executive for onshore work and anticipate the regulations for offshore industry. This was done by holding regular discussions with the training departments of the companies which sent students for training. The training departments of the companies carefully debriefed all students attending the Centre's courses and were, therefore, in a position to provide precise feedback. Meetings were held twice a year with each of the companies. Each time major changes were made in the courses, the views of the company doctors were also taken into account. The majority of these doctors were in regular contact with the Centre and took considerable interest in the development of the courses. It was because companies had developed apparently effective means of evaluating the courses that it was decided that the study of the course evaluation should be undertaken by the personnel conducting the course also. The first is a 4 day course for individuals with no previous formal first aid training. The second is a 3 day course for individuals who have undergone the combined survival/firefighting course at the Survival Centre at Robert Gordon's Institute of Technology, which includes instruction in resuscitation and the control of bleeding. Alongside these courses a 2 day refresher course is held for individuals who are currently in possession of a valid first aid certificate. It was felt by the Centre that the one day refresher course was too short.

On the basis that 50% of the course should be practical a one day refresher course would only allow 3 hours of practical activity. This was considered quite insufficient time to refresh practical skills which deteriorate rapidly and take time to refresh fully. The course book has proved a popular and effective aid to offshore health teaching. It can give continuing theoretical instruction, but it is no substitute for supervised practise.

The philosophy adopted in these courses, which are similar to those now provided for British Antarctic Survey personnel, is that no lecture should exceed 45 minutes and the lecture should be illustrated by a means of slides or overhead transparenceies. Each main subject is usually covered in 3 separate ways. Firstly, by the lecture, accompanied by slides, secondly by means of showing a video dealing with the subject and thirdly a practical demonstration associated with the main activity. The practical aspect of each main subject accounts for about 50% of the total time spent on that subject: a lecture and a video account for the other 50%. Each course is controlled by 2 qualified nurse teachers with many years experience in first aid training. The ratio for practical group teaching is 10 trainees to 1 instructor. Weighting is given to areas that have been indicated by the Accident and Emergency and Offshore studies as being of major importance, eg fractures.

It was also found that there was no text book geared precisely to the population at risk and the 'Offshore Health Handbook' was thus written to cover this requirement (Norman and Brebner 1987). In addition, a series of specific handouts for each subject was also compiled and appropriate slides constructed. As these courses were developing it seemed necessary to evaluate them as critically as possible. The results of this evaluation, which extend over a complete year, are now reported.

## METHODS

The first stage of this study was the construction of the self-administered questionnaire which may be seen in Figure 30. The normally poor response rate for questionnaires was overcome by collecting them at the end of the examination. The questionnaire contained 15 questions. Questions 1 and 2 were aimed at picking up attitude change to the subject be it positive or negative. Questions 3, 4 and 5 were aimed at establishing fairly precisely how long, in the students opinion, the course should be. Question 6 aimed to establish the students' feelings about the balance between theoretical instruction and supervised practice. Questions 7 - 10 aimed to establish the perceived value of visual aids and to rank their importance. Question 11 is an open opportunity for subjective assessment of the instructor's ability to teach. Questions 12 - 15 are aimed at establishing if the course syllabus including examination had increased the student's confidence and perceived ability to cope with an incident. It was self-explanatory and required the respondent to circle the appropriate answer. In practice, it took between one and 2 minutes to complete. Various problems were met initially, but these were ironed out within a month and thereafter the questionnaire was administered for all students during a

12 month period, giving a total of 979 completed questionnaires. The return rate was 100%.

The design of the questionnaire took into account computerisation, data protection and ethical clearance. All the information was entered on to a mainframe computer, (Honeywell 66) and the data was analysed using SPSSX statistical package for social sciences.

The first part of the examination considered whether the student passed or failed. According to the Health and Safety Executive Guidelines the candidate has to demonstrate an ability to carry out resuscitation effectively, to be capable of dealing with an unconscious casualty, including a demonstration of the recovery position, and to demonstrate that they can stop external bleeding. To achieve this standard after 3 days training is relatively simple and, thus, only 2 students failed the examination during the study. After pass/fail has been established, the examiner then proceeds to establish a grade by more detailed questionning of other areas. The grades used were 'Excellent', 'Very Good', 'Good', 'Average' and 'Poor'. The same group of examiners was used throughout the year (approximately 10 in total) and they were a mixture of lay instructors, nurses and doctors all of whom had completed the course themselves. In order that they could decide on a grade the examiner was allowed to ask about any practical or theoretical aspect of the course but there was no written component. They were instructed on the type of questions to ask and on the grades which they should provide, and they used the same technique for each student. Some examiners marked consistently higher than others, however. The evaluation form shown in Figure 30 is, in fact, mark 4. A series of problems were encountered during its development, which included the following:-

a) The initial questionnaire was more than one page long and led to a situation of partially completed questionnaires.

b) The phraseology of some of the questions was changed due to written comments stating that the question could not be understood or was ambiguous.

c) Originally the student was asked to tick the appropriate answer. It was found that some ticks were between answers or so large that they covered more than one answer. It was, therefore, decided to ask the student to circle the answer.

## RESULTS

The total number of students attending first aid courses during the period of the study was 979. Of these, 478 (48.9%) attended the 3 day course, 273 (27.9%) attended the 4 day course and 228 (23.2%) attended the 2 day refresher course. The 3 day course was thus the most popular course and it accounted for nearly 50% of all students.

The vast majority of trainees attending the courses were males, the females accounting only for 10.3%. The contractors were also responsible for sending over 70% of the students on these courses, while the operators were responsible for 29.3%.

The results of the examinations can be seen in Figure 31 when the grades for all 3 courses are added together. This is a normal distribution for a course which has been well assimilated, and it was gratifying to note that the largest section fell into the classifications of 'Very Good' and 'Good'.

533 (54.7%) students had no previous experience of first aid while 444 (45.3%) had some previous experience. When the exam results were considered in the light of previous experience the grades obtained are set out in

Figure 32. The distribution of results in terms of previous experience showed a rather similar pattern in both instances, but those with previous experience produced greater numbers of the category 'Excellent' and 'Very Good', while below that level there were more people with no experience who produced 'Good' or 'Average' grades. This tends to suggest that previous experience is likely to produce a better grade in the examination, but the difference is not considerable.

When class size is taken into account the distribution of exam grades can be seen in Figure 33. As might be expected the smaller classes have produced larger numbers of higher grades. In a class of less than 15, 53% of the students obtained an 'Excellent' or 'Very Good' classification in the examination, while in a class of between 15 and 30 only 45% of the students obtained 'Excellent' or 'Very Good' grades. When consideration is given to the lower grades of 'Good' to 'Average' there were 50% who achieved that classification in classes between 15 and 30 while 46% achieved that grade in classes of less than 15 persons. It can thus be seen that a smaller class appears to produce a higher number of 'Good' classifications than a larger class. The class size does not seem to make much difference to those who are going to achieve lower classifications. Chi-squared analysis of the findings, however, revealed that there was no significant difference in exam grades related to class size, ($P > 0.1$).

The distribution of exam results produced a similar pattern in the 4 day, 3 day and the 2 day refresher courses, as can be seen in Figure 34.

When the views of the students were canvassed on whether they thought that a first aid course was necessary 87 (9%) thought that it was not necessary before the course, while 892 (91%) thought that it was. After the course, only 6 students still felt that it was not necessary and the balance (973) felt that the course was necessary. Of the 892 students who felt that the course was necessary initially none changed their minds after the course. From general discussion it was felt that those students who initially thought the course was unnecessary were those who had been sent against their will by their employer. There were, in fact, no dropouts during the study period. This is perhaps because it was made compulsory by the companies.

In determining the students assessment of the course, in terms of their view of the teaching standard and their general level of satisfaction, views were divided into those which came from classes of less than 15 and those which came from classes of 15 to 30 people. The results can be seen in Tables 16 and 17.

The opinion from 20% of the students was that the teaching standard was excellent and that it was good in the remaining 80%. In no instance was it felt to be either average or poor. The opinion appeared very similar in both class sizes.

In a 4-point classification of the general level of satisfaction with the course, there was once again no difference in the answers given in the smaller or larger classes. All the answers fell within the top 2 classifications of 'Completely Satisfied' or 'Happy', there being 40.4% in the 'Completely Satisfied' category and 59.6% in the 'Happy' category. There was no incidence of an 'Unhappy' or 'Completely Dissatisfied' student.

In considering the students' opinion of the visual aids used, the answers received are set out in Figure 35, where it can be seen that in the 'Very Useful' classification the descending order of opinion for usefulness is the course book, slides, handouts and videos. It is fairly obvious that in the lower classification of 'Useful' that the reverse trend will be shown while only an insignificant number placed the 4 visual aids into the 'Not Useful' category. When opinion was canvassed on the ratio of theory to practice it was gratifying to note that in all 3 courses studied the vast majority felt that the balance of theory to practice was correct. The results can be seen in Figure 36.

The students' opinion on the length of the course can be seen in Figure 37, but it can be seen that 62% of the students thought that the 3 day course was the correct length, while only 3% thought it was too long and 35% thought it was too short. On the 4 day course 67% thought that the course was the correct length, while only 3% thought that it was too long and 30% thought that it was too short. The 2 day refresher course showed a similar trend with 56% stating that the course was the correct length. No student thought this course was too long, but 44% thought that it was too short.

## DISCUSSION

The self-administered questionnaire approach was used for evaluation because it was convenient and inexpensive. This was important due to financial constraints. It was thought to be better than the employment of trained observers. This would both have been too expensive and subject to observer biase. The main drawback of the questionnaire approach is the well recognised poor response rate. During the study period the questionnaire was introduced and explained to the student at the beginning of the course. Questions were answered and the student was allowed to retain the form. The completed forms were collected at the time of examination which guaranteed a 100% response. The completed form was anonymous and simply placed face down in a wire basket in front the examiner. The student was given the exam result immediately which meant that the examiner could not be influenced by reading the questionnaire. Student opinions on teaching quality are, of course, subjective, but it would seem reasonable to assume that they would be more likely to retain information if they felt the standard of teaching and presentation were good.

Although only 2 out of the 979 attendees at the course failed, and the reasons for this have been stated already, the spectrum of results was not unlike any other evaluation of a population, with the largest number coming into the 'Very Good' and 'Good' classifications. The 3 day course contained the largest numbers and it was attended largely by males indicating the population group for whom the course was aimed. It was noted that 10% of students felt that the course was probably not necessary before they completed it and only a very small number felt that it was still not necessary at the end of the course. It was also noted that over 70% of the students found the course book the most useful aid to learning and the videos the least useful. This is possibly because the book was specifically written for the offshore industry while the videos were drawn from a wide range of background courses. When the teaching standard was evaluated 100% of the answers were that it was either excellent or very good. No-one was unhappy or dissatisfied with the course.

It has been shown that previous experience made little difference to the grades that were obtained at the examination. This could be taken to suggest that the students were all starting from the same point and that there was little influence from previous experience of the subject. The question of the decay of skills is one which is of great importance in this area at the present time, and there have been studies carried out, (McKenna and Glendon, 1984) which have endeavoured to determine the optimum time and frequency for refresher training in first aid if an adequate immediate response is to be expected when an emergency takes place. The size of the class does not seem to make much difference to those who are to achieve an average type of classification, but there seems little doubt that smaller classes produce more candidates who achieve an 'Excellent' or 'Very Good' result.

The 2 day refresher course seemed to produce the same results. 56% of the students felt that it was the correct length. By far the largest number felt that the theory/practice ratio was correct and only a very small number thought there was either too much theory or too much practice.

It appears that a class of around 15 is a reasonable size on the basis of the present study. The length of the course is probably about correct and that seemed to be the opinion of the vast majority of students. An insignificant number felt that it was too long, but a not inconsiderable number felt that it was one day short. Incipient legislation will probably put this right. A very important opinion which came from this survey was that the balance of theory to practical work on the course was about correct. This is an extremely important result for a very practical subject which has tended to be taught in the past with a vastly overloaded theoretical compared to practical component. It thus seems clear from the results of this survey that the course which has been evaluated and elaborated over the years is relevant to the industry for whom it is intended. It appears to have the correct balance, to be about the correct length and to contain appropriate elements of teaching expertise, class size and associated aids. It is gratifying that a course which appears to fulfil the requirements of the industry has been produced in advance of legislation.

# CHAPTER VI

## COMMUNICATION SYSTEMS FOR REMOTE HEALTH CARE

In order to provide effective health care for workforces operating in remote places the importance of clear and precise communications has been emphasised repeatedly, (Morrison, 1976; Roberts, House and McNamarra, 1977; Norman and Brebner, 1987; Norman and Laws, 1988). In recent years communication technology has made enormous progress and with the advent of tropospheric scatter, and the widespread use of telex, clear discussions can be undertaken and the decisions for management of accidents confirmed with precision by an exchange of telexes. The more recent advent and general availability of satellite communications has extended this facility on a world wide basis, (Schwarz and Johnson, 1977).

In any well organised system of health care for remote and offshore communities it must be accepted that the individual in charge of the remote site patients is likely to be a junior member of the team who, although well trained for his job, is unlikely to have the wide range of specialist knowledge required to cater for all needs. It is thus essential that he should be in a position to provide clear communications so that the whole range of specialist advice can be made available at the remote worksite. This concept has been practised for some time in the offshore industry in the North Sea and also in the occupational health service of the British Antarctic Survey, (Norman, 1983; Norman and Laws, 1988).

The concept was probably pioneered, however, in the care of the remote communities of Labrador and Newfoundland by specialist service provision from Memorial University Life Sciences Faculty in St John's, Newfoundland. Daily discussions are held by the specialists in St John's with the nurses who are in charge of these communities, (Charbonneau, 1982). The advent of slow-scan television (SSTV) has made it possible to extend this provision by the transmission of clinical pictures on the one hand and X-rays on the other, (Roberts, House and Canning, 1981; Webber, Wilk, Pirruccello and Aiken, 1973; Andrus, Dreyfuss, Jaffer and Bird, 1975).

SSTV works by allocating a different auditory tone to each of 256 shades of grey. The auditory tones are passed down a standard telephone wire and the picture is reformed at the other end. Pure black and white signals such as come from ECG and EEG tracings can thus be transmitted with no loss of quality whatsoever. There is, however, a certain loss of quality in the clinical pictures which have to be in black and white and also in the X-rays which are transmitted, (Roberts, House and Canning, 1981; Bennett, Rappaport and Skinner, 1978; Harrington, Cerva, Greene and Kerlin, 1982).

In full motion television a frame of video composed of many picture elements is repeated 30 times per second. The camera takes 60 images per second and they are transmitted as 30 complete video frames. In an SSTV system the TV camera generates the same number of complete video frames but the SSTV unit grabs only one of these and freezes it. This still video image is then broken down into its individual picture elements and transmitted to one or more receiving sites where the picture is recreated in its entirety.

The time taken to transmit a picture is dependent on the resolution level of the video image and upon the mode of transmission. The standard video for diagnostic purposes has 512 x 240 visible picture elements with 256 shades of grey. It will take 76 seconds to transmit a picture over a standard voice grade telephone line (Meyer and Brown, 1975).

A basic medical SSTV system at the transmitting site consists of a standard television camera and TV monitor, a telephone and a SSTV unit. The receiving site needs only a telephone, a TV monitor and an SSTV unit, (Figure

38). SSTV equipment may be used with a lightbulb for transmitting X-rays and for permanent record keeping SSTV can be connected to a digital disc storage system, audio or video tape recorder or a video disc. To facilitate uninterrupted oral and visual communications, 2 telephone circuits should be used, the one for voice communications and the other for picture transmission/reception.

The earliest documented experiment transmitting X-rays by SSTV took place between 1973 and 1975 from Broken Hill, Nebrasca to the University of Nebrasca in Omaha, (University of Nebrasca, Medical Centre, 1975). An average accuracy rate of 91.4% was recorded with a range of 83.3% to 96.6%. In 1977 the first major SSTV tele-medicine/tele-health programme was established linking Toronto and scattered village communities in the Sioux Look-out Zone (Dunn, Conrath, Acton and Higgins, 1980). This is a 295,000 km region of Northern Canada inhabited only by 10,000 individuals in 27 communities. Conventional black and white television, colour television, a simple telephone service and the new technology of SSTV were all tested in this project. The research team concluded that slow-scan video was as good as broad band television for almost all types of diagnosis and that its nominal costs made it the most satisfactory technology. It was also concluded that black and white slow-scan video was initially preferable to colour since colour adjustments were costly and could lead to faulty diagnosis if not adjusted properly for colour, (Rappaport, Skinner, Friend, Gayler and Gitlin, 1979).

Dunn, Conrath, Bloor and Tranquada, (1977), described their experience with slow-scan television and they stated that picture transmission via slow-scan video is a process which is easy to learn. If a nurse needed to send pictures she would first call to discuss the problem and receive permission to transmit. She then focussed a standard TV camera on the desired object, froze a picture, pressed a button and 78 seconds later the full picture was seen at headquarters. The picture was then discussed by the health care professionals at each site. X-rays accounted for nearly 40-50% of the total slow-scan transmissions. The authors felt that the quality of the transmission was as good as the original X-rays. An additional advantage pointed out by them was that details could be enlarged or enhanced for transmission. These blow-ups often provided a clearer view of the problem area than normal viewing allows. When the whole scheme was evaluated by those who used it it was felt to be much more useful by the nurses than by the doctors involved, and the nurses were particularly enthusiastic in welcoming the addition of a visual image support system connected to a major medical facility, (Charbonneau, 1982).

In 1983 House, Memorial University, St John's, set up a trial of tele-medicine using the Mobil semi-submersible rig, Sedco 706, in order to determine whether the system was of value in supporting the health care requirements of the offshore industry, (House, 1985). During the trial the project had access to satellite telephone channels. The system was connected to the sickbay of the offshore installation and the 2 lines allowed tele-conferencing to take place at the same time as the transmission of the slow-scan images and the EEG and the ECG printouts. It was thus possible for the physician to discuss the patient with the offshore medic and at the same time to be shown clinical pictures, X-ray images and EEG and ECG tracings as required. Certain changes had to take place to accommodate for rig movements and wave heights up to 30 feet. In high seas although there was some interruption of signal, limited voice communication was always possible. It seemed clear following this experiment that SSTV provided a useful adjunct to the practice of offshore medicine, with particular regard to clinical pictures and to black and white EEG and ECG tracings, but there was some doubt as to whether the quality of the X-rays was sufficiently good to be really diagnostic.

If the SSTV system is to prove useful, however, not only for the offshore industry but also for such very remote places as the Antarctic the diagnostic quality of the X-rays transmitted is a key factor in determining the value of the whole system in remote medical care. It has to be remembered that most people could recognise a major fracture of a long bone, but the interpretation of skull radiology and more particularly chest radiology or of an IVP are not always easy for the young doctor or the nurse. It was this point that seemed worthwhile to address at this time. An experiment was thus set up with the collaboration of Memorial University of St John's, Newfoundland and with equipment loaned by Colorado Video to determine the diagnostic quality of the X-rays which could be transmitted by SSTV.

The experiment itself was a joint effort between the Centre for Offshore Health, RGIT and Memorial University in St John's. It was set up to transmit X-ray images across the Atlantic from St John's to Aberdeen and from Aberdeen to St John's using Dr Max House in St John's to interpret the films received there, and Professor L A Gillanders, the Professor of Radiology at the University of Aberdeen to provide radiological interpretation of the X-rays transmitted from St John's to Aberdeen.

## METHODS

Ten X-rays were transmitted from Aberdeen to St John's, Newfoundland and then from St John's to Aberdeen to allow an assessment to be made by the radiologists of:

(a) the loss of quality consequent upon transmission of the images and

(b) the diagnostic usefulness of the images as compared to the original.

A single telephone point only was available and discussion could only take place in between the transmission of the X-rays. The following X-rays were chosen:-

| | |
|---|---|
| Film 1 | Pneumothorax |
| Film 2 | Obstructed right kidney |
| Film 3 | Depressed fracture of occiput |
| Film 4 | Fracture - lower lateral wall of maxillary antrum |
| Film 5 | Intestinal obstruction |
| Film 6 | Pleural effusion |
| Film 7 | Normal chest X-ray |
| Film 8 | Fractured cervical spine |
| Film 9 | Hairline fracture of parietal bone of skull |
| Film 10 | Mitral valve disease |

These X-rays were chosen by consultant radiologist A, to represent a cross-section of the problems encountered in radiology. A grading system was established under the following headings:-

(i) Technical quality of the X-rays

(ii) Confidence of the findings

(iii) Confidence of diagnosis

In order to allow more ready assessment of the results 5 grades were used (a to e) and they were each invested with an arbitary value at 15% intervals thus:

(a) Was considered to be 100%

(b) Was considered to be 85%

(c) Was considered to be 70%

(d) Was considered to be 55%

(e) Was considered to be 40%

Anything below (e) was rated as zero per cent as this would indicate that it was totally unsatisfactory. In practice before the ratings were established the radiologist first assessed the full size X-ray images and then usually asked for a close-up of a particular part of the film. This became an established technique in the experiment.

