Medical aspects of the expeditions of the Heroic Age of Antarctic exploration (1895-1922)

Submitted by Dr Henry Raymund Guly FRCP FRCEM to the University of Exeter as a thesis for the degree of Doctor of Philosophy by publication in History.

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Abstract

This thesis describes medical aspects of the expeditions of the Heroic Age of Antarctic exploration (1895-1922). It is divided into three sections.

Section 1 describes the drugs and medical equipment taken to the Antarctic by these expeditions. There is an introductory discussion followed by papers on ophthalmic drugs, injections, inhalations and suppositories, oral drugs and topical preparations. Sledging medical cases are considered separately. Brandy was often used as a medicine and the medical uses of alcohol are described. Some expeditions took what were described as “medical comforts”. This term was sometimes used as a euphemism for alcoholic beverages but, in fact, encompassed a wide range of foods for invalids. Burroughs Wellcome and Co. supplied many of the expeditions with drugs and their medical chests. They used the expedition link in their advertising and the relationship between the expeditions and drug companies is described.

Section 2 describes some of the medical problems encountered. The most serious problems were scurvy and a condition often called “polar anaemia”, which seems to be the same as a condition known at the time as “ship beriberi” and what is now described as “wet beriberi”. The controversy as to whether Captain Scott and his colleagues died of scurvy is also discussed. Other problems included frostbite and snow blindness. At least 11 general anaesthetics were given, including two for amputation of frostbitten toes. Psychological problems were common and there was some serious psychiatric illness including alcohol abuse.

Section 3 describes the doctors and some of the research that they carried out. The most common research done by doctors was bacteriological. Most doctors collected biological data on the explorers including weights and haemoglobin measurements. This was largely for health monitoring but one doctor pursued physiological research. Three doctors and a medical student studied geology.

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Abbreviations used in this thesis

AAE	Australian Antarctic Expedition
AM	Albert Medal
BAE	British Antarctic Expedition
BAS	British Antarctic Survey
BASMU	British Antarctic Survey Medical Unit
BNAE	British National Antarctic Expedition
BW&Co	Burroughs Wellcome and Company Ltd.
DSO	Distinguished Service Order
gr	grain (as a drug dose)
ITAE	Imperial Transantarctic Expedition
kg	kilogram
lb	pound (weight)
MD	Doctorate of Medicine
mg	milligram
min	minim (drug dose)
m/mol	millimole
mmHg	millimetres of mercury
NZ	New Zealand
oz	ounce
PhD	Doctorate of Philosophy
REM	rapid eye movement
RN	Royal Navy
SAD	seasonal affective disorder
T3 (as in polar T3 syndrome)	triiodothyronine
µm	micrometre

Introduction

General introduction

In 1997 the Emergency Department at Derriford Hospital took on the contract for running the British Antarctic Survey Medical Unit (BASMU), which has the responsibility for providing medical services to the Antarctic bases and ships run by the British Antarctic Survey. The Director of BASMU was Mr Iain Grant but I was involved in BASMU from then until I retired in 2011 and I continue to lecture on the MSc in Remote Healthcare that is part of the training for doctors who are employed by BASMU (and others). As a result of that, I developed an interest in Antarctic medicine. I have also been fortunate to visit British bases and ships in Antarctica on behalf of BASMU on three occasions. From this, I became interested in the history of Antarctic exploration and on reading many of the books about the Antarctic, I became fascinated by the medical aspects of those expeditions.

The exploits of Robert Scott, Roald Amundsen and Ernest Shackleton in their bids to be first at the South Pole are well known and numerous books have been written about them. These books tell of frostbite, snow blindness, scurvy and the deaths of Scott and four companions on his second expedition and there were other deaths among Shackleton's Ross Sea Party and Scott's *Discovery* expedition. Less well known is the fact that there were no fewer than 18 expeditions to the Antarctic from eight nations during the Heroic Age of Antarctic exploration, excluding the voyages by the *Morning* and *Terra Nova* to relieve the *Discovery*, as well as the missions to rescue the survivors of the shipwrecks of the *Endurance* and the *Antarctic*. The majority carried one or more doctors and most expeditions experienced medical problems, with deaths on the majority of them. The aim of my research was to fully explore the experiences, challenges and roles of expedition doctors during the Heroic Age of Antarctic exploration (1895-1922), and to situate their beliefs and practices in the social and medical context of the turn of the twentieth century. Most previous writing on the Antarctic has been about specific expeditions, individual expedition leaders or, perhaps, linking two or more expeditions such as the two German expeditions, the rivalry between Scott and Shackleton, or the "race" to

the South Pole by Scott and Amundsen. This research uses information from all the expeditions of the era.

The Heroic Age: science, exploration and empire

Antarctic exploration can, perhaps, be said to have started on 17th January 1773 when Captain Cook became the first man to cross the Antarctic Circle. Exploration continues to the present time but this thesis covers the Heroic Age as this is of particular historic interest.