The films were graded by consultant A and then transmitted to Newfoundland by slow scan TV where they were assessed by consultant radiologist B. The films were then sent to Canada by post and transmitted to Aberdeen by slow scan TV where they were read by consultant radiologist C. They were finally returned by post to Aberdeen.

A second experiment was next carried out using the same equipment but on this occasion the transmission was from Halley in the Antarctic to Aberdeen. The equipment was mounted in the radio room of the RRS Bransfield and the transmissions took place during November and January 1986-87 both while the ship was at sea and also when it was moored at Halley (75°S; 60°S). Several technical problems were experienced during this experiment and, in particular, interfacing of the telephone unit with the INMARSAT satellite system had to be achieved and consideration had to be given to the position of the ship with regard to the satellite. On one occasion when the satellite was astern, the funnel of the ship interferred with the transmission. When these problems had been overcome and reasonable lighting arrangements set up in the radio room of the ship the transmissions took place without further problems.

On this occasion consultant radiologist A chose 4 X-rays and consultant radiologist, D, assessed them in Aberdeen.

A third experiment was carried out in Scotland when a new generation of Digital equipment came on the market (Photophone System) which meant that there would be virtually no loss in quality resulting from the transmission of the image, and conversation could proceed at the same time as picture transmission.

The reasons for this experiment were to confirm the quality of the X-ray transmissions with the Digital equipment and also to determine whether the system could be of value in remote parts of Scotland. One piece of equipment was set up in the X-ray Department of the Balfour Hospital in Kirkwall, Orkney, and this was provided with a direct communication link by telephone with the Department of Diagnostic Radiology at Aberdeen Royal Infirmary. Several sessions were held and 15 radiographs were transmitted by the Radiographer to the Radiologist in Aberdeen, once again, after a learning period. The X-rays transmitted included:-

1. A wrist joint showing a fracture of the scaphoid bone.
2. A normal chest X-ray.
3. A knee joint with a possible fracture of the patella.

4. A serial examination of the renal tract using intravenous pyelography.

5. A cervical spine showing a fracture of the odontoid process of C2.

6. A child's chest X-ray.

7. A chest X-ray showing a cavitating lung neoplasum.

8. A barium examination showing a malignant lesion.

There was a learning curve needed in all of these experiments, but aside from minor initial problems created by unfamiliarity on the part of the operator with the apparatus there were no real technical problems met.

RESULTS

There can be seen in Figure 39 the ten X-rays transmitted across the Atlantic in the first experiment between Aberdeen and St John's, Newfoundland. They were chosen by Consultant Radiologist A to provide a representative array governing the problems of radiology. They were assessed for technical quality, confidence in findings and confidence in diagnosis according to the scale described above and the results of these evaluations are set out in Table 18. The films selected were of high technical quality and the results of the radiologist's evaluation achieved 95% or more in all 3 areas of classification.

When the images were transmitted by slow-scan television from St John's to Aberdeen the assessments made by Consultant Radiologist B are set out in Table 19, where the assessments have been given numerical values in the a to e classification. Corrections to these values were added on the basis of the original quality assessment made by Radiologist A and the final value is set out in the second column of the table. It can be seen that all the values lay between 80% and 90%. The technical quality achieved the lowest value at 83.2%, but the confidence in findings and in diagnosis both received values greater than 89%.

The films were next sent to St John's by post and transmitted back to Aberdeen by slow-scan television where they were evaluated by Consultant Radiologist C using the same classification. The results may be seen in Table 20. The evaluations of Consultant Radiologist C shown on the left side of the figure were, once again, adjusted by the factors laid down by Consultant Radiologist A on the original films. Consultant Radiologist C marked the results rather lower than Consultant Radiologist B. In particular, technical quality was graded at 76% rather than 83% in this series of transmissions, though, once again, the confidence in findings and in diagnosis achieved high scores being greater in both cases than 87%.

The 4 X-rays taken to the Antarctic on RRS Bransfield were Numbers 1, 2, 3 and 4 on Figure 39. Four transmissions were made from the Antarctic, 3 being made from Halley on separate occasions, and 1 from Rothera on the West side of the Antarctic peninsula. The assessments were made by Consultant Radiologist D in Aberdeen and the values obtained from him may be seen in Table 21. The corrected values are also shown in the Table using the weighting factors prescribed by Consultant Radiologist A. The values obtained from the Antarctic are very similar to those achieved by the transmissions from Newfoundland to Aberdeen. The technical quality result is almost identical and the confidence in findings and in diagnosis remains high being only 1% lower than the transatlantic values.

DISCUSSION

The word telognosis was used as far back as 1950 to describe a 2 year experiment transmitting røentenographic facsimiles via commercial telephone lines between hospitals in Winchester and Philadelphia, USA, (Gershon-Cohen and Cooley, 1950). Many studies have been carried out subsequently with apparently successful results but the technique has only been taken seriously relatively recently. It comes into its own, however, in the consideration of the medicine of the remote communities. The studies carried out in the USA as described above, however, were really subjective assessments of the usefulness of this system and would not appear to have been carried out in a scientifically rigorous fashion.

When the initial capital outlay has been made the running costs of the system are easily calculated on the basis of the current rate for telephone calls. Experience has shown that the average time for the telephone call from the start of the conversation to the diagnosis is likely to be between 10 and 15 minutes.

Some facts have emerged from the experiment which are worth considering. In the first instance there is a requirement for a certain amount of expertise at the

sending end, but at the receiving end the ultimate expertise is that of the radiologist. Even the best radiologist requires familiarisation and he will only be able to extract the information from the original radiograph if he is in clear communication with the camera operator at the sending end and has some experience based on trial transmission in the past.
In order to obtain a good X-ray, the positioning of the patient on the radiograph and the exposure used are vital to the production of a high quality original radiograph. In the past the medical officers of the British Antarctic Survey have been trained to take straight forward X-rays with the apparatus with which they are provided, (Horsley, 1985), and it has been shown that a high standard of basic radiography can be obtained in a relatively short period of time from such personnel, (Norman and Laws, 1988). It has also been shown that it is possible to train a layman to operate the system and demonstrate the X-ray films in the appropriate manner in a similar short period of time but periodic practice is necessary to maintain expertise.

An appropriate series of radiographs may be required for the full demonstration of the pathology. The eventual diagnosis also may only become possible from the late film of a series, eg in the intravenous pyelogram. In further relation to transmission, the expertise of the operator is just as important as that of the radiologist. Accurate focussing of the camera on the illuminated radiograph and appropriate adjustment of brightness level are essential. It is likely that an intense bright light may be required to illuminate specific dark areas of the radiograph. Precise localisation of a particular area and a degree of close-up (zoom) are essential to get the utmost out of the system.

The confidence of the diagnosis would always be dependent on the experience of the radiologist. He can make allowances if experienced for images less than of ideal quality, and with inadequate anatomical/physiological demonstrations. It may not be possible to demonstrate the pathology completely, yet arrive at a diagnosis which is quite sufficient from the practical point of view.

By the transatlantic experiment it has been demonstrated that provided certain criteria are met in the quality of the original radiograph and in the training of the personnel to be used in transmitting the image that a useful aid to radiological diagnosis from a remote site can be provided at a relatively low cost. It would, however, be wrong to give the impression that this system is without drawbacks. A summarised critical review of the analogue system used is necessary. The following problem areas are worthy of consideration:-

a) The whole system is dependent on the quality of the original X-ray, and since these are seldom taken by qualified radiographers this is undoubtedly the first and major stumbling block.

b) The analogue system works by means of converting the signal to an auditory tone. The receiving system, therefore, is prone to minor confusion in interpretation of these auditory tones with a resultant drop in quality.

c) The resolution of this system is limited to 512 by 240 visible picture elements.

d) This system is limited to the use of 256 shades of grey.

e) The system is also totally dependent on the technical expertise of the individual who is arranging for the transmission of these films; such aspects as accurate focussing of the camera on the illuminated radiograph and appropriate adjustment of brightness level are critical.

f) Observer variation between consultant radiologists was indeed demonstrated during this trial. This is to be expected, since there is no reason why this system should have the capability to eliminate observer variation, although there is no reason to suggest that observer variation should either be increased or decreased by the use of such a system.

An additional study looking at observer variation on slow scan images may well be a valuable piece of work which could be undertaken in the future.

The extent of the slow scan trial was limited by means of resources and finance. However, it was possible for the trial to be scientifically rigorous enough to highlight the above critical aspects.

Radiologist A reached his findings on technical quality, confidence in findings and confidence in diagnosis from the original X-ray film. These were graded as 95% for technical quality, 98.8% for confidence in findings and 96.3% for confidence in diagnosis. Consultants B and C reached their findings from a slow scan image and their results are shown in Tables 19 and 20. Since they were working from an image derived from an X-ray film which had been regarded as less than perfect by Radiologist A it was felt appropriate to show not only their absolute gradings, but also a corrected grading. This was Radiologist B and C's grading shown as a percentage of Radiologist A's findings.

As can be seen in Tables 19 and 20 there was a variation in findings between consultants B and C. Assessment of technical quality varied between 76.3% and 83.2%, confidence in findings from 87.7% to 89.9% and confidence in diagnosis from 87.7% to 89.6%. Indeed, this is undoubtedly as a result of observer variation.

As has been demonstrated by Radiologists B and C, there is indeed a loss in technical quality which has taken place during the transmission of the slow scan image. This loss in quality would, of course, become more important with the finer aspects of diagnosis. In order to attempt to overcome this problem the radiologists invariably used the transmission of an enlarged section of the slow scan image. They stated that they found this to be very useful in the further investigation of a suspicious area of the film. It must be accepted, however, because of the previously mentioned limitations of the system that they will undoubtedly reach a point when a finer aspect of diagnosis may be missed as a result of reduced transmission quality. It is not intended, however, to give the impression that the slow scan image transmission by an analogue system is a perfect solution to radiological diagnosis at this time, but merely a useful aid on certain occasions to general diagnosis.

The second part of the experiment was to mount one of the cameras on the RRS Bransfield. This was to determine, by the same criteria, what could be obtained over a wide geographical area from the Antarctic to

Aberdeen using medical officers and medics as radiographers or the same personnel or even laymen as transmission technicians. In fact it was shown that the images received from the Antarctic were slightly better than those obtained from the trans-Atlantic series. At that point Digital equipment became available and when it was tested it was found possible to transmit X-ray images with no loss of quality whatsoever. There seems little doubt that X-ray images can now be transferred from one location to another without loss of quality, but the full value of the system can only be obtained with proper training of the personnel at the remote site, not only in taking the X-rays, but in demonstrating them to the radiologist at the other end.

It is now possible to provide the specialists advising the remote site with not only detailed clinical information, but also with X-ray tracings, ECG tracings, high quality X-rays and clinical pictures, and by this means it should ultimately be possible to provide clinical advice and management in a remote place which is almost as good as that which can be obtained in a major hospital provided the initial training of the remote medical team is of a high standard and it is equipped with appropriate materials to carry out the instructions of the consultants at a distance, (Harrison and McIntosh, 1984; Michaels, 1989).

Most remote worksites are, however, associated with one environmental hazard or another, and in the course of this study it seemed appropriate to investigate one such area in some detail. It was noted that there was a high incidence of heat illness in one of the worksites in the Arabian Gulf, where the author conducted training courses during the prosecution of this study, and that these heat illnesses seemed rather different from those described in the literature or indeed those seen in the interior of the Arabian continent. A study was thus made of the conditions occurring during a period of 2 months in the height of the Arabian summer.

# CHAPTER VII

## AN INVESTIGATION INTO HEAT ILLNESS IN THE ARABIAN GULF

For several years the author was part of a 2 man team which spent several weeks each year providing training in immediate care and casualty handling techniques on Das Island in the Arabian Gulf.

Das is an island which lies about 200 miles East of Abu Dhabi in the Arabian Gulf. It is a flat piece of land which is about one mile square, and it is the scene of intense industrial activity, employing a workforce of around 4,000 personnel. It provides a gathering system for the oil produced by the Abu Dhabi offshore installations and also the gas. The oil is stored in vast reservoirs and shipped out by tanker, while the gas is processed into its various components before it is exported. The plant is now around 20 years old and requires considerable maintenance. There is thus a requirement for much outdoor activity, even during the very hot months of the year.

It was noted that there was a considerable incidence of collapse from heat illness admitted to the small hospital which provides for the needs of the industrial population. This is in marked constrast to the incidence of heat illness which was noted in the desert stations of the interior, where the population is equally high and the work equally hazardous. Temperature may indeed be higher in the desert, but the humidity is much lower. In the desert stations heat illness occurs rarely and normally only in association with some other accident occurrence, such as a car accident, with the casualties unable to move until rescued.

It thus seemed reasonable to determine the frequency with which heat illness occurs on Das and to investigate both its nature and the factors associated with its occurrence. If this could be done it seemed possible that recommendations might be made which would reduce the incidence of this aspect of morbidity in the workforce.

Classically, there are 3 main types of heat illness described, namely heat cramps, heat exhaustion and heat stroke. To have an understanding of these conditions and their environmental associations it is necessary to consider the physical factors related to heat exchange in the body. Heat is being produced constantly by the metabolic processes and in order to maintain optimal function it is necessary to keep the body temperature within $1/2^{o}C$ of $37^{o}C$, (Clark and Edholm, 1985b). This narrow tolerance is mainly required for the higher intellectual functions of judgement, competence and other aspects of mental efficiency and normally it can be achieved by the body's regulatory mechanisms though the physical cost may be considerable. If it cannot be achieved because environmental stress has become too great, the first thing that happens is a loss of mental efficiency, during which accidents could occur. After that, the physical heat illnesses begin to appear, (Lee, 1935).

The body has 2 main mechanisms to help it adjust to heat, namely a variable insulation on the surface and the sweating mechanism. The surface insulation is the fine adjustment: it allows the skin surface to be flooded with blood which radiates heat to the environment if it is too hot, and pulls the blood back to the body core if it is too cold. The sweating mechanism is a powerful mechanism. The sweat is secreted on the surface of the skin and when it is evaporated into the surrounding air the latent heat of evaporisation is drawn from the surface of the body. Thus, for every gram of sweat evaporated 0.58 Kcal of heat are drawn form the surface of the body, (Clark and Edholm, 1985e).

The efficiency of this mechanism is very much related to the humidity of the atmosphere and the more saturated the air is with water vapour the more difficult it is to get sweat evaporated. Where the relative humidity approaches 100% sweat cannot be evaporated and the core temperature of the body must rise, (Heins, 1983).

Thus there will be a great difference in thermal comfort, efficiency of the body and in the heat illnesses which develop offshore on the coast and in the desert. There should also be different methods of prevention and of management of the conditions which occur. This is why it seemed important to investigate the problem in an industry working in severe environmental heat and high humidity and where there was a high incidence of heat illness.

In addition to the body's internal thermal adjusting mechanisms, it must come into equilibrium with the physical environment in terms of conduction, convection and radiation. Conduction is normally not important since air is a poor conductor and only the soles of the feet are in contact with a good conductor - the ground. Following collapse or when a man is injured and falls to the ground the situation changes since half of the body is now in contact with a good conductor and heat gain is accelerated. Water conducts heat about 25 times better than air and heat gain or loss is rapid following immersion, (Hall and Polte, 1956; Pugh, 1964). Thus, heavy sweating with saturation of the clothing assembly can greatly reduce the insulative value of clothing, (Pugh, 1964, 1966). Heat gain rapidly accelerates following both collapse and saturation of the clothing with sweat.

Convection is mainly important in terms of wind speed. If air is still, it is difficult to lose heat by convection because the layer of air close to the body is still and remains here in equilibrium with the body. Increasing air movement increases the thermal gradient between the body and the surrounding air and so accelerates heat loss. Air movement is particularly important in maritime conditions where thermal balance depends upon evaporating sweat into the already humid air. Increasing air movement removes the near saturated air from the body surface and provides a supply of air with the space to accept more water.

Radiation is probably the main source of heat gain in hot climates and accounts for at least 60% of the possible thermal load. Sea and sand are good reflecting surfaces and so the radiation effects come both from direct rays from the sun and reflected rays from sea or sand in maritime or desert conditions, (Lee, 1964). The importance of shade in both the prevention and management of the heat illnesses cannot be over emphasised, (Lee and Pendleton, 1951).

Heat cramps, (Talbott, 1935) is probably the least serious of the clinically described heat illness. It usually occurs in people who sweat profusely and do not replace the salt loss. The cramps come on when the salt concentration of the body reaches a critical level. It is said to occur most commonly in unacclimatised individuals who still have a high concentration of salt in the sweat.

Heat exhaustion is described as fluid and electrolyte imbalance caused by the body's attempts to adjust to a high thermal load. Sweating still takes place and the skin feels cool and moist. The temperature is still normal and the only described abnormality is a feeling of dizziness and severe malaise, (Lee, 1964).

Theoretically, at least, if the condition is not recognised it can lead to the life threatening condition of heat stroke. This takes place when there is no more fluid available for sweating; the skin is thus hot and dry and the temperature consequently rises rapidly and irrevocably towards death. This condition is not only more serious on account of the rising temperature, but also on account of the severe fluid depletion, which means that the blood becomes viscous, with consequent effects on the heart, since the oxygen needs of the tissues are further increased by over-heating. Those who are unfit or who have present or previous heart disease must be particularly vulnerable and death often takes place from heart failure in this condition before the temperature rises sufficiently high to damage the brain, (Malamud, Haymaker and Custer, 1946; Lee, 1935).

With these classical descriptions in mind it seemed reasonable to attempt to determine the type of heat illness which affected the personnel on Das, with a view to determining what preventive action could be taken, how the casualties could best be managed and how the illness affected both safety and individual efficiency.

## METHODS

All cases of heat illness admitted to Das Hospital during the months of July and August 1987 were admitted to the study. July and August were chosen as the 2 hottest and most humid months of the year. A questionnaire was drawn up which included both clinical and laboratory questions.

The meteorological information was obtained from the meteorological unit at Das harbour and the haematological and biochemical values were obtained from the laboratory in Das hospital.

## RESULTS

During the 2 months of the study 66 cases of heat illness presented at the hospital in Das from a total population of around 3,000. Of these, 48 cases were fully documented and are presented here.

The main physical characteristics of the casualties are shown in Table 22. The average age of the casualties was 30.8 $\pm$ 6.2 years and they all originated from some part of the Indian sub-continent or the Philippines. They were all labourers or outside workers (masons, carpenters, etc) and they were all contractors. The average height was 170.8 cm and the average weight was 68.9 kg. The environmental conditions present during the 2 months when the heat illnesses occurred are shown in Table 23, where it can be seen that the temperature ranged between 30$^{o}$C and 37$^{o}$C. These measurements were made as close to the time when the illness took place as possible. Temperature was associated with a relatively low wind speed which varied between 6 and 7 knots, and the relative humidity averaged 52.9% and varied between 42% and 66%.

The clinical measurements of the casualties on admission to the hospital may be seen in Table 24. It can be seen that the temperature was not elevated above the normal range and while the pulse rate was rapid it was still within the accepted limits of normality as was the blood pressure and the respiratory rate. The average temperature on admission was 36.7°C (range 36.0°C - 37.4°C) and the average pulse rate was 86.9 beats per minute (range 64 - 104). The mean value of blood pressure was 120/80 (range 100 - 150/50 - 70) and the respiratory rate was 20 breaths per minute (range 16 - 22 breaths per minute).

The measurements of specific gravity and chloride made on the first urine specimen obtained in hospital may be seen in Table 25. Not all subjects were able to pass urine immediately, and some (12) only passed sufficient urine to measure specific gravity after an intravenous infusion was begun. Others had drunk fluid before presentation. The average specific gravity as measured was 1.015 (range 1.00 - 1.025). The average chloride was 0.5 gm per DL (range 0.1 - 1.4 gm per DL).

The measurements of serum electrolytes and urea made following admission of casualties to hospital are set out in Table 26. Of the serum values the sodium averaged 151.3 mmol per litre, the potassium 4.4 and the chloride 100.7 mmol per litre. The average value for blood urea was 32.2 mg per DL. Normal values accepted in the Das Hospital laboratory are shown in Table 27.

The haematological measurements which were made are shown in Table 28, and these measurements were made from blood which was removed as soon as the casualties arrived in the hospital. The average value for haemaglobin was 15 gm per DL (range 12 - 17 gm per DL) and PCV was 47.7% (range 42 - 54%). The average value for MCHC was 30.4 gm per DL (range 28.6 - 34.0 gm per DL).

The universal presenting symptom was giddiness while a feeling of weakness and nausea were commonly complained of. Other less common complaints were vomiting, fatigue and excessive sweating while muscle cramps was a rare complaint.

All but 2 casualties were in the open when the episode took place and all but 9 had some form of head protection. Fluids were available at the site to 40 of the patients; 16, however, drank nothing in the 2 hours preceding the episode. The average fluid intake in the 2 hours preceding the incident was 0.25 litres per hour. Salt tablets were available to the men and 41 took them regularly.

The incidence of heat illness requiring hospital treatment during the hot months of the year on Das is high, but since all recovered it does not appear to be of a serious nature.

The classical description which it follows most closely is heat exhaustion and the haematology and biochemical values achieved suggest that it is basically a mixed disturbance with elements of both salt and water depletion.

The subjects were still able to sweat freely and the pulse, blood pressure and respiratory values suggest that they were not critically ill at the time of admission. The ambient temperature was high and the wind-speed low and though the relative humidity was high it rarely exceeded 60% so there was still room in the air to evaporate sweat. The environmental conditions are severe, but not so severe as to make it possible - by education - to obtain better results and hopefully to increase efficiency.

The elevated serum sodium is the best indicator in the study of water deficiency. The haemoglobin achieves normal values, but it is possible that this group of casualties would have some form of anaemia, so the normal haemoglobin values could contain an element of haemoconcentration. This view is supported by the low MCHC.

The serum chloride value is low, and possibly its true value would be lower if there was no haemoconcentration.

This is reflected in the low urinary chloride, which, although low, was not quite as low as expected, since on average it was at the lower level of normal. In some cases it was very low, but in a substantial number it was, in fact, in the normal range.

All this points to the importance of the water deficiency element of the problem since although the salt values are low, they are not excessively low. The average fluid intake prior to admission to hospital was 1/4 litre/hour. It may well be that much of this could be prevented by an educational programme which pointed out the basic problems of heat exchange in hot, humid conditions and gave some positive advice about the importance of shade and wind movement in addition to some clear guidance about how much water to drink in the hot months - a solution of a teaspoonful of salt in a litre of water (1/4 strength saline) is acceptable drinking fluid in these conditions, (Edholm, 1978).

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The heat illness has the features of heat exhaustion, with a greater element of dehydration than salt deficiency. It is not life-threatening, but it appears to be associated with marked intellectual impairment, since mental confusion was a constant finding in the full-blown picture. It is thus reasonable to suppose that there is a degree of impairment of efficiency in a large proportion of the workforce who do not proceed to the full-blown picture of heat exhaustion. This must make the possibility of mistakes and accidents more likely in the hot months.

The most worrying feature of this condition is the associated mental impairment and thus decline in judgement and efficiency in the midst of a heavy industry. Gopinathan et al, 1988 and Sharma et al, 1986, have shown that it is likely that fluid depletion is mainly responsible for the decrease in cognitive function from exposure to heat. It is thus possible that the establishment of the water requirements for outside work on Das in summer, backed by a simple educational programme, insisting that the water requirements were met, could result in a reduction of the incidence of heat exhaustion. It would also be likely to result in a more efficient workforce in summer and possibly also in fewer accidents.

The heat illness which takes place on Das has been shown not to be life threatening in a physical sense. The interference with mental performance which it causes, however, is a source of some considerable risk in a worksite associated with heavy industrial activity. It is important that this illness should, if possible, be prevented. To this end it is necessary to make certain recommendations on the basis of the findings to date. These would include:-

1. A good supply of cool fresh water should be freely available and workers should be encouraged strongly to drink at least 100 - 200 ml every 15 - 20 minutes whilst at work.

2. Salt should be added to food, particularly in the warm months of the year.

3. Care should be taken to provide shade for the workers wherever this is possible.

4. A basic education programme should be implemented for the workforce relating to work in hot climates. This should include an understanding of the basic problems and their prevention.

5. All cases of heat illness should be fully documented and the incidence followed until it is reduced to elimination.

6. Further work should be done to determine the heat stress to which the workforce is subjected in summer. Following that information collection a

system of work/rest regimes should be implemented according to the heat stress and the physical requirements of the work.

## CONCLUSION AND EPILOGUE

The background to the formation of an occupational health service for the North Sea oil and gas industry has been described, together with the problems of health care met in other remote populations in various parts of the world. A similar occupational health service has been elaborated for the British Antarctic Survey and that system has also been described. In addition, the various environmental hazards with which such remote areas are associated have been discussed with particular reference to environmental heat, cold and the hyperbaric environment.

Thereafter, a series of studies described the pattern of injury and illness associated with the offshore oil and gas industry in the North Sea and with British Antarctic territories. By examining these areas from different angles an attempt was made to determine the adequacy of the health care provided for the populations at risk. Dental conditions, both in the North Sea and in the Antarctic, have emerged as a major problem while the possibility of a changing pattern of injury and illness in the North Sea with an ageing workforce has also been considered. It was noted, however, that the older members of the workforce did not contribute much to the need for medical evacuation.

The adequacy of the health service currently provided and the high standard of training of the medics is suggested by the relatively small number of occasions in which emergency evacuation, by a dedicated helicopter, has been required, on the one hand, and by the similarity of the pattern of definitive diagnoses, in the accident and emergency study, when compared with the working diagnoses arrived at by the offshore medic, in consultation with his onshore medical colleagues, on the other.

It was noted in the text that retrospective studies have problems and that there would be value in proceeding to a prospective study of medical evacuations from offshore. It can be reported now that such a prospective study has indeed been set up with a consortium of ten operating offshore oil and gas companies and with the support and participation of the Department of Energy. The study has now been in existence for two years and two annual reports have been made to the group. In both years the pattern of illness and injury has been similar to that noted in the retrospective offshore study and this provides further evidence of its value.

In the prospective study report completed for 1989, the number of illnesses requiring evacuation has, for the first time, exceeded the injuries. There is, however, no further evidence that the older members of the workforce require medical evacuations more frequently than in the past.

The importance of training for the population at risk and of communications has been emphasised throughout the study. The evaluation carried out over a period of a year has indicated that the training has at least met the needs of the trainees. The course is now increasingly in demand in many overseas locations, particularly the Middle East and the Far East. Arrangements are now underway to strengthen it with a second text book and with a series of appropriate video tapes. Communication technology continues to advance and following the demonstration made on Christmas Eve, 1986 - and reported in the thesis - that it was possible to send an acceptable radiograph from the Antarctic to Aberdeen by slow scan television, arrangements are now being made, in association with the European Space Agency, to proceed to an investigation into the wider possibilities of telescience. It is intended to determine the extent to which health maintenance can be monitored from a considerable distance with a view to providing the same level of health care for long term space travellers, as has been provided for remote communities on earth.

The environmental hazard briefly considered was heat. Extensions of that investigation were, however, delayed by the oil recession in the Middle East. Interest has increased again with the recovery of Middle East industry and arrangements are now being made to undertake an investigation into the cause of the high number of road accidents in desert drivers during the Arabian summer.

The work reported in this thesis acted as a foundation for the ongoing development of systems of health care for people who work in remote places with hazardous environmental conditions. Since these studies were made they have been extended, confirmed and developed. Attention has most recently been directed towards the challenge of long term space travel and its medical support.

# THE PROVISION OF HEALTH CARE

# IN REMOTE HOSTILE ENVIRONMENTS

JOHN ALEXANDER BREBNER

A thesis in two volumes in partial fulfilment of the requirements of the Council for National Academic Awards for the degree of Doctor of Philosophy.

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Robert Gordon's Institute of Technology in collaboration with the British Antarctic Survey (NERC) and Memorial University of St John's, Newfoundland.

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# VOLUME II

# CHAPTER II

## THE PATTERN OF INJURY AND ILLNESS IN THE OFFSHORE OIL AND GAS INDUSTRIES

CONSORTIUM RESEARCH PROJECT 1982

Information to be retrieved from company records regarding medical evacuations.

| | |
|---|---|
| Name of installation? | |
| Operator | |
| Name of patient? (surname, forenames) | |
| Date of birth? | |
| Age? | |
| Marital status? | |
| Nationality? | |
| Most recent medical? (date, sheet no) | |
| Any other medical? (dates, sheet nos) | |
| Job title? | |
| Employer? | |
| Incident - description (text) | |
| Nature of incident? | Illness: self inflicted / non self inflicted<br>Injury: accidental / non accidental |
| Incident reported to medic | Date<br>Time |
| Incident onset/occurrence | Date<br>Time |
| Location on installation? | |
| On/Off duty? | |
| First aid administered | Yes/No |
| Qualifications for first aider? | |
| Equipment used | 1. Brookes<br>2. Guedal<br>3. Resuscitator<br>4. Entonox<br>5. Oxygen<br>6. Stretcher<br>7. Splints<br>8. Other |
| Medics' diagnosis? | |
| Diagnostic tests? | |
| Assessment and treatment of patient (text) | |
| Consultation medical adviser | Yes/No |
| When? | Date<br>Time |
| Status? | |
| Qualifications of escort? | 1. None<br>2. First aid<br>3. Escort<br>4. Other |
| Destination? | 1. Intended<br>2. Actual |
| Heliport<br>Hospital<br>Medical barge<br>Other | |
| Met by: | 1. Ambulance<br>2. Doctor<br>3. Company representative<br>4. Not met |
| Name of medic? | |
| Did patient survive? | |
| If no - cause of death? | |
| Treatment | 1. Admitted<br>2. OPD (inc A and E)<br>3. GP<br>4. Company doctor |
| Length of time prior to return to work? | 1. Days<br>2. Permanent |
| Was patient ill before going offshore? | Yes/No |
| Was doctor contacted before going offshore | Yes/No |
| Drugs administered and route? | |
| I/V line attempted? | Yes/No |
| Successful? | Yes/No |
| Fluids administered? | |
| Was patient evacuated? | Yes/No |
| Who decided to evacuate? | 1. Medic<br>2. OIM<br>3. Doctor |
| Decision to evacuate? | Date<br>Time |
| Emergency/routine? | |
| When evacuated? | Date<br>Time |
| Method of evacuation? | 1. Air<br>2. Sea |
| Was stretcher used? | Yes/No |
| Treatment during evacuation? (text) | |
| Escort? | Yes/No |

FIGURE 1. The questionnaire used in the offshore study.

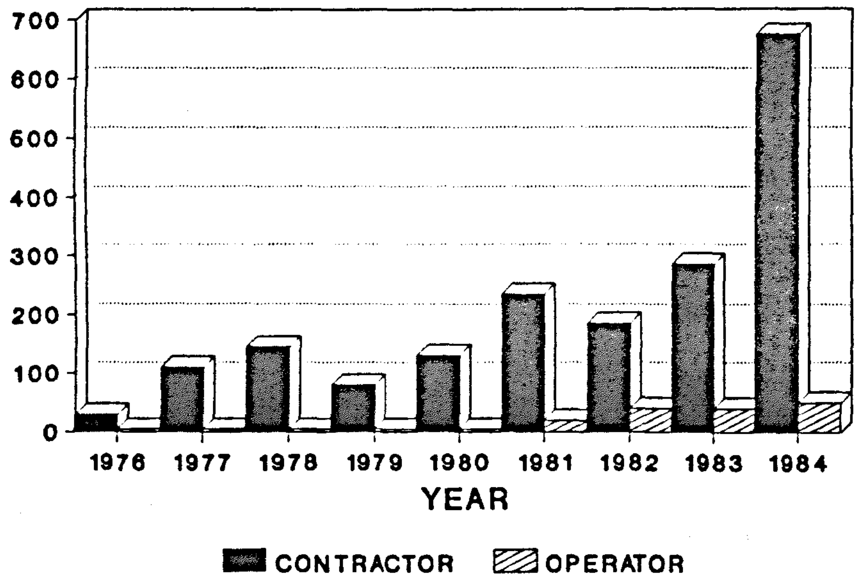


FIGURE 2. ANNUAL FIGURES FOR EVACUATIONS FROM 1976-1984
THE RATIO OF OPERATORS' TO CONTRACTORS PERSONNEL
IS SHOWN FOR EACH YEAR.

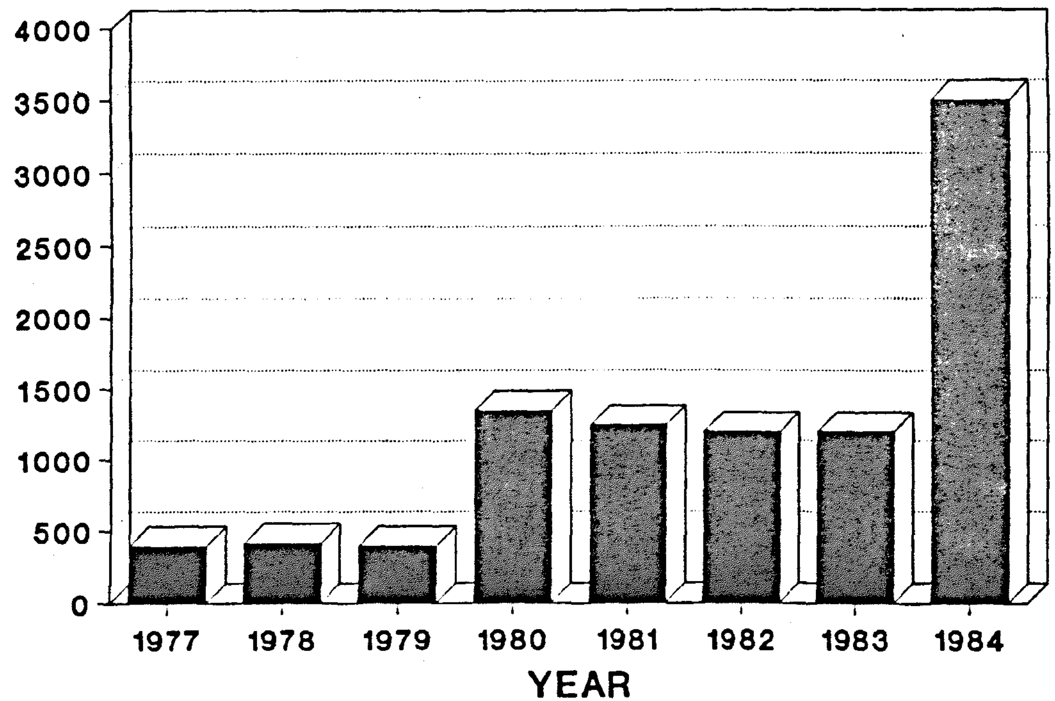


FIGURE 3. TOTAL OFFSHORE POPULATION OF THE FOUR COMPANIES DURING THE YEARS OF THE STUDY. ONLY ONE WAS OPERATING AT THE BEGINNING,TWO MORE BEGAN OPERATIONS IN 1980 AND THE FOURTH TOWARDS THE END OF 1983.

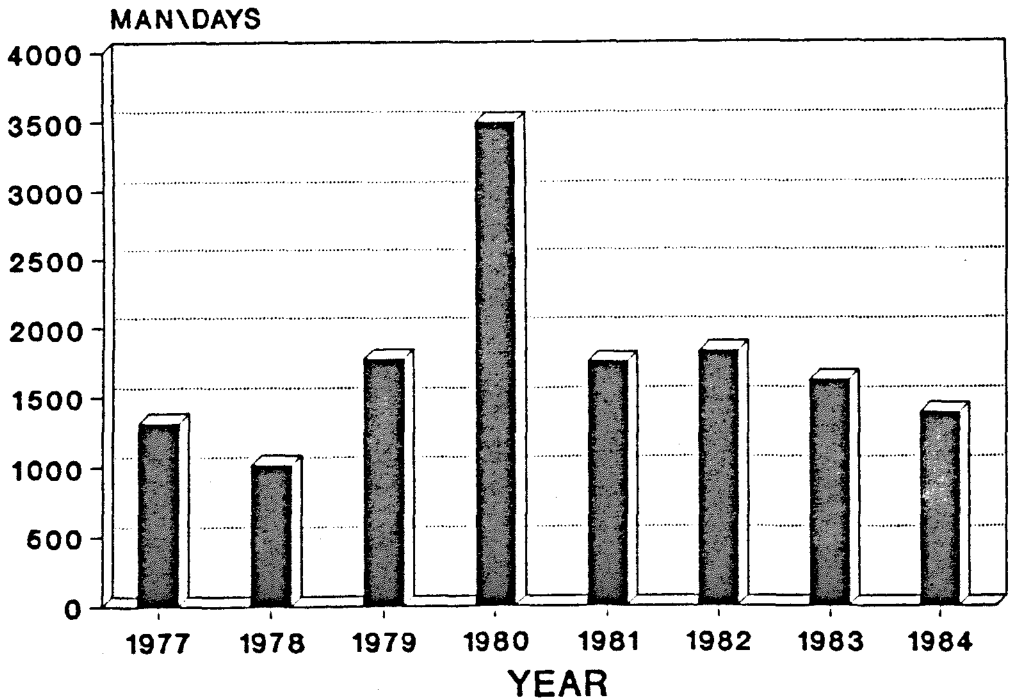


FIGURE 4. ANNUAL NUMBERS OF MAN DAYS WORKED OFFSHORE PER EVACUATION FOR THE FOUR COMPANIES.IN 1980 3,500 MAN DAYS WERE WORKED FOR EACH EVACUATION.

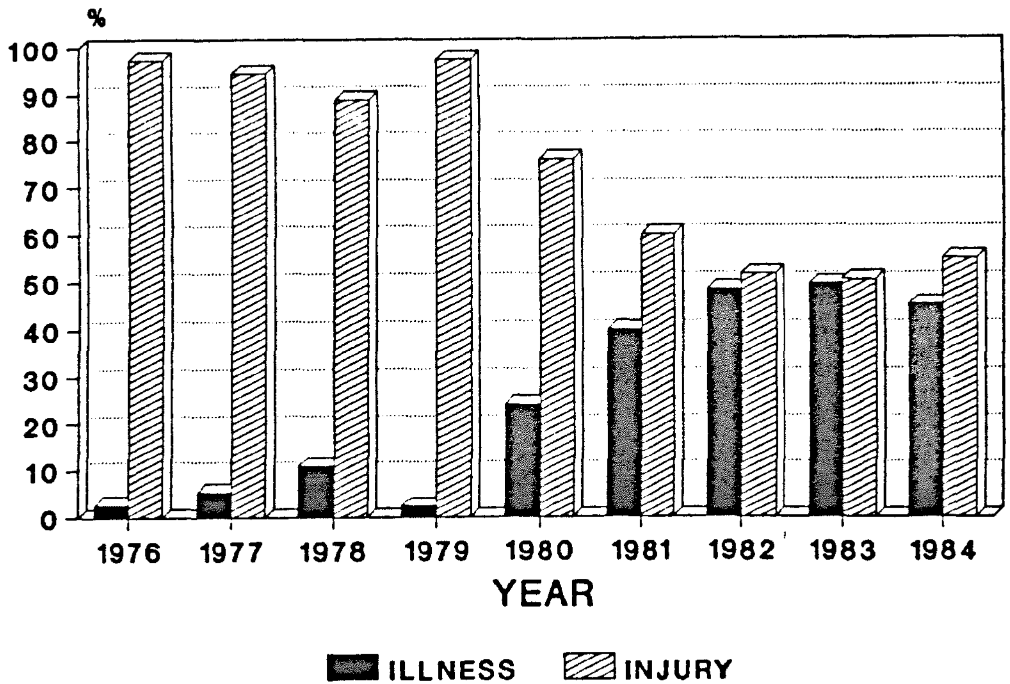


FIGURE 5. BAR CHART SHOWING THE RELATIVE INCIDENCE OF ILLNESS COMPARED TO INJURY FOR EACH YEAR OF THE STUDY.

| | No | % |
|---|---|---|
| Disorders of the digestive system | 239 | (20.9%) |
| Disorders of the musculo-skeletal system | 156 | (13.6%) |
| Disorders of the respiratory system | 117 | (10.2%) |
| Disorders of the nervous system (incl eyes and ears) | 96 | (8.4%) |
| Mental disorders | 42 | (3.7%) |
| Disorders of the cardio-vascular system | 41 | (3.6%) |
| Disorders of skin and subcutaneous tissue | 33 | (2.9%) |
| Genito-urinary disorders | 26 | (2.3%) |
| Infections and parasite infestations | 35 | (3.1%) |
| Miscellaneous specified disorders | 5 | (0.4%) |
| Undiagnosed, vague symptoms | 354 | (30.9%) |