The start of the Heroic Age of Antarctic exploration is generally accepted as 1895 when the International Geographical Congress resolved:

> "that the exploration of the Antarctic Regions is the greatest piece of geographical exploration still to be undertaken. That, in view of the additions to knowledge in almost every branch of science which would result from such a scientific exploration, the Congress recommends that the scientific societies throughout the world should urge, in whatever way seems to them most effective, that this work should be undertaken before the close of the century."[1]

The first expedition following the International Geographical Congress resolution was the *Belgica* expedition (1897-9) and this was also the first to over-winter in the Antarctic. Polar historians debate when the Heroic Age ended: some say that it concluded with the end of Sir Ernest Shackleton's *Endurance* expedition but others feel that Shackleton's death is a more logical end of the era. This study takes the end of Shackleton's final expedition – 1922 – as the end of the Heroic Age.

As the Congress suggested, the justification for most of the expeditions was science and the scientific importance of the proposed exploration was described by Murray and others in 1897.[2] It was also described in guides published for the *Discovery* and *Pourquoi Pas?* expeditions.[3, 4] Perhaps most obviously, Antarctica was the last totally unknown area of the world. Its edges had not been mapped and it was even uncertain as to whether it was a continent or a series of islands linked by ice. There were new fauna and flora to be investigated: whales, seals and penguins had been hunted but never properly

studied, but perhaps more important were the smaller and microscopic fauna and flora including worms, parasites and plankton, many of which were previously unknown. A number of the doctors contributed to this zoological and botanical research. The geology was important and I have described this, and the three doctors and medical student who contributed to it, in section 3d. There was also an understanding that the Antarctic weather might influence the weather in other parts of the world and that many of the ocean currents had their origin in the Antarctic ice and so both of these needed study, along with magnetism because of its importance for navigation. Not mentioned by Murray was the relatively new science of bacteriology. Some bacteriology had been done in the Arctic and it was felt important to investigate whether the Antarctic was similar. This is described in section 3b.

A successful expedition added to national prestige but there were other motives in addition to the science. The second half of the 19th century was a time of major colonial expansion, in particular the "scramble for Africa," and parts of Antarctica were claimed for the explorers' country. The British had played a major role in the exploration of the Arctic but were beaten by the Norwegians to the discovery of the North West Passage in 1906 and by the Americans to the North Pole in 1909 and so it became important that Scott was the first to the South Pole. This has been explored in a recent book by Maddison who uses the phrase "scramble for Antarctica".[5] This refers mainly to a later time than the Heroic Age, and has resulted in overlapping claims, with a part of the Antarctic Peninsula currently claimed by the UK, Argentina and Chile. National pride, however, did not prevent cooperation between nations. Thus the British sought advice from the Norwegian, Nansen who was, perhaps, the greatest Arctic explorer, and the British *Discovery* and German *Gauss* expeditions cooperated especially over research into magnetism. In addition, members of expeditions were celebrated, and personal ambition and rivalry played a role in many of the expeditions: Scott, Shackleton and Amundsen all wanted to make their name by discovering the South Pole and Sir Clements Markham used his position as Secretary to the Royal Geographical Society to further a long-standing ambition to organise polar expeditions led by the Royal Navy, seeing Shackleton's and Bruce's expeditions as drawing funds and publicity from his own plans. Expeditions were also seen as a means of employing and maintaining the skills

of naval officers in times of peace. The history of scientific expeditions has been described by MacLeod.[6]

The funding of expeditions came from various sources. Many of the scientific expeditions received significant funding from governments and scientific bodies, but some were private expeditions and relied more on donations and sponsorship. Newspapers sponsoring expeditions could get exclusive stories and major sponsors might get their name attached to a part of this new continent. Thus the Caird Coast and Coats Land are named for sponsors of the *Endurance* and *Scotia* expeditions respectively. Smaller sponsors would donate, or sell at cost price, food and equipment and would use the Antarctic connection in their advertising. I have given examples of advertising of drugs and medical equipment (section 1h), medical foods (section 1j) and alcohol (section 2i) but other foods, clothing, ink, photographic equipment, tents and many other items were advertised using the Antarctic connection.[7]

This era of Antarctic exploration is described as the "Heroic Age".[a] Haddelsey suggests that this term was first used by the British polar historian J. Gordon Hayes in 1932 in his book, *The Conquest of the South Pole*, where he wrote: 'As a small tribute to these gallant men it is suggested that this period should be known as the Heroic Era of Antarctic Exploration.'[8] Although perhaps a cliché, the label needs explanation. Shackleton is supposed to have advertised for expedition members using the words:

> "Men wanted for hazardous journey. Small wages, bitter cold, long months of complete darkness, constant danger, safe return doubtful. Honour and recognition in case of success." [9]

He could have added other words such as discomfort, poor food and isolation with no contact with the outside world in the event of anything going wrong. The source of this has never been found and he probably never did write these words but this quote sums up the difficulties and dangers that expedition members might face in the name of exploration, science and national pride and this was regarded as heroic. In particular, Robert Falcon Scott was, for many years considered to be the embodiment of the qualities of heroism and self-

[a] The words "Heroic Age" are sometimes capitalised and sometimes not, depending on the house style of the publishers or journal.

sacrifice. Later expeditions shared many of the hardships and risks but had learned from the early explorers and did have radio communication with the outside world.