**TABLE 1.** The distribution of illnesses which required evacuation classified into body systems.

| | No | % |
|---|---|---|
| Fractures of head and face | 23 | (1.6%) |
| Fractures of spine and trunk | 45 | (3.0%) |
| Fractures of upper limb | 234 | (15.8%) |
| Fractures of lower limb | 140 | (9.5%) |
| Dislocations | 13 | (0.9%) |
| Sprains and strains | 192 | (13.0%) |
| Intra cranial injury without skull fracture | 35 | (2.4%) |
| Crush injuries | 62 | (4.2%) |
| Open wounds of head and trunk | 65 | (4.4%) |
| Open wounds of limbs | 120 | (8.1%) |
| Superficial injuries (abrasions etc) | 29 | (2.0%) |
| Contusions | 132 | (8.9%) |
| Foreign bodies | 156 | (10.6%) |
| Burns | 71 | (4.8%) |
| Welders flash | 9 | (0.6%) |
| Nerve and cord injuries | 6 | (0.4%) |
| Traumatic complications and vague unspecified injuries | 81 | (5.5%) |
| Poisoning - medicinal and biological substances | 48 | (3.3%) |
| Toxic effects - non medicinal substances | 7 | (0.5%) |
| Effects of external environment eg air pressure | 5 | (0.3%) |
| Complications of medical and surgical care | 3 | (0.2%) |

**TABLE 2.** The distribution of injuries which required evacuation classified into body systems.

Site on Installation

| | No | % |
|---|---|---|
| Deck | 137 | 20.0 |
| Drill Floor | 128 | 18.7 |
| Pipe Deck | 71 | 10.4 |
| Stairways | 50 | 7.4 |
| Catwalks | 22 | 3.2 |
| Work Shop | 31 | 4.5 |
| Cabin | 34 | 5.0 |
| Standby Vessels | 21 | 3.1 |
| Dive Skid | 20 | 2.9 |
| Derrick | 18 | 2.6 |
| Landing Pad | 16 | 2.3 |
| Scaffolding | 16 | 2.3 |
| Production Decks | 16 | 2.3 |
| Unspecified | 105 | 15.3 |

**TABLE 3.** Distribution of locations of the 685 casualties at the time of injury.

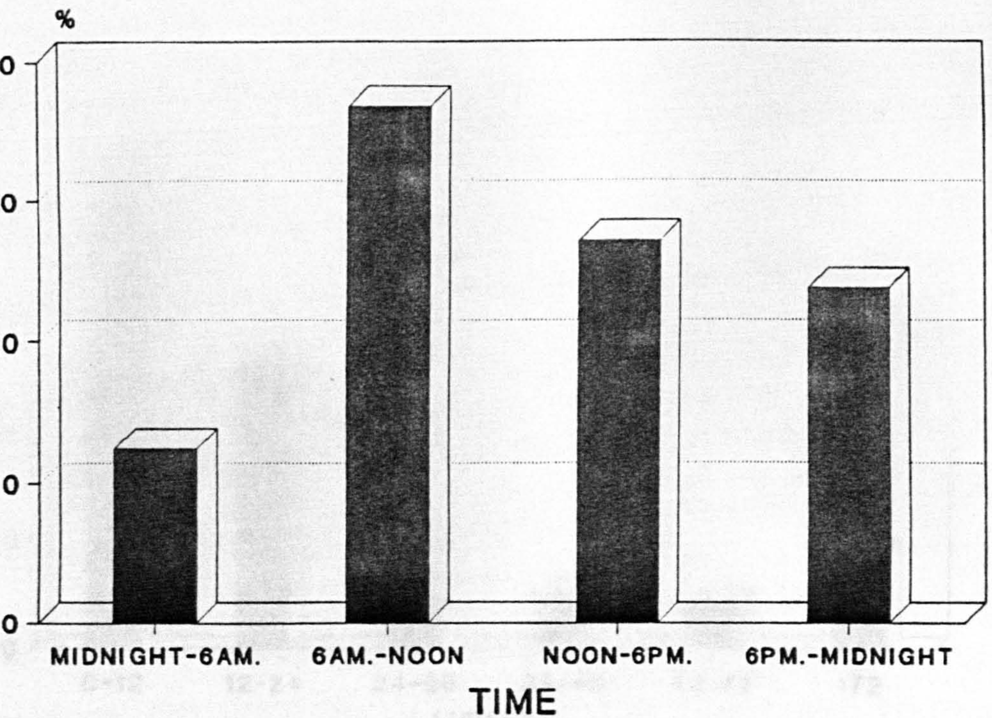


FIGURE 6. DISTRIBUTION OF TIME OF DAY WHEN THE INCIDENT WHICH RESULTED IN EVACUATION WAS REPORTED TO THE RIG MEDIC.

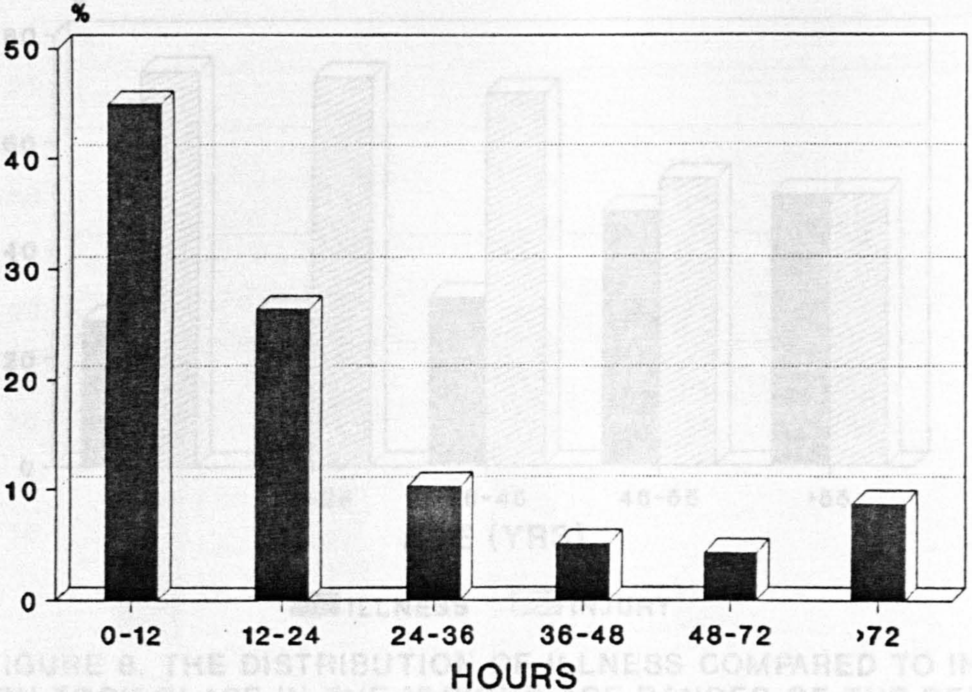


FIGURE 7. THE NUMBER OF HOURS WHICH ELAPSED BETWEEN THE INCIDENT BEING REPORTED TO THE RIG MEDIC AND EVACUATION TAKING PLACE.

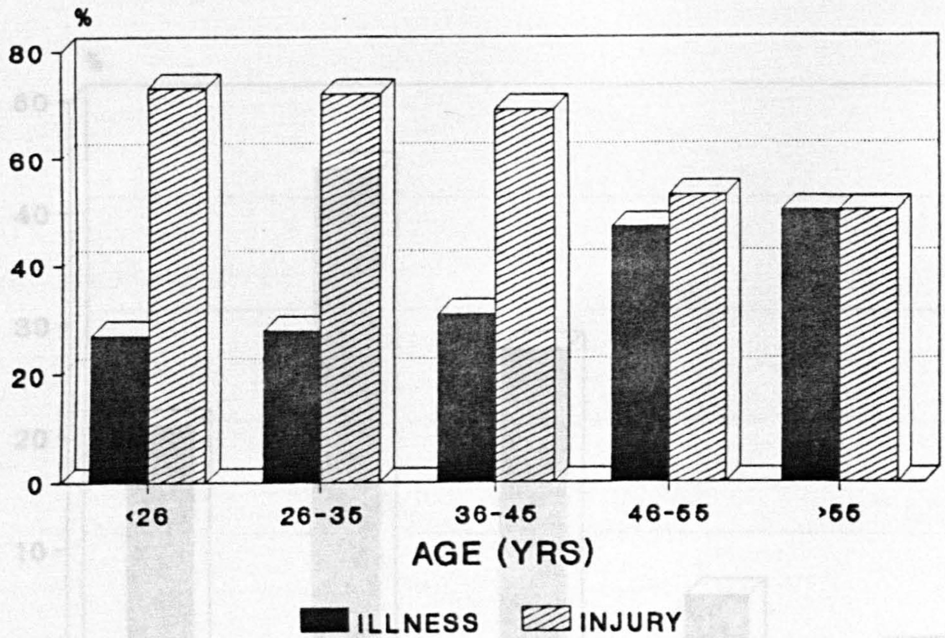


FIGURE 8. THE DISTRIBUTION OF ILLNESS COMPARED TO INJURY WHICH TOOK PLACE IN THE VARIOUS AGE RANGES OF THE PERSONNEL EVACUATED.

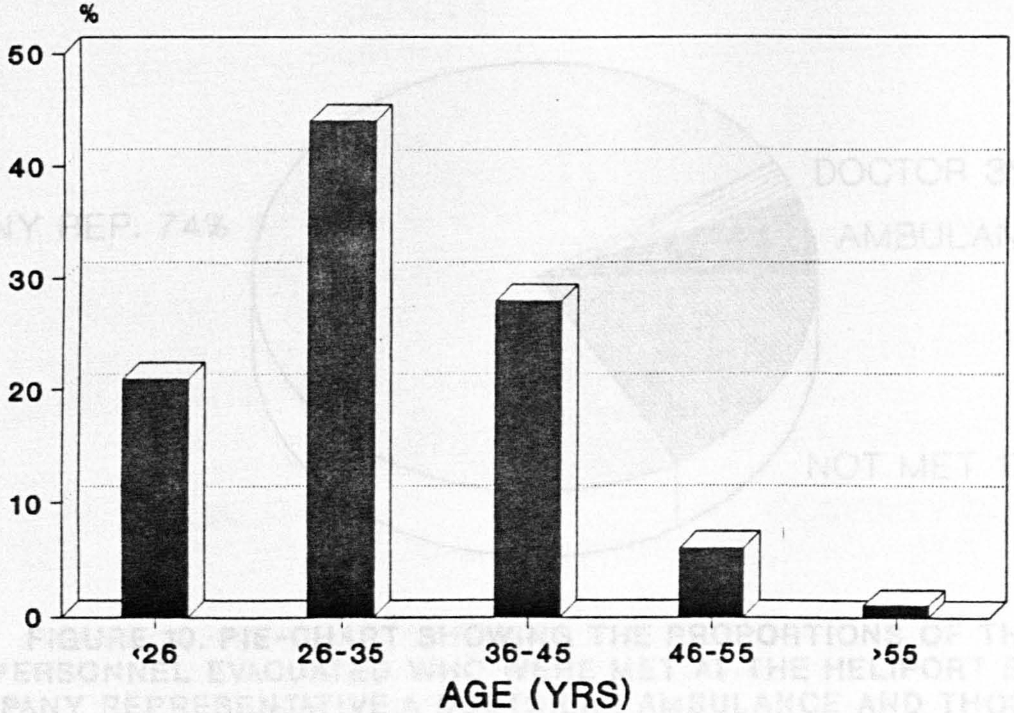


FIGURE 9. THE AGE DISTRIBUTION OF THE 2,162 PERSONNEL EVACUATED.

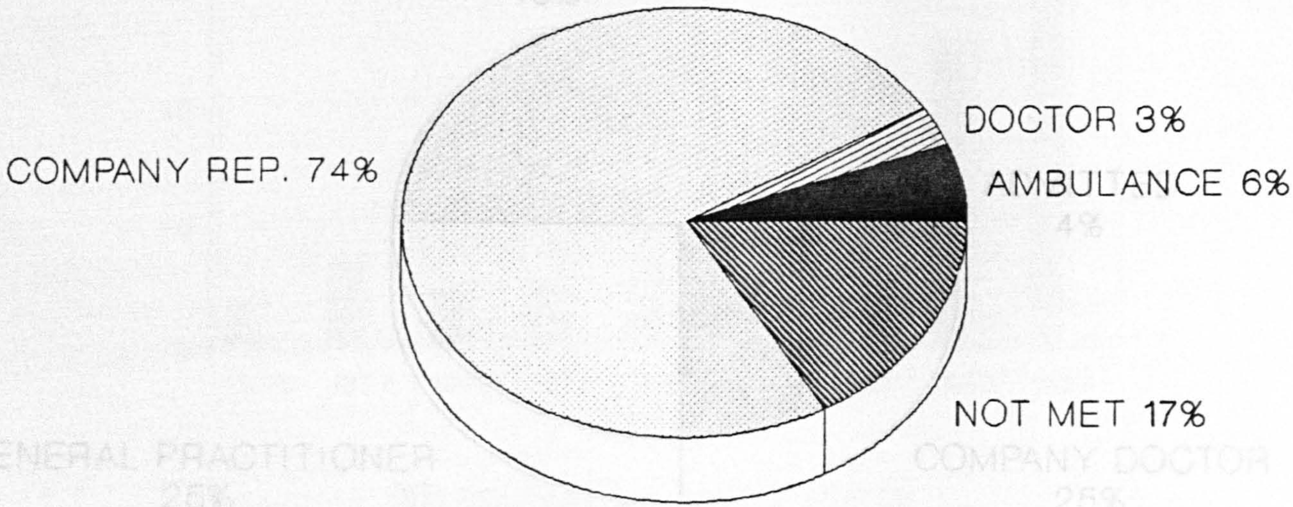


**FIGURE 10. PIE-CHART SHOWING THE PROPORTIONS OF THE PERSONNEL EVACUATED WHO WERE MET AT THE HELIPORT BY A COMPANY REPRESENTATIVE,A DOCTOR,AN AMBULANCE AND THOSE WHO WERE NOT MET AT ALL.**

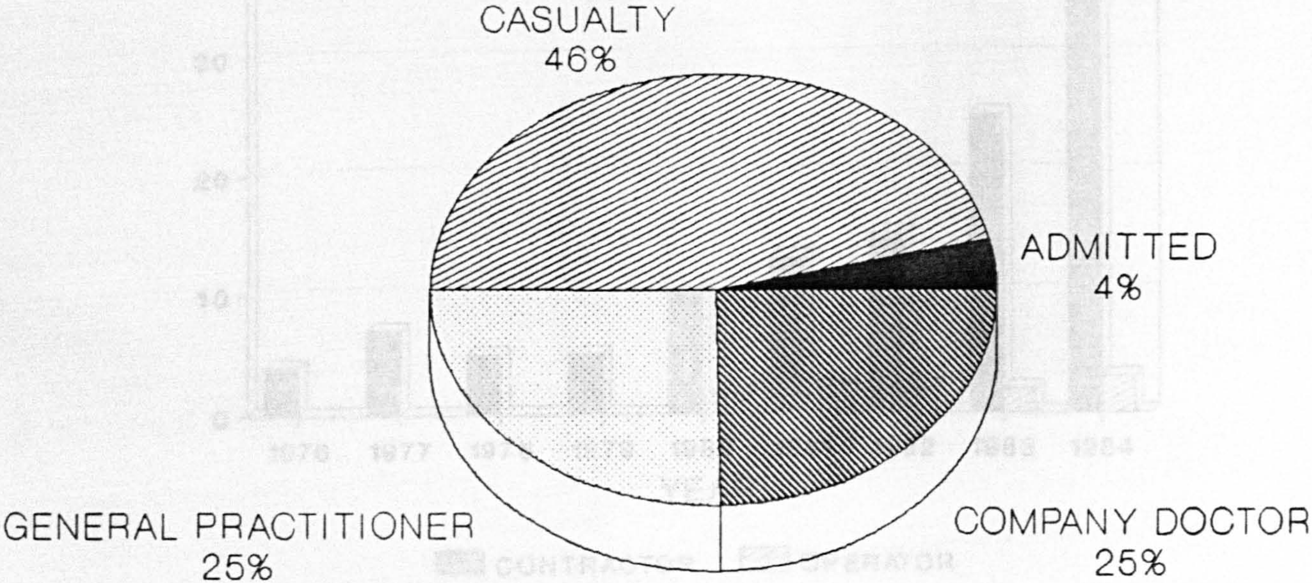


**FIGURE 11. PIE-CHART SHOWING THE PROPORTIONS OF THE PERSONNEL EVACUATED WHO WERE INITIALLY TREATED BY A GENERAL PRACTITIONER OR A COMPANY DOCTOR AND THOSE WHO WERE INITIALLY TREATED IN A CASUALTY DEPARTMENT OR ADMITTED DIRECTLY TO HOSPITAL.**

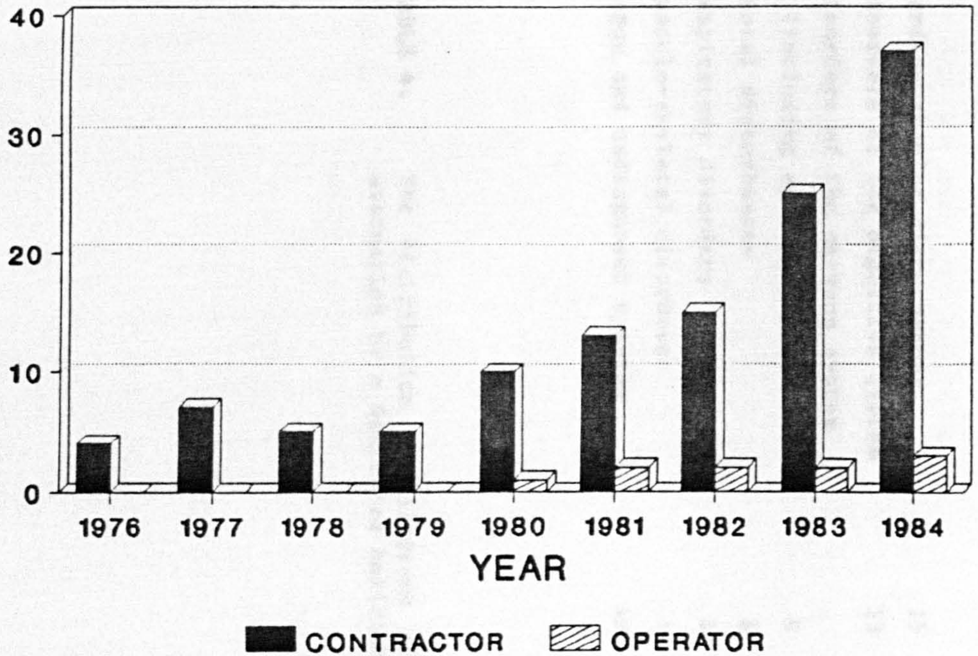


FIGURE 12. ANNUAL FIGURES FOR EMERGENCY EVACUATIONS WHERE A DEDICATED HELICOPTER WAS REQUIRED. CONTRACTORS' AND OPERATORS'PERSONNEL ARE SHOWN FOR EACH YEAR.

| | No | % |
|---|---|---|
| Cardio-vascular disturbances | 15 | (16.7%) |
| Disorders of the digestive system | 13 | (14.4%) |
| Disorders of the nervous system (including eyes and ears) | 9 | (10.0%) |
| Mental disturbances | 6 | (6.7%) |
| Respiratory disorders | 4 | (4.4%) |
| Musculo-skeletal disorders | 1 | (1.1%) |
| Vague and undiagnosed symptom | 42 | (46.7%) |

**TABLE 4.** The distribution of illnesses requiring emergency evacuation by a dedicated helicopter.

| | No | % |
|---|---|---|
| Fractures of skull and face | 10 | (8.0%) |
| Fractures of spine and trunk | 9 | (7.2%) |
| Fractures of upper limb | 8 | (6.4%) |
| Fractures of lower limb | 17 | (13.6%) |
| Dislocations | 2 | (1.6%) |
| Strains and sprains | 1 | (0.8%) |
| Head injury without fracture | 10 | (8.0%) |
| Open Wounds - head neck and trunk | 5 | (4.0%) |
| - upper limb | 11 | (8.8%) |
| - lower limb | 3 | (2.4%) |
| Foreign body | 6 | (4.8%) |
| Burns | 12 | (9.6%) |
| Welders flash | 5 | (4.0%) |
| Crush injuries | 5 | (4.0%) |
| Bruises, abrasions etc | 11 | (8.8%) |
| Poisoning | 2 | (1.6%) |
| Unspecified vague injuries | 7 | (5.6%) |
| Totally unspecified evacuation | 1 | (0.8%) |

**TABLE 5.** The distribution of the injuries which required emergency evacuation.

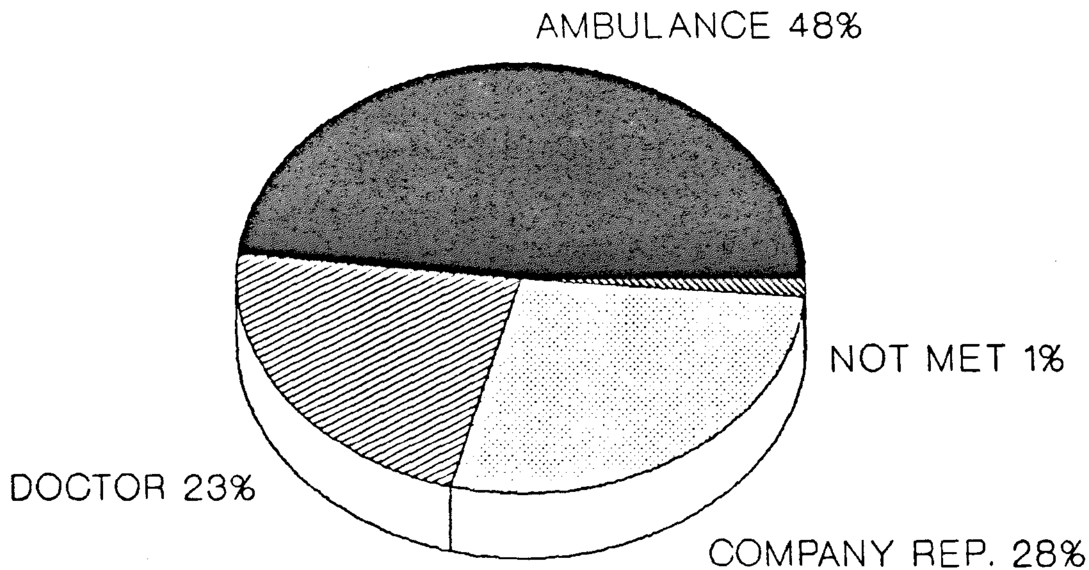


**FIGURE 13. PIE-CHART SHOWING THE PROPORTIONS OF EMERGENCY EVACUATIONS WHERE THE PERSONNEL WERE MET AT THE HELIPORT BY AN AMBULANCE,A DOCTOR,A COMPANY REPRESENTATIVE AND THOSE WHO WERE NOT MET AT ALL.**

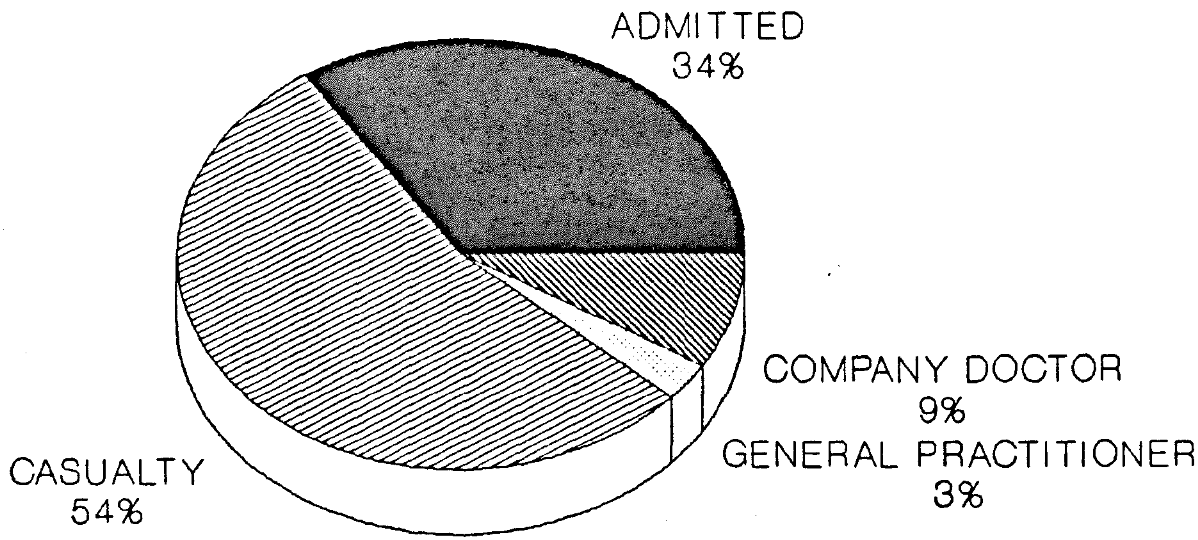


**FIGURE 14. PIE-CHART SHOWING THE PROPORTIONS OF PERSONNEL EVACUATED BY THE EMERGENCY MODE WHO WERE TREATED INITIALLY BY A CASUALTY DEPARTMENT OR ADMITTED DIRECTLY TO HOSPITAL AND THOSE WHO WERE TREATED BY A GENERAL PRACTITIONER OR A COMPANY DOCTOR.**

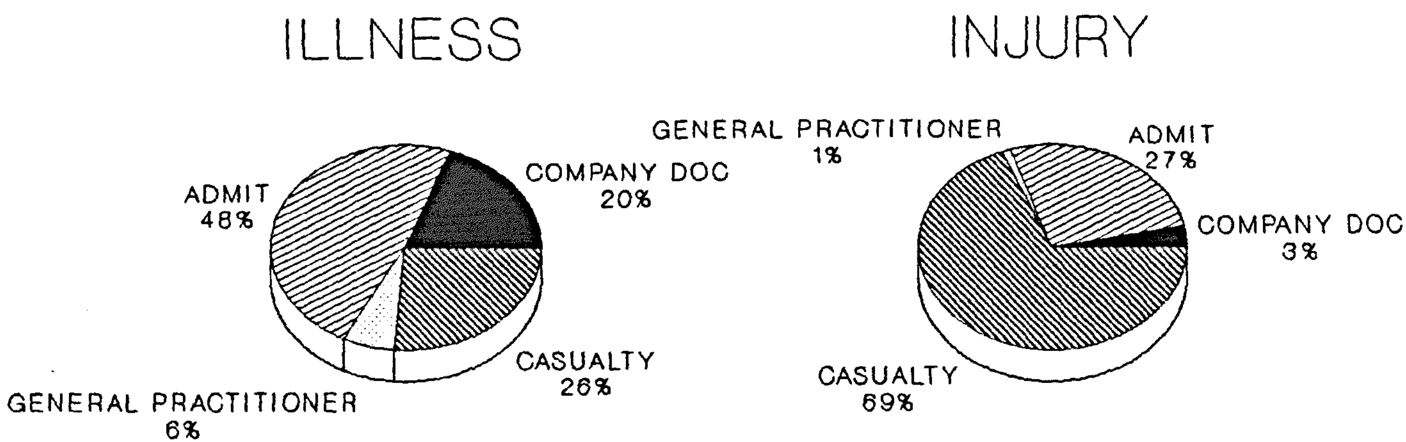


**FIGURE 15. PIE-CHARTS SHOWING THE MEDICAL DISPOSAL OF THOSE PERSONNEL EVACUATED BY THE EMERGENCY MODE SUFFERING FROM AN ILLNESS AND THOSE WHO WERE EVACUATED BECAUSE OF AN INJURY.**

# CHAPTER III

## INCIDENCE OF ACCIDENTS FROM THE OFFSHORE INDUSTRY ADMITTED TO ABERDEEN ROYAL INFIRMARY FROM 1978 TO 1986

| ACCIDENT & EMERGENCY DEPARTMENT | ABERDEEN ROYAL INFIRMARY | | NO. |
|---|---|---|---|
| Surname | First Names | | D.O.B. ........... Age .......... S M W |

Address ........................................................................

........................................................................

Employer ........................................................................

Occupation ............................................. Date ....................

Time A.M. P.M.

Doctor's Name and Address:

History and Examination:

**MR. G. PAGE**

Doctor's Initials ....................

X-Ray Reports:

X-Ray No. ....................

Doctor's Initials ....................

| Diagnosis: | Disposal: |
|---|---|
| S.245 | Dr, Written: |

FIGURE 16. Layout of an Aberdeen Royal Infirmary Accident and Emergency Card.

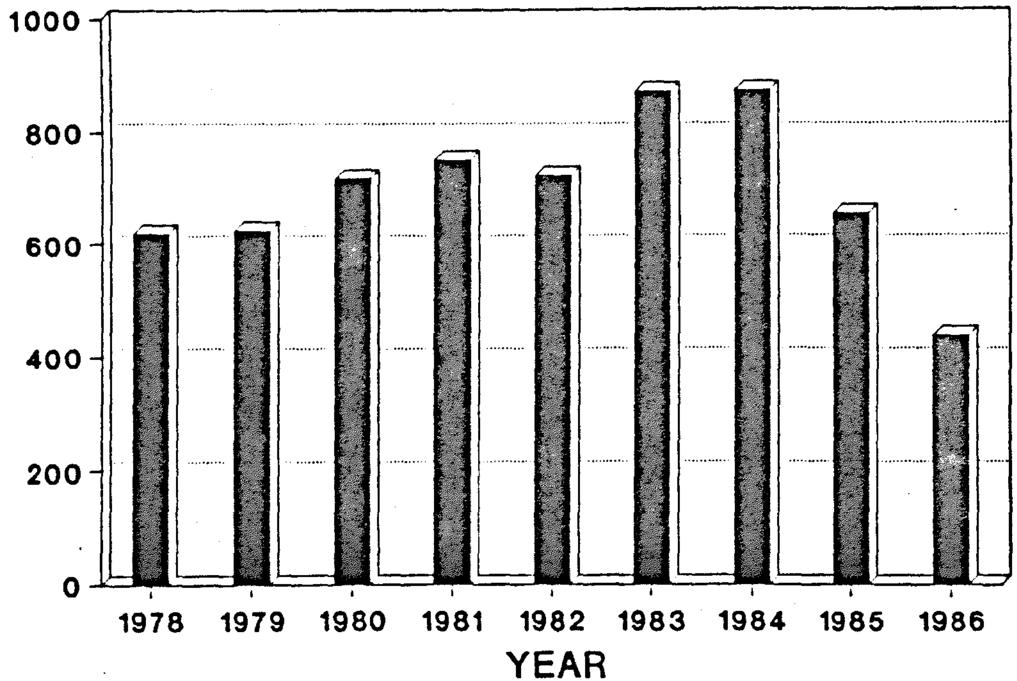


FIGURE 17. BAR CHART SHOWING THE ANNUAL NUMBER OF CASUALTIES RECEIVED FROM THE OFFSHORE INDUSTRY AT THE ACCIDENT AND EMERGENCY DEPARTMENT OF ABERDEEN ROYAL INFIRMARY DURING THE STUDY.

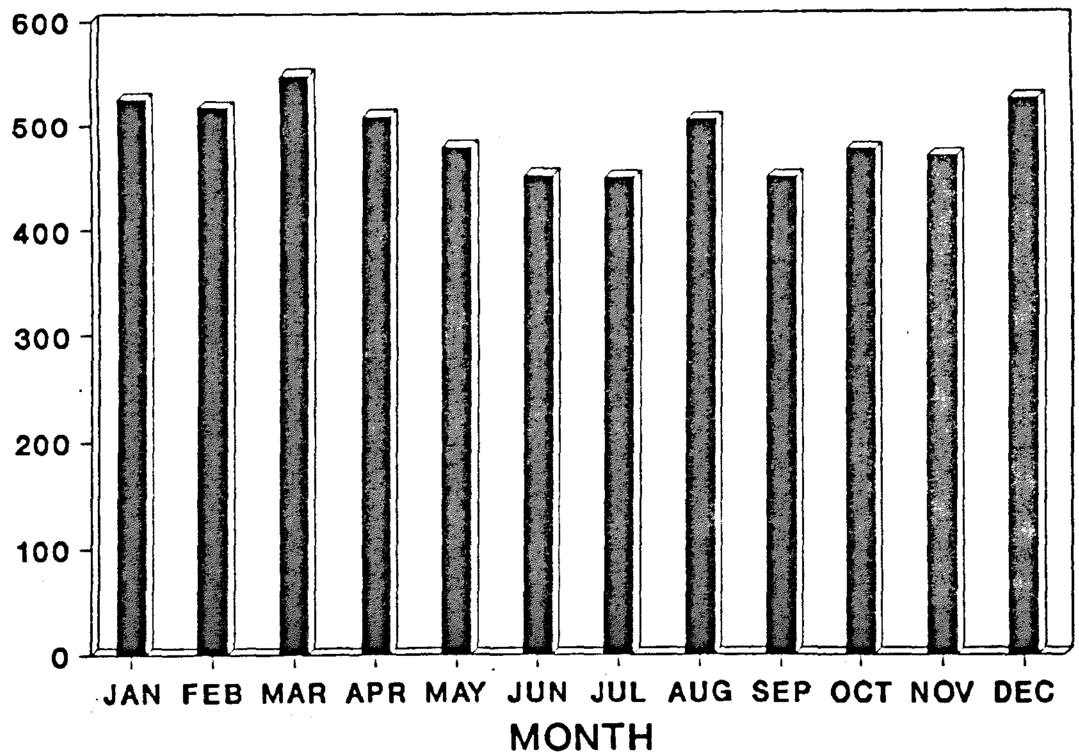


FIGURE 18. BAR CHART SHOWING THE NUMBER OF CASUALTIES PRESENTING DURING THE NINE YEARS OF THE STUDY AMONG THE TWELVE MONTHS OF THE YEAR.

| | No | % |
|---|---|---|
| Summer | 1378 | 23.4% |
| Autumn | 1428 | 24.2% |
| Winter | 1516 | 25.7% |
| Spring | 1572 | 26.7% |

**TABLE 6.** Seasonal incidence of injuries presenting at the Accident and Emergency Department from offshore.

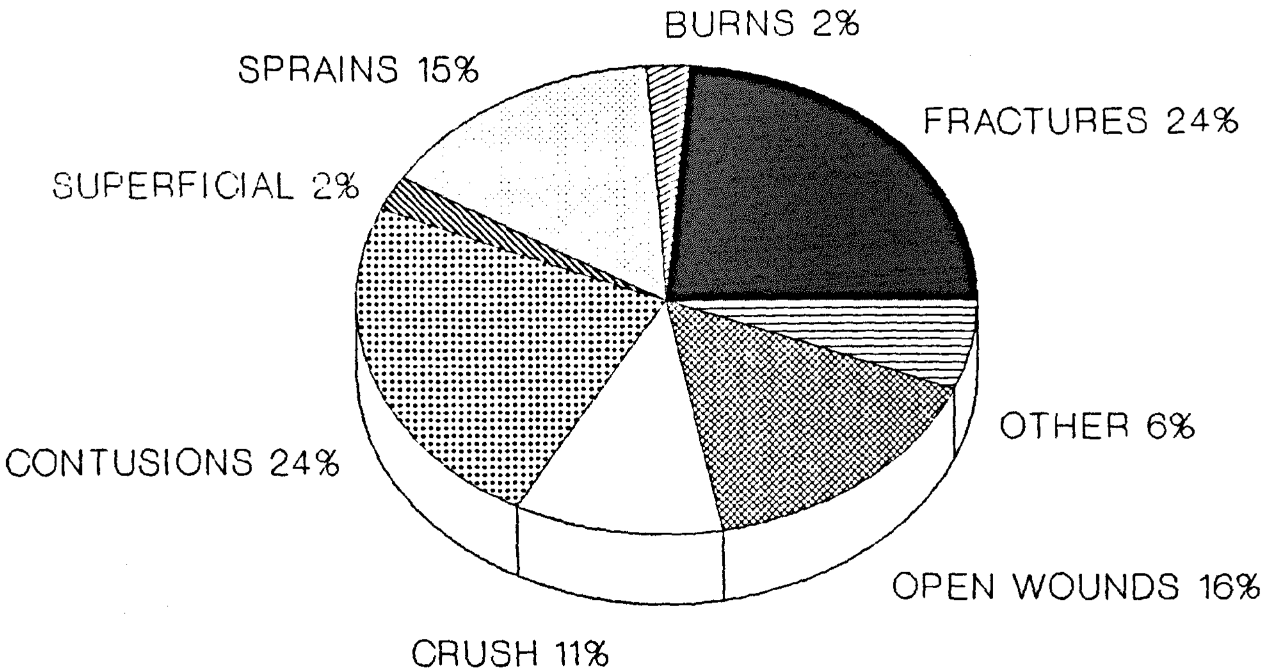


**FIGURE 19. PIE-CHART SHOWING THE PROPORTIONS OF THE VARIOUS TYPES OF INJURY WHICH PRESENTED AT THE ACCIDENT AND EMERGENCY DEPARTMENT DURING THE NINE YEARS OF THE STUDY.**

| N = | 619 | 624 | 718 | 751 | 722 | 871 | 873 | 654 | 438 |
|---|---|---|---|---|---|---|---|---|---|
| Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| Fractures | 22% | 21% | 21% | 26% | 27% | 26% | 25% | 27% | 26% |
| Sprains | 15% | 11% | 17% | 12% | 16% | 17% | 15% | 16% | 16% |
| Contusions | 24% | 26% | 19% | 26% | 25% | 22% | 27% | 25.7% | 26% |
| Crush | 12% | 12% | 13% | 9% | 9% | 10% | 9% | 12% | 10% |
| Open Wounds | 14% | 15% | 20% | 12% | 13% | 13% | 13% | 11% | 15% |
| Superficial | 1% | 4% | 2% | 2% | 3% | 2% | 2% | 1.3% | 2% |
| Burns | 5% | 2% | 2% | 3% | 2% | 3% | 2% | 3% | 3% |
| Other | 7% | 9% | 6% | 10% | 5% | 7% | 7% | 4% | 2% |

**TABLE 7.** The frequency with which each injury type presented each year.

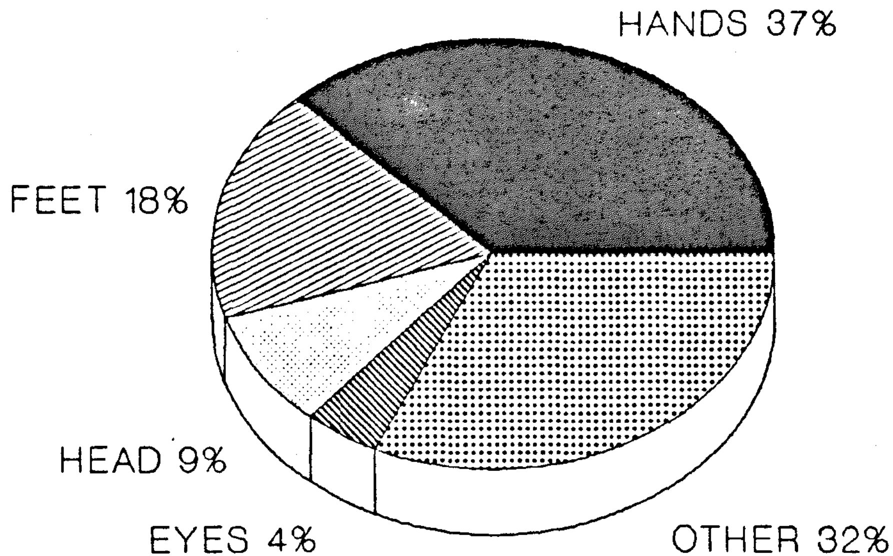


**FIGURE 20. PIE-CHART SHOWING THE PROPORTION OF INJURIES AFFECTING THE BODY PART MOST OFTEN INJURED IN THIS STUDY.**

| | N = | 619 | 624 | 718 | 751 | 722 | 871 | 873 | 654 | 438 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| Hands | | 36.2% | 41.0% | 44.0% | 37.1% | 38.3% | 34.0% | 33.6% | 40.5% | 32.4% |
| Feet | | 15.3% | 17.9% | 15.6% | 22.7% | 18.6% | 16.5% | 18.7% | 14.9% | 16.9% |
| Head | | 10.2% | 9.1% | 7.4% | 8.6% | 10.6% | 8.9% | 7.7% | 8.0% | 9.3% |
| Eyes | | 4.1% | 8.1% | 4.4% | 5.7% | 3.3% | 4.1% | 4.1% | 2.5% | 3.3% |

**TABLE 8.** The distribution of injuries to the body parts - hands, feet, head and eyes noted for the period of the study.

| Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|---|---|
| Conscious | 619 | 624 | 718 | 751 | 722 | 871 | 873 | 654 | 438 |
| | 99% | 99% | 99% | 99% | 98% | 98% | 98% | 98% | 98% |
| Unconscious | 9 | 10 | 6 | 12 | 20 | 21 | 26 | 17 | 12 |
| | 1% | 1% | 1% | 1% | 2% | 2% | 2% | 2% | 2% |

**TABLE 9.** The annual distribution of evacuees who had been unconscious at any time from the accident to hospital reception.

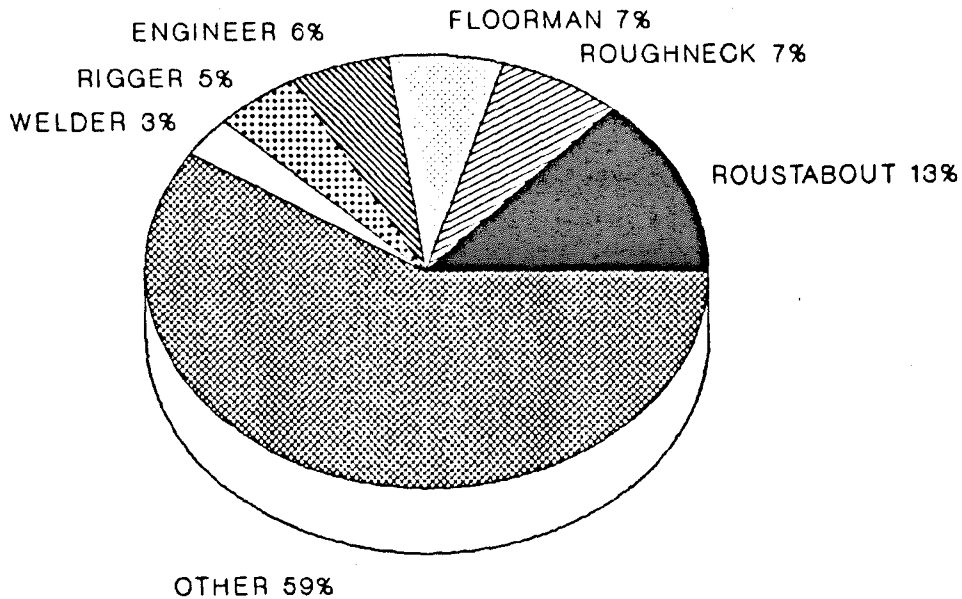


**FIGURE 21. PIE-CHART SHOWING THE PROPORTION OF INJURIES AFFECTING THE SIX OCCUPATIONAL GROUPS MOST OFTEN INJURED IN THIS STUDY.**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| N = | 619 | 624 | 718 | 751 | 722 | 871 | 873 | 654 | 438 |
| Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| Roustabout | 13% | 16% | 12% | 14% | 11% | 12% | 15% | 18% | 15% |
| Roughneck | 10% | 7% | 5% | 7% | 7% | 5% | 5% | 7% | 8% |
| Floorman | 6% | 5% | 6% | 9% | 8% | 6% | 7% | 8% | 6% |
| Engineer | 4% | 6% | 7% | 5% | 5% | 5% | 5% | 4% | 5% |
| Rigger | 5% | 5% | 7% | 5% | 5% | 6% | 5% | 4% | 5% |
| Welder | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 0% | 2% |
| Other | 59% | 58% | 60% | 57% | 61% | 63% | 60% | 59% | 59% |

**TABLE 10.** The annual distribution of occupations requiring evacuation among the population of occupations accounting for 41% of injuries.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| N = | 619 | 624 | 718 | 751 | 722 | 871 | 873 | 654 | 438 |
| Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| **EMPLOYER:-** | | | | | | | | | |
| CONTRACTOR | 90% | 84% | 84% | 87% | 92% | 90% | 93% | 88% | 81% |
| OPERATOR | 10% | 16% | 16% | 13% | 8% | 10% | 7% | 12% | 19% |

**TABLE 11.** The distribution of operators' and contractors' personnel presenting from offshore with injuries.

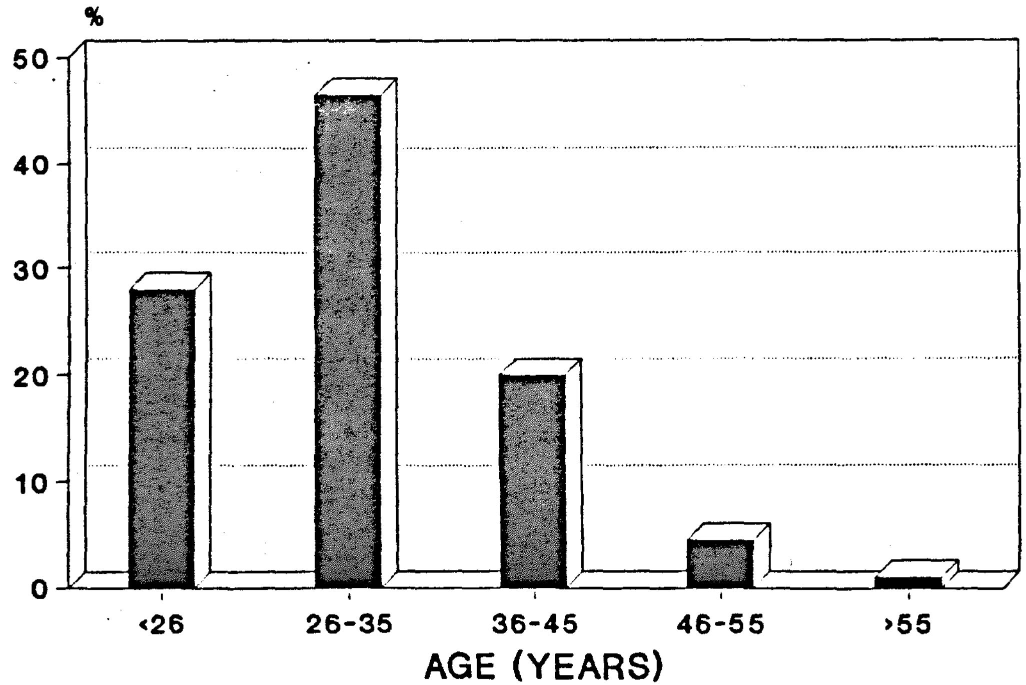


FIGURE 22. BAR CHART SHOWING THE AGE DISTRIBUTION IN DECADES OF THE CASUALTIES PRESENTING DURING THE NINE YEARS OF THE STUDY.

| Age | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|---|---|
| <30 Years | 58.38% | 59.87% | 57.08% | 58.38% | 56.02% | 49.87% | 53.33% | 50.00% | 44.20% |
| > 30 Years | 41.62% | 40.13% | 42.92% | 41.62% | 43.98% | 50.13% | 46.67% | 50.00% | 55.80% |

**TABLE 12.** The distribution of presentations at the Accident and Emergency department around 30 years of age.

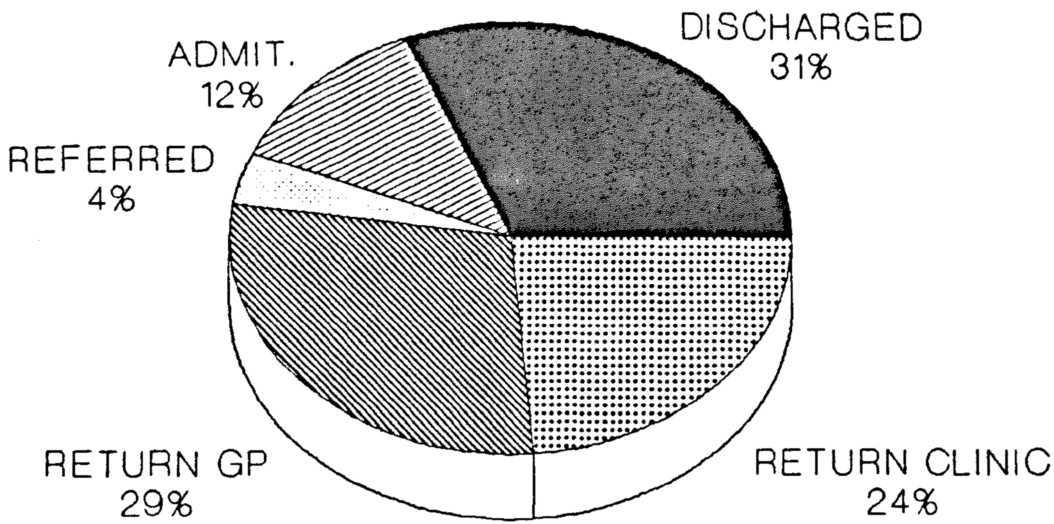


**FIGURE 23. PIE-CHART SHOWING THE DISPOSAL OF THE CASUALTIES AFTER INITIAL ASSESSMENT OR TREATMENT AT THE ACCIDENT AND EMERGENCY DEPARTMENT.**

| N = | 619 | 624 | 718 | 751 | 722 | 871 | 873 | 654 | 438 |
|---|---|---|---|---|---|---|---|---|---|
| Year | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
| Discharged | 33.8% | 35.5% | 30.9% | 28.0% | 27.4% | 30.3% | 27.1% | 32.5% | 36.0% |
| Admitted | 5.3% | 6.6% | 4.8% | 15.3% | 15.3% | 15.5% | 17.6% | 16.2% | 21.2% |
| Referred | 3.7% | 4.7% | 2.3% | 3.6% | 4.8% | 4.4% | 3.8% | 4.9% | 3.1% |
| Return GP | 30.8% | 27.0% | 35.0% | 26.9% | 30.1% | 27.3% | 29.4% | 25.6% | 20.2% |
| Return Clinic | 26.3% | 25.8% | 26.5% | 25.5% | 21.9% | 21.9% | 21.9% | 20.5% | 19.2% |
| Self Discharge | 0.1% | 0.3% | 0.5% | 0.7% | 0.5 | 0.6% | 0.2% | 0.3% | 0.3% |
| DOA | - | 0.1% | - | - | - | - | - | - | - |
| Died in A and E | - | - | - | - | - | - | - | - | - |

**TABLE 13.** Categories of disposal of offshore patients presenting at the Accident and Emergency Department, Aberdeen Royal Infirmary.

# CHAPTER IV

## THE INCIDENCE OF ILLNESS AND INJURY IN BRITISH ANTARCTIC TERRITORIES OVER 25 YEARS

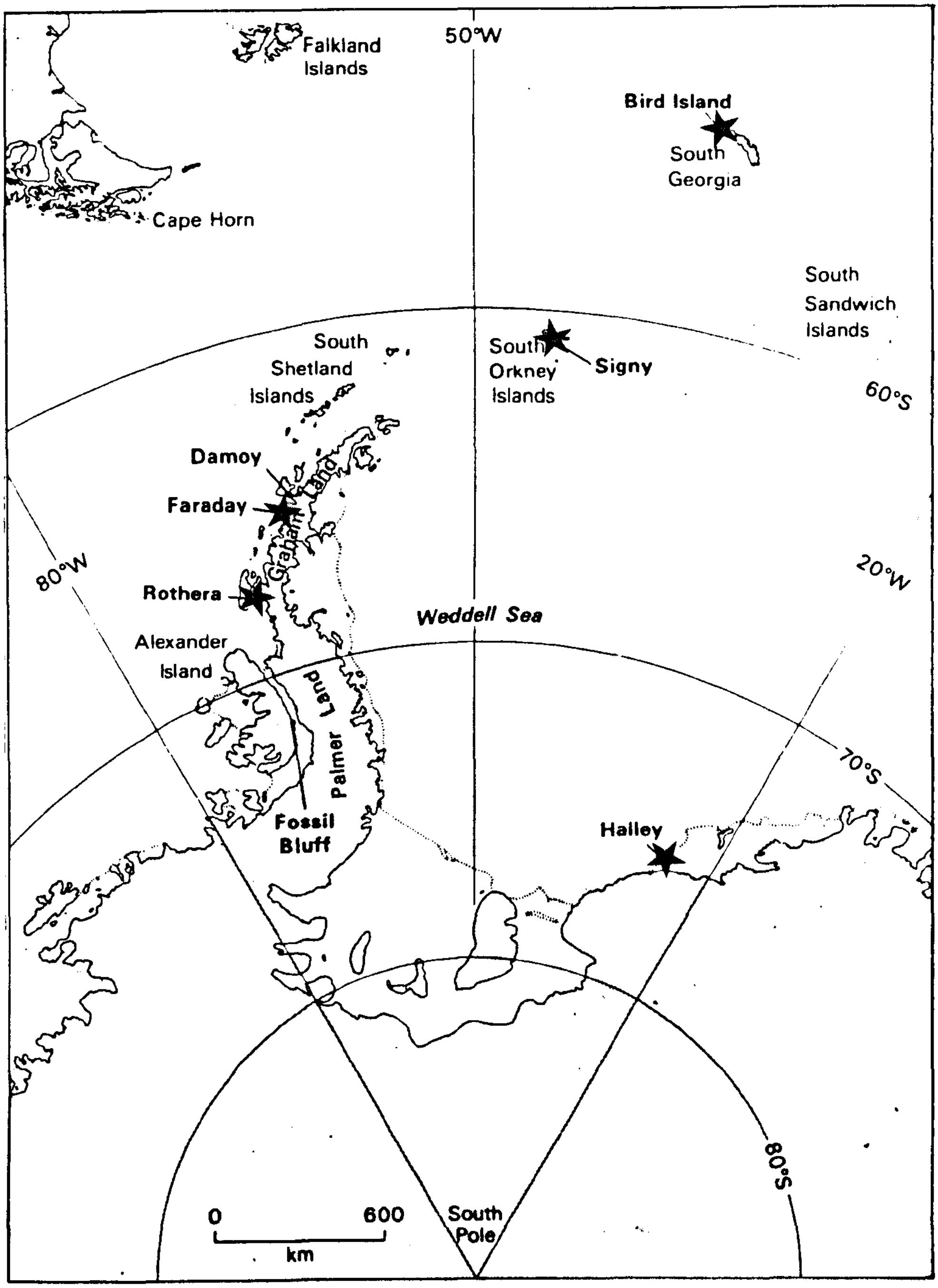


FIGURE 24. Map of Antarctica showing the position of the British Antarctic Survey stations.

FIGURE 24A. The British Antarctic Survey base on Signy Island, (60° South; 45° West).

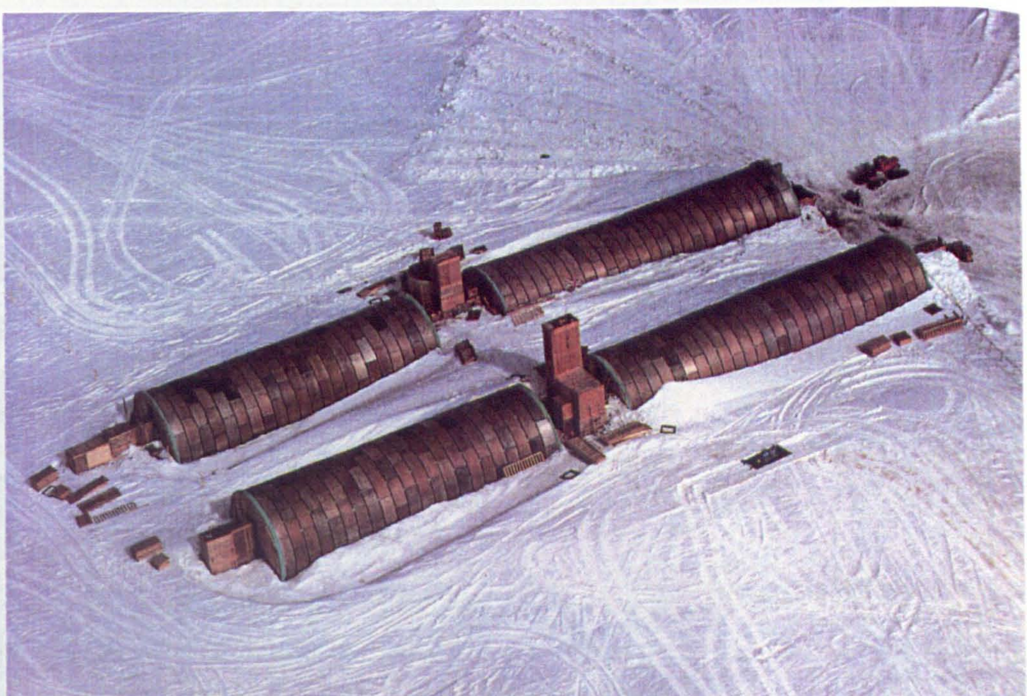

FIGURE 24B. The British Antarctic Survey base at Halley, (75° South; 60° West).

FIGURE 24C. The British Antarctic Survey base at Rothera, (65° South; 64° West).

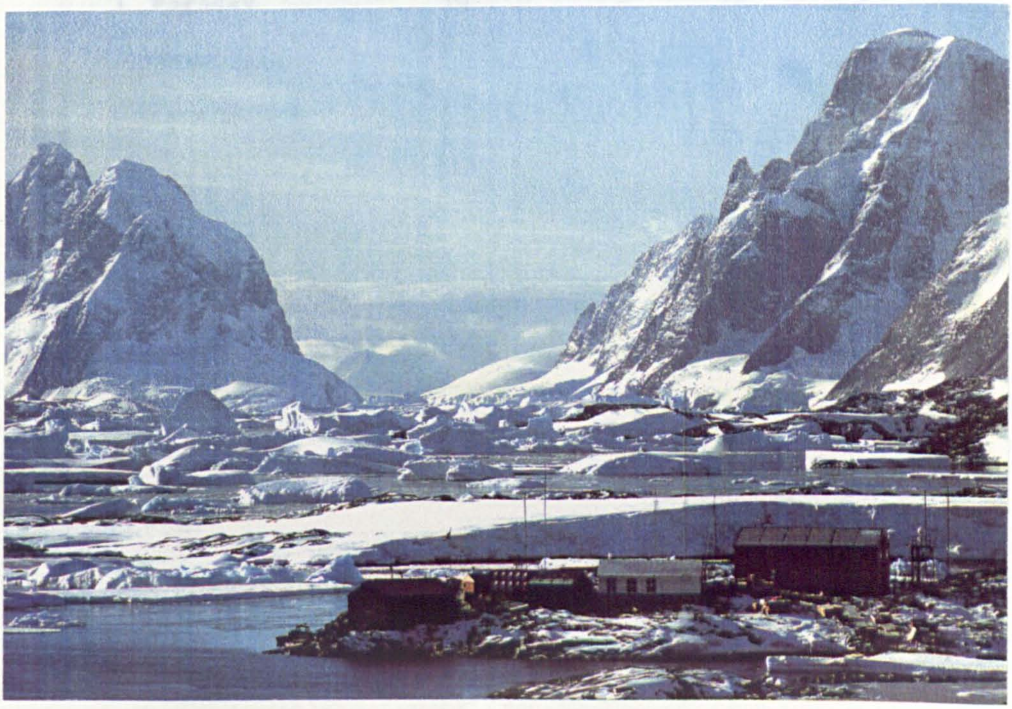

FIGURE 24D. The British Antarctic Survey base at Faraday, (65° South, 64° West).

| Base | Winter | Summer |
| --- | --- | --- |
| Halley | 17 | 17 |
| Signy | 16 | 25 |
| Rothera | 25 | Up to 70 |
| Faraday | 10 | 15 |
| Bird Island | 3 | 3 |

**TABLE 14.** The average winter and summer populations of the British Antarctic Survey bases at the present time.

| | No | % |
|---|---|---|
| Digestive tract (including teeth) | 60 | (23.8%) |
| Skin problems | 54 | (21.4%) |
| Trauma | 52 | (20.6%) |
| ENT | 32 | (12.7%) |
| Eyes | 17 | (6.7%) |
| Diving related | 13 | (5.2%) |
| Respiratory tract | 8 | (3.2%) |
| Genito-urinary tract | 8 | (3.2%) |
| Psychological | 8 | (3.2%) |

**TABLE 15.** Distribution of illnesses and injuries which took place on British Antarctic Survey bases during the season 1987/88.

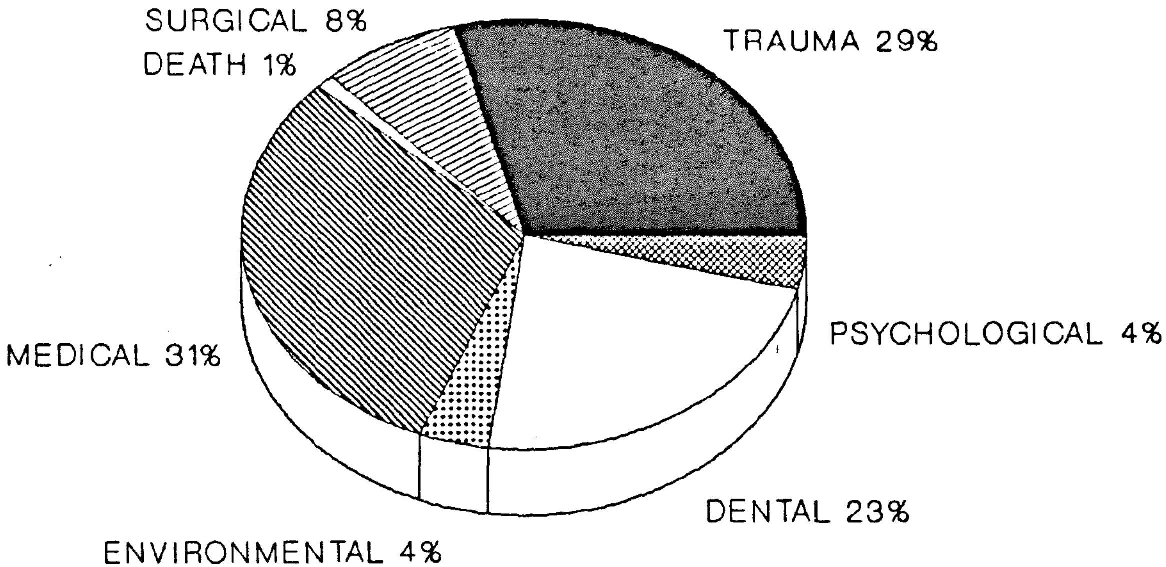


**FIGURE 25. PIE-CHART SHOWING THE DISTRIBUTION OF THE VARIOUS TYPES OF PROBLEM WHICH OCCURED DURING 25YEARS IN THE BASES OF THE BRITISH ANTARCTIC SURVEY.**

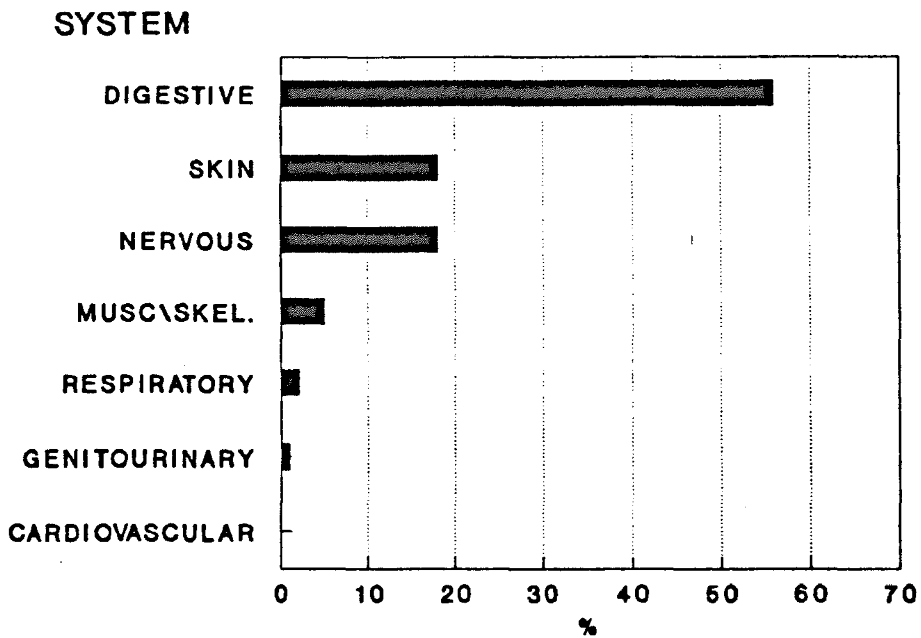


FIGURE 26. BAR CHART SETTING OUT THE DISTRIBUTION OF ILLNESSES WHICH OCCURED IN BRITISH ANTARCTIC SURVEY BASES DURING THE 25YEARS STUDIED.

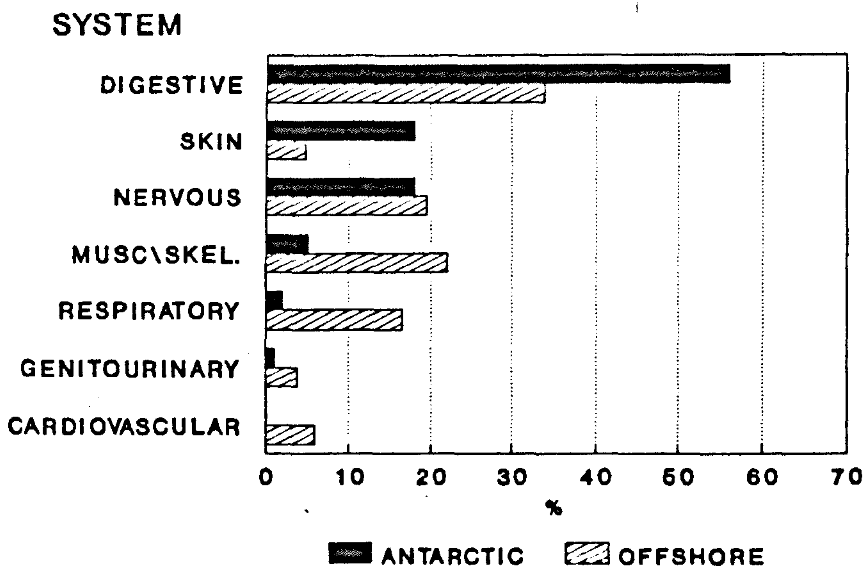


FIGURE 27. DOUBLE BAR CHART COMPARING THE DISTRIBUTION OF ILLNESSES NOTED IN THE BRITISH ANTARCTIC SURVEY STUDY WITH THOSE FOUND IN THE OFFSHORE NORTH SEA STUDY.

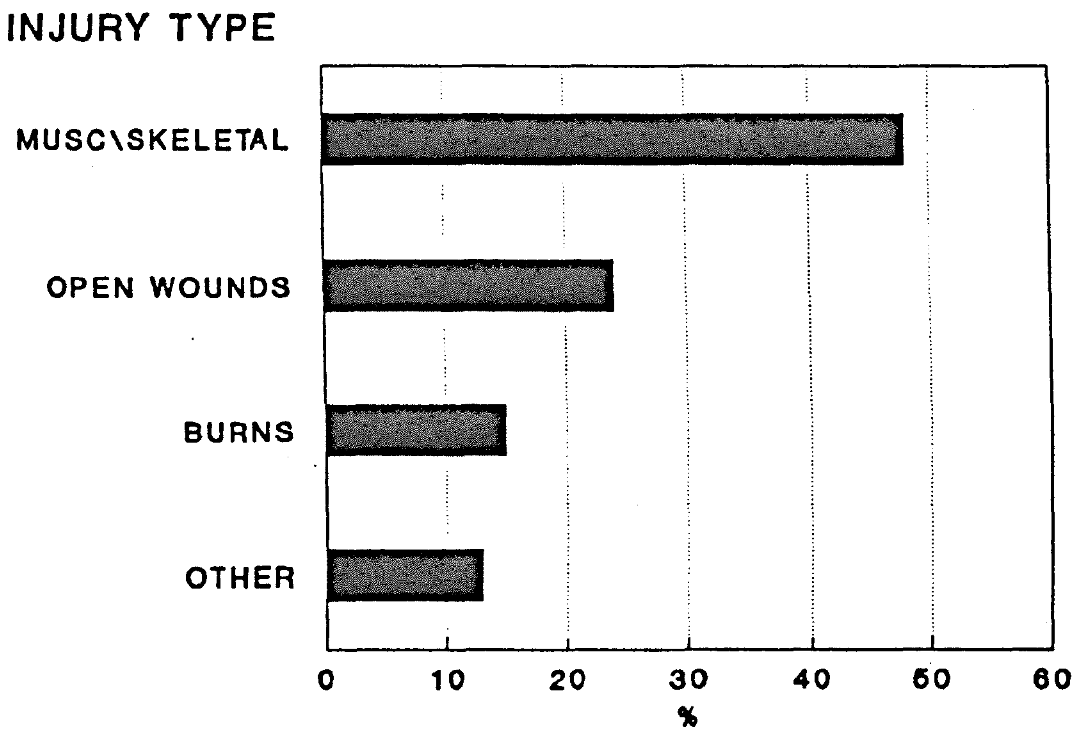


FIGURE 28. BAR CHART SHOWING THE DISTRIBUTION OF INJURIES WHICH OCCURED IN THE BRITISH ANTARCTIC SURVEY BASES DURING THE 25YEARS STUDIED.THE BAR LABELLED OTHER CONTAINS 8% OF EYE INJURIES.

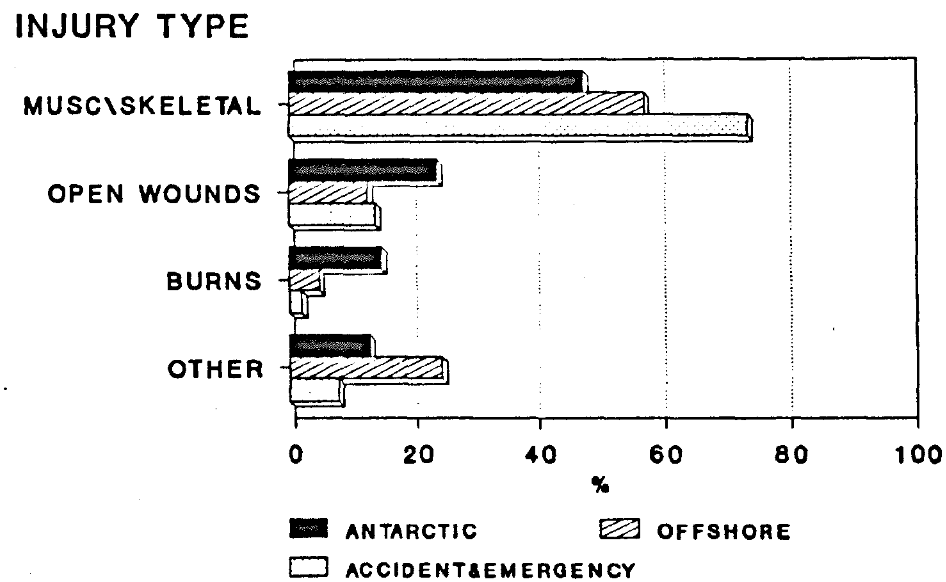


FIGURE 29. TREBLE BAR CHART COMPARING THE DISTRIBUTION OF INJURIES NOTED IN THE BRITISH ANTARCTIC SURVEY WITH THAT FOUND IN THE OFFSHORE NORTH SEA STUDY AND ALSO WITH THE ACCIDENT AND EMERGENCY DEPARTMENT STUDY.

# CHAPTER V

## EVALUATION OF IMMEDIATE CARE TRAINING

## COURSE EVALUATION

**PLEASE CIRCLE THE APPROPRIATE ANSWER**

| | | | | |
|---|---|---|---|---|
| 1. | Before attending the course, did you think it was necessary? | | YES | NO |
| 2. | After attending the course, did you think it was necessary? | | YES | NO |
| 3. | Do you feel the course is | CORRECT LENGTH | TOO LONG | TOO SHORT |
| 4. | If too long, would you shorten it by | 1 DAY | 2 DAYS | MORE |
| 5. | If too short, would you increase it by | 1 DAY | 2 DAYS | MORE |
| 6. | Ratio of theory/practice | CORRECT BALANCE | TOO MUCH THEORY | TOO MUCH PRACTICE |
| 7. | Videos were | VERY USEFUL | USEFUL | NOT USEFUL |
| 8. | Slides were | VERY USEFUL | USEFUL | NOT USEFUL |
| 9. | Course book was | VERY USEFUL | USEFUL | NOT USEFUL |
| 10. | Course handouts were | VERY USEFUL | USEFUL | NOT USEFUL |
| 11. | Standard of teaching was | EXCELLENT / ACCEPTABLE | | GOOD / POOR |
| 12. | I feel an examination should be included | | YES | NO |
| 13. | After completing the course, I felt more confident about dealing with a casualty | | YES | NO |
| 14. | Have you had any previous first aid training? | | YES | NO |
| 15. | On completion of the course, I felt | COMPLETELY SATISFIED / HAPPY / UNHAPPY / COMPLETELY DISSATISFIED | | |

FIGURE 30. The questionnaire used to evaluate the courses.

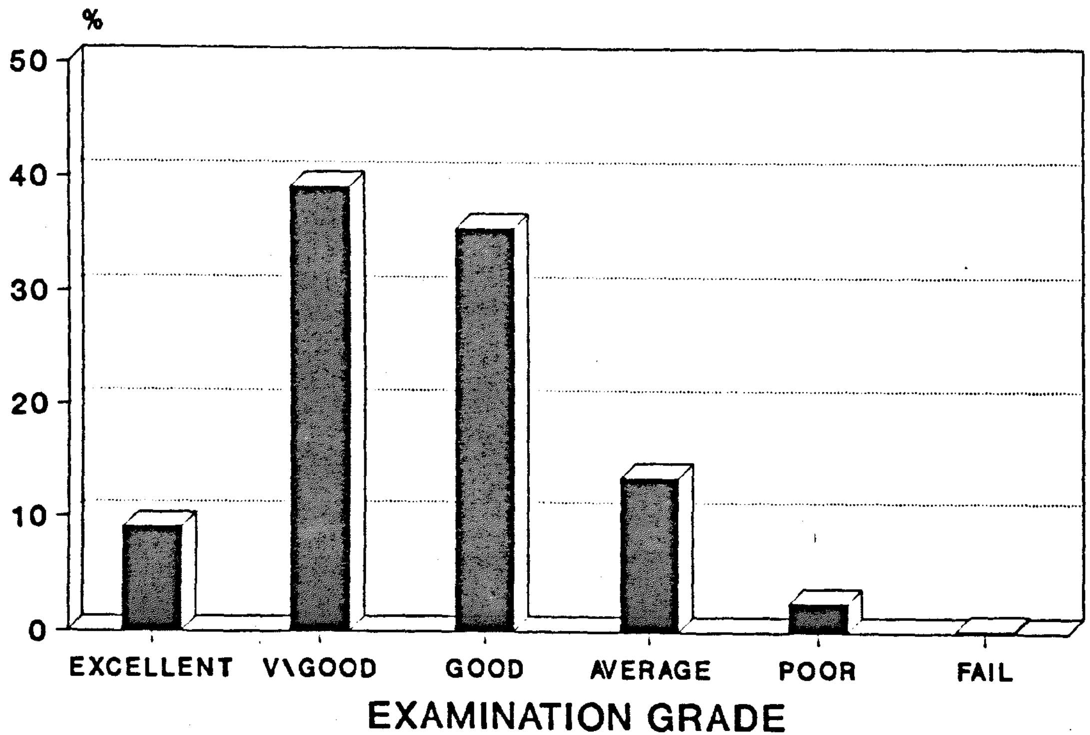


FIGURE 31. BAR CHART SHOWING THE DISTRIBUTION OF EXAMINATION GRADES AWARDED TO THE STUDENTS ATTENDING ALL THE COURSES EVALUATED.

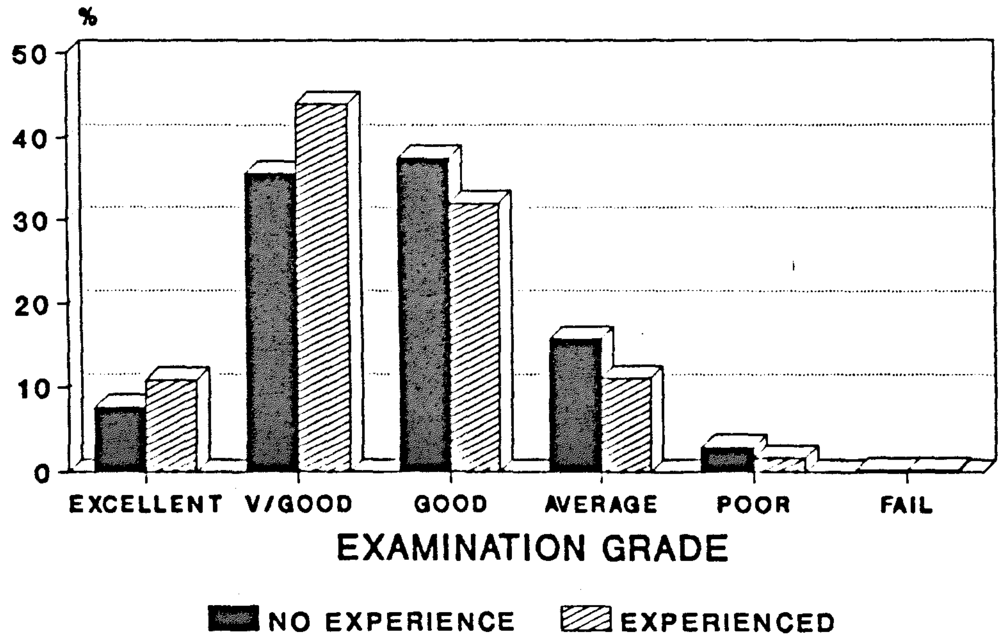


FIGURE 32. DISTRIBUTION OF EXAMINATION GRADES IN THOSE WHO HAD NOT PREVIOUSLY RECEIVED TRAINING IN IMMEDIATE CARE AND IN THOSE WHO HAD PREVIOUS EXPERIENCE.

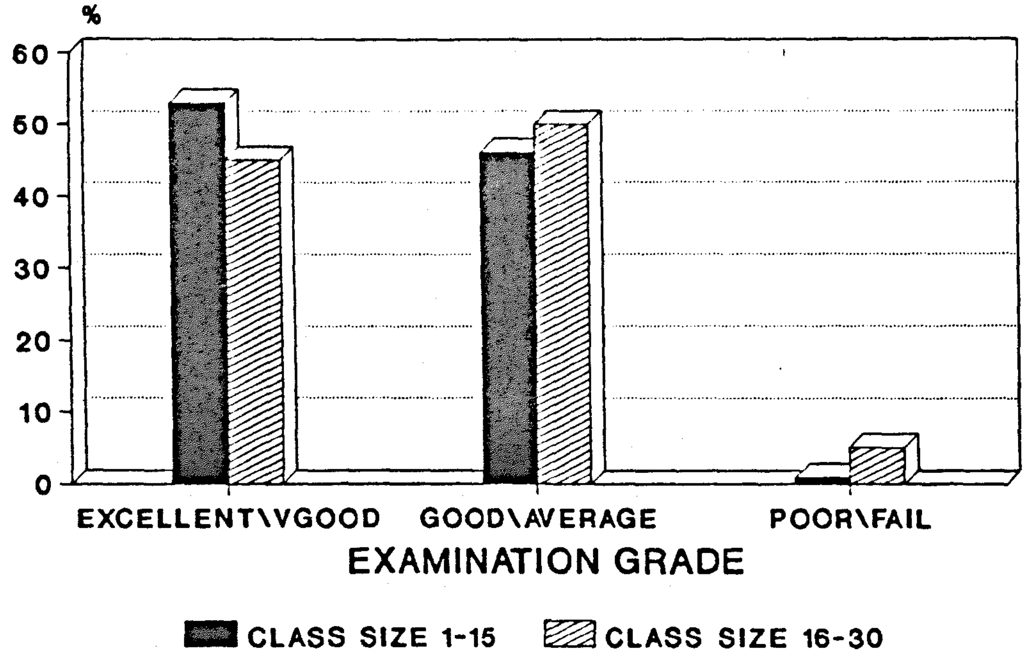


FIGURE 33. DISTRIBUTION OF EXAMINATION GRADES COMPARING CLASSES OF LESS THAN FIFTEEN STUDENTS WITH CLASES CONTAINING 16-30 STUDENTS.

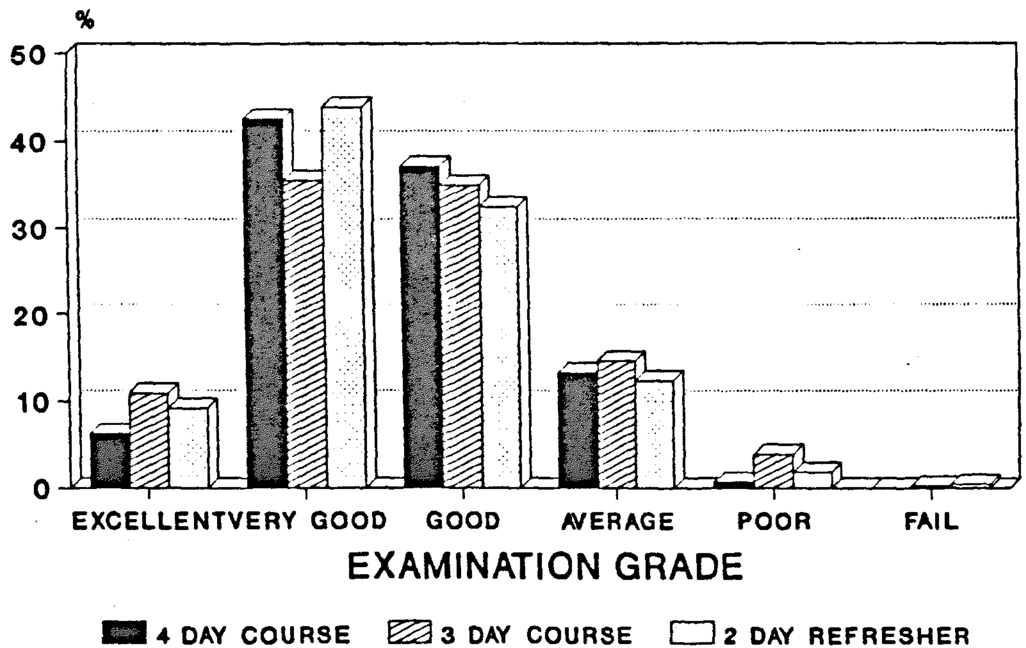


FIGURE 34. DISTRIBUTION OF EXAMINATION GRADES COMPARING THE FOUR DAY COURSE WITH THE THREE DAY COURSE AND THE TWO DAY REFRESHER COURSE.

| | Class Size | | Overall |
|---|---|---|---|
| | 1-15 | 15-30 | |
| Excellent | 19% | 21% | 20% |
| Good | 81% | 79% | 80% |
| Average | 0 | 0 | |
| Poor | 0 | 0 | |

**TABLE 16.** Trainees' assessment of the teaching standard of the course in those who were part of classes containing less than 15 trainees.

| | Class Size | | Total |
|---|---|---|---|
| | 1-15 | 15-30 | |
| Completely Satisfied | 40.0% | 41.0% | 40.4% |
| Happy | 60.0% | 59.0% | 59.6% |
| Unhappy | 0 | 0 | 0 |
| Completely Disatisfied | 0 | 0 | 0 |

**TABLE 17.** Trainees' assessment of the teaching standard of the course in those who were part of classes containing more than 15 trainees.

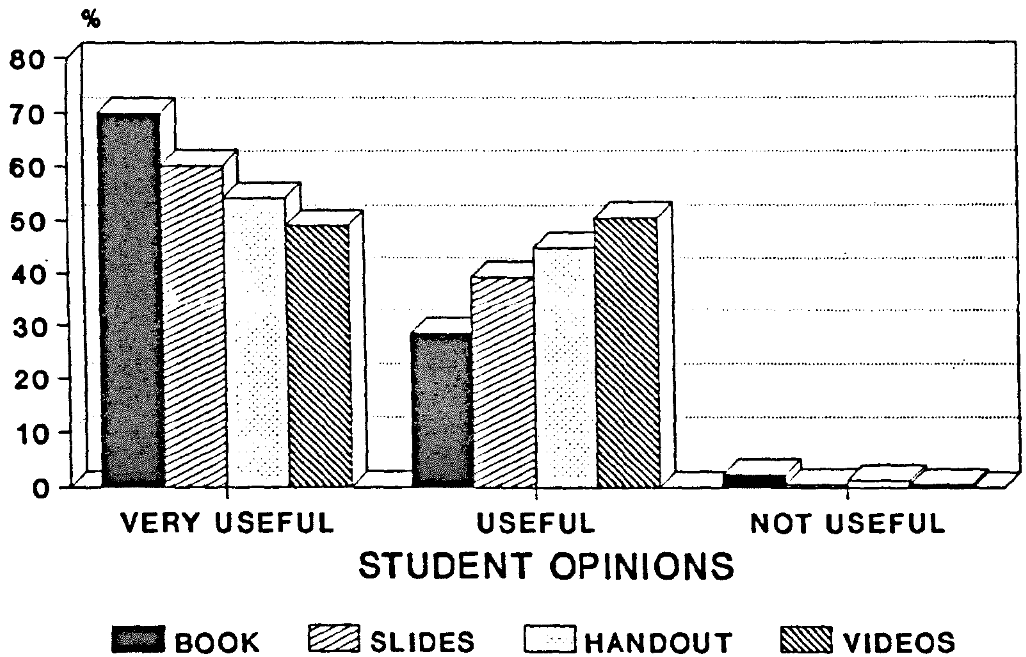


FIGURE 35. DISTRIBUTION OF STUDENT OPINIONS ON THE VALUE OF THE VARIOUS VISUAL AIDS USED.

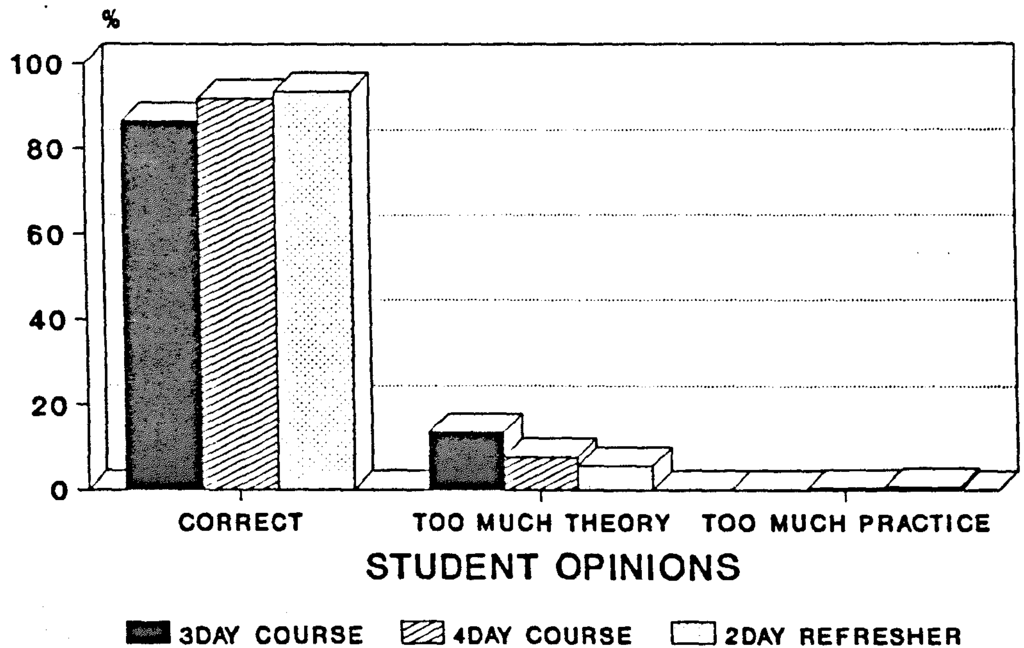


FIGURE 36. DISTRIBUTION OF STUDENT OPINIONS ON THE BALANCE BETWEEN THEORY AND PRACTICAL WORK IN THE COURSES EVALUATED.

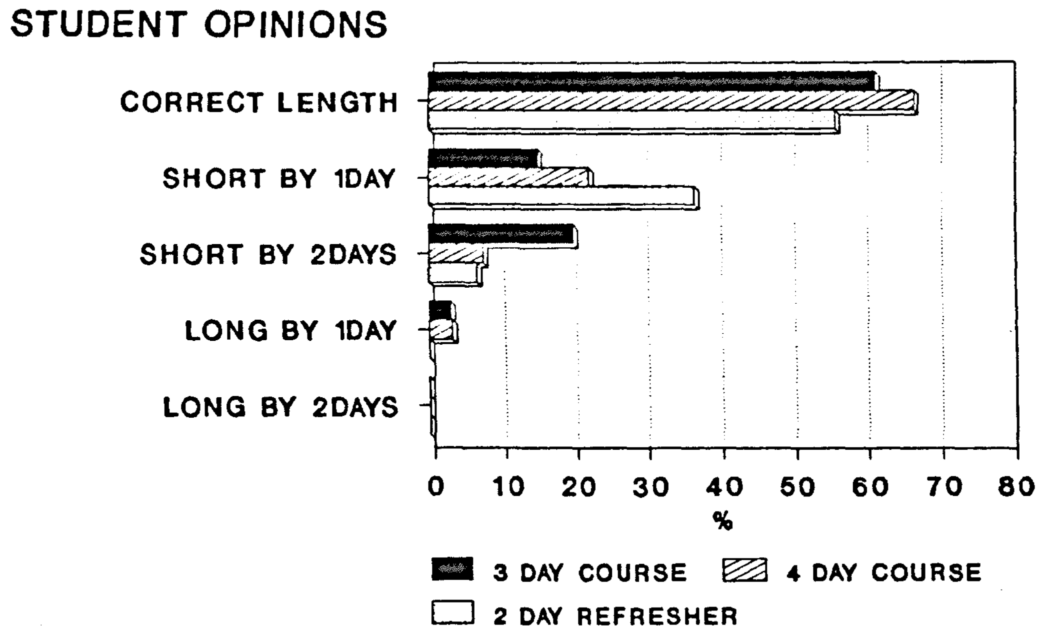


FIGURE 37. DISTRIBUTION OF STUDENT OPINIONS ON THE LENGTH OF THE VARIOUS COURSES EVALUATED.

# CHAPTER VI

# COMMUNICATION SYSTEMS FOR REMOTE HEALTH CARE

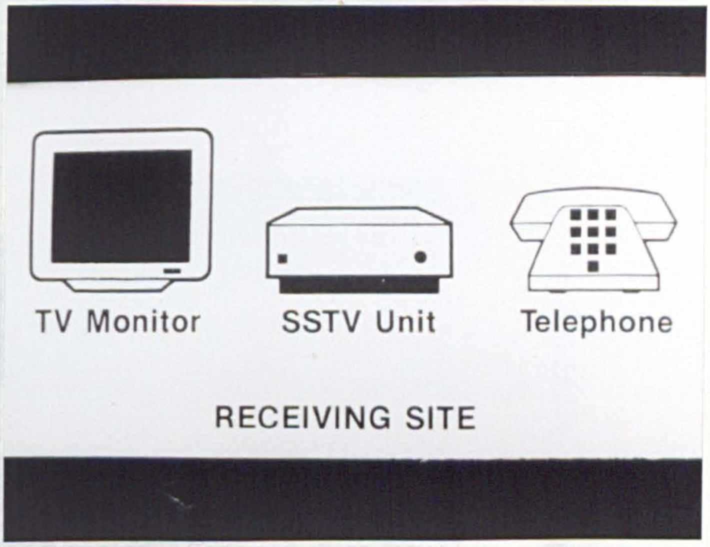


FIGURE 38. Slow Scan Television System.

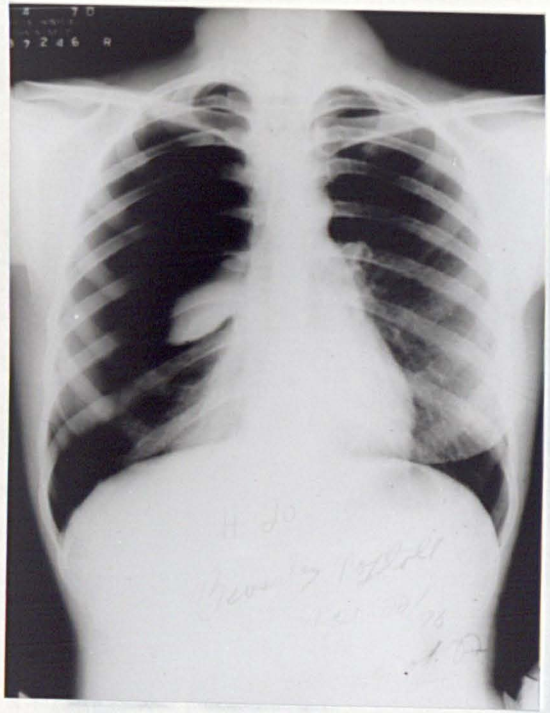

FIGURE 39(i). Pneumothorax.

FIGURE 39(ii). Obstructed right kidney.

FIGURE 39(iii). Depressed fracture of occiput.

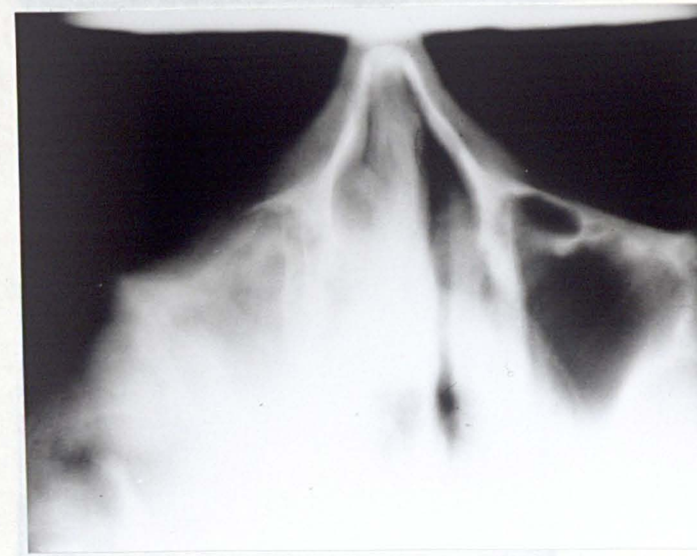

FIGURE 39(iv). Fracture of lower lateral wall of maxillary antrum.

FIGURE 39(v). Intestinal obstruction.

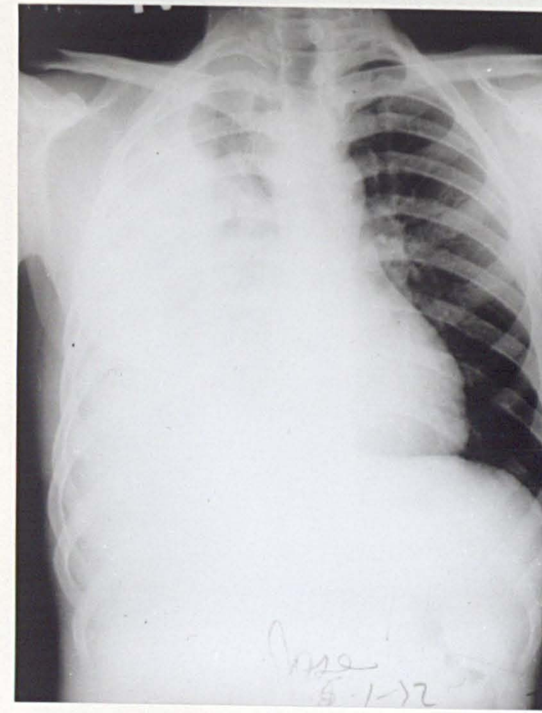

FIGURE 39(vi). Pleural effusion.

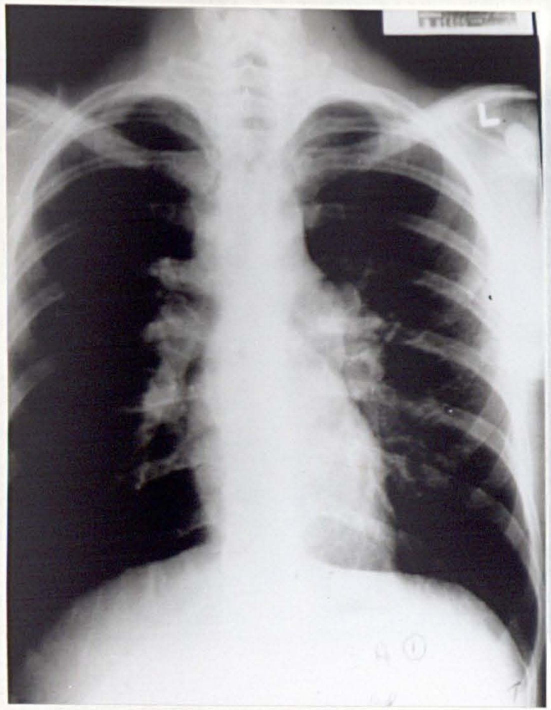

FIGURE 39(vii). Normal chest X-ray.

FIGURE 39(viii). Fractured cervical spine.

FIGURE 39(ix). Hairline fracture of parietal bone.

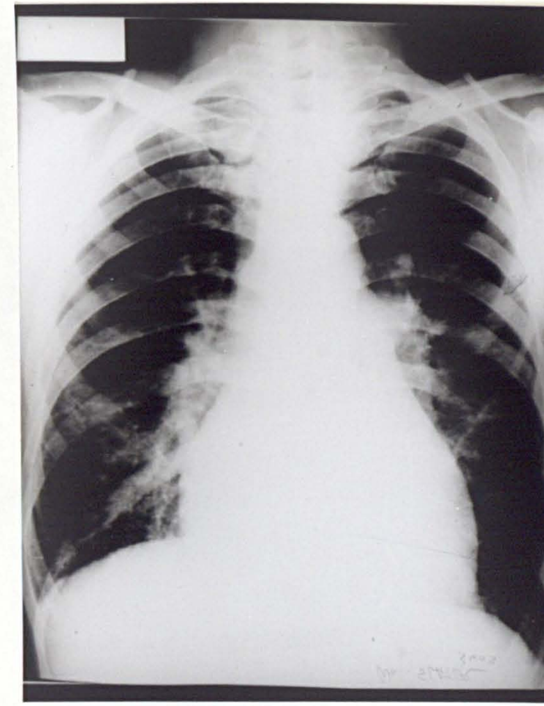

FIGURE 39(x). Mitral valve disease.

| X-RAY QUALITIES | GRADE % |
| --- | --- |
| Technical Quality | 95.0 |
| Confidence in Findings | 98.8 |
| Confidence in Diagnosis | 96.3 |

**TABLE 18.** Mean values of the grades given to the original X-rays when assessed by Radiologist A on basis of three different headings.

| X-RAY QUALITIES | GRADE % | CORRECTED GRADE % |
|---|---|---|
| Technical Quality | 79.0 | 83.2 |
| Confidence in Findings | 88.8 | 89.9 |
| Confidence in Diagnosis | 86.3 | 89.6 |

**TABLE 19.** Mean values of the grades given by Consultant Radiologist B, in Aberdeen, when the images were transmitted by SSTV from St John's. The corrected grade was that provided when a weighting factor was applied to take account of Consultant Radiologist A's assessment of the original X-rays.

| X-RAY QUALITIES | GRADE % | CORRECTED GRADE % |
|---|---|---|
| Technical Quality | 72.5 | 76.3 |
| Confidence in Findings | 86.6 | 87.7 |
| Confidence in Diagnosis | 86.6 | 87.7 |

**TABLE 20.** Mean values of the grades given by Consultant Radiologist C, in St John's when X-ray images were transmitted by SSTV from Aberdeen. The corrected grade was provided when a weighting factor was applied to take account of Consultant Radiologist A's assessment of the original X-rays.

| X-RAY QUALITIES | GRADE % | CORRECTED GRADE % |
| --- | --- | --- |
| Technical Quality | 73.0 | 76.8 |
| Confidence in Findings | 85.0 | 86.0 |
| Confidence in Diagnosis | 85.0 | 86.0 |

**TABLE 21.** Mean values of the grades given by Consultant Radiologist D in Aberdeen, when X-ray images were transmitted by SSTV from the Antarctic. The corrected grade was provided when a weighting factor was applied to take account of Consultant Radiologist A's assessment of the original X-rays.

# CHAPTER VII

# AN INVESTIGATION INTO HEAT ILLNESS IN THE ARABIAN GULF

| | Average | Range |
|---|---|---|
| Age (years) | 30.8 | 20 - 41 |
| Height (cm) | 170.8 | 159 - 187 |
| Weight (kg) | 68.9 | 59 - 93 |

**TABLE 22.** The mean physical characteristics of the casualties.

| | Average | Range |
|---|---|---|
| Ambient Temp ($^{o}C$) | 34.0 | 30.8 - 37.0 |
| Wind Speed (knots) | 7.0 | 6.3 - 7.7 |
| Relative Humidity (%) | 52.9 | 42.6 - 66.7 |

**TABLE 23.** The environmental factors present on average when the cases of heat illness occurred.

| | Average | Range |
|---|---|---|
| Temp ($^{o}C$) | 36.7 | 36.0 - 37.4 |
| Pulse Rate (beats/min) | 86.9 | 64 - 108 |
| Blood Pressure | 118/81 | 100 - 150 / 70 - 100 |
| Respiratory Rate (beats/min) | 20 | 16 - 22 |

**TABLE 24.** The clinical measurements made on the cases of heat illness when they presented at the hospital.

| | Average | Range |
|---|---|---|
| Specific Gravity | 1.015 | 1.000 - 1.025 |
| Chloride gm/dl | 0.5 | 0.1 - 1.4 |

**TABLE 25.** Measurements made on the first urine specimen obtained in the hospital.

| | Mean | Range |
|---|---|---|
| Sodium (mmol/L) | 151.3 | 146.2 - 160.4 |
| Potassium (mmol/L) | 4.4 | 3.5 - 5.7 |
| Chloride (mmol/L) | 100.7 | 93.0 - 108 |
| Urea (mg/dl) | 32.2 | 17.0 - 45.0 |

**TABLE 26.** Measurements of serum electrolytes and urea made on the casualties on admission to the hospital.

| | | |
|---|---|---|
| Blood Urea | 10 - 45 | mg/dl |
| Serum Sodium | 135 - 140 | mmol/litre |
| Serum Potassium | 3.8 - 5.0 | mmol/litre |
| Serum Chloride | 96 - 108 | mmol/litre |
| Haemoglobin | 14 - 18 | G/litre |

**TABLE 27.** Range of normal values quoted from the hospital laboratory on Das Island, Arabian Gulf.

| | Mean | Range |
|---|---|---|
| Haemoglobin (gm/l) | 15.0 | 12.1 - 17.1 |
| Packed Cell Volume (%) | 47.7 | 42.0 - 54.0 |
| Mean Corpuscular Haemoglobin Concentration (gm/dl) | 30.4 | 28.6 - 34.2 |

**TABLE 28.** Haematological measurements made on the cases of heat illness following admission to the hospital.

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