The historical interest of the Heroic Age, is shown by the large number of books published about this period and the fact that new books are still being written. Haddelsey has noted references to expedition leaders on the internet: there are over a million internet references to Shackleton and nearly 800,000 to Scott. The highest scoring leader of an expedition in what he calls the "Post Heroic Age" was Vivian Fuchs but his internet references were just 5.2 per cent of the number of references to Captain Scott.[8]

Medicine in the Antarctic

This study links two topics – Antarctic exploration and medicine at the end of the 19th and beginning of the 20th century. As far as Antarctic exploration is concerned, medicine (now, as well as then) plays a very small role compared to the major problems of exploration, scientific research and logistics. The exploring parties were mostly small groups of healthy young men who would not be expected to become unwell. Yet the role for doctors was, and still is, considered vital as the environment is hostile, injuries and scurvy could be expected and evacuation of casualties impossible. Although Antarctic medicine is a very specialised and tiny part of medicine, this study also throws light on medicine as it was practised in that era.

As Bynum has described, the period 1870-1920 was a time of great change in medicine and therapeutics.[10] The discovery of bacteria had sparked the new science of bacteriology. Germ theories of disease causation which were initially resisted by many doctors brought great benefits when the causes of previously unexplained diseases were found. They also, however, caused difficulties by slowing down the discovery of the cause of non-bacterial diseases when these were attributed to as yet undiscovered bacteria. Thus scurvy was attributed to a bacterial toxin and beriberi was also thought to have a bacterial cause.[11] On the other hand, Carter suggests that the adoption of germ theories entailed fundamental changes in the concept of disease and the way that diseases should be investigated to demonstrate causation. Our current understanding, for

instance, of vitamin deficiency diseases can be seen as a direct consequence of the changes resulting from the adoption of germ theory.[12] The discovery of vitamins during the time of the Antarctic expeditions is reflected by the changing understanding of scurvy and beriberi over this era as I describe in sections 2a and 2b.

Bacteriology was still performed by generalist doctors rather than specialised bacteriologists and was one of the sciences studied by the doctors on a number of the expeditions (see section 3b). The end of the 19th century also saw the emergence of scientific and laboratory medicine, particularly in physiology, which led to new forms of medical education despite much opposition from those who thought medicine was an art rather than a science and that the introduction of measuring instruments would reduce clinical acumen. The introduction of the sphygmograph, the sphygmomanometer, the polygraph and, later, the electrocardiogram led to the development of cardiology as a specialty though, again, with opposition from those who felt subdividing the practice of medicine into ever smaller parts of the body was a weakness. These developments and arguments have been described by Lawrence.[13, 14] Dr McLean was the first doctor to do physiological research in the Antarctic though others used a sphygmograph (see section 3c).

This was also a time of discovery of new drugs. Burger lists 15 drugs that were discovered or synthesised between 1880 and 1909,[15] and Swann gives another two.[16] The influence of the introduction of new drugs is shown in the Antarctic by aspirin replacing sodium salicylate and adrenaline (hemasin), and novocaine being introduced on later expeditions. Endocrinology developed from the 18th century but particularly in the late 19th century with the active ingredient of the thyroid being described in 1895 and the word hormone being coined in 1906.[17] Doctors tried to find uses for these new discoveries and thus it was wondered if thyroid extract might be useful for scurvy (see section 2a). Antisepsis and anaesthesia had not only improved the prognosis of surgery but enabled a wider range of surgical procedures. Other improvements included vaccines, serum therapy and X-rays,[18] though these were not used in the Antarctic.

Antarctic medicine past and present

Many aspects of medicine in early Antarctic exploration are unique. Expeditions were isolated for several years and were operating in a harsh environment with medical problems specific to that environment, especially those related to the cold and the 24 hour darkness of the Antarctic winter. Some of the doctors were very inexperienced. There were a number of deaths and these and some of the illnesses influenced the outcome of some of the expeditions. Despite these unique aspects, there are obviously links with medicine at sea, military medicine, medicine in the whaling industry and medicine on other types of expeditions and so this study throws light on these areas as well.

Many aspects of Antarctic medicine today are, of course, very different from that of 100 years ago. Some of the diseases such as scurvy and beriberi are no longer seen in practice but others, including frostbite and snow blindness, are still potential problems. Hypothermia is an obvious risk and undoubtedly occurred but does not seem to have been well recognised.

However, there are also similarities with modern Antarctic medicine and we can still learn lessons from our forebears. Doctors are not treating “patients” – they are treating their friends (and, occasionally, enemies) and single-handed doctors have to treat themselves. Psychological problems in small isolated communities in harsh conditions are still a major challenge and have been identified as a potential problem in future manned space travel. While some of the psychological problems will be the same, others may be very different: isolation is reduced by modern methods of communication and the presence of women on modern Antarctic bases will alter inter-personal dynamics from those on an all-male base. Alcohol abuse can still be a problem. The modern Antarctic doctor is usually still young and, while they may have been qualified for four or five years (compared with some of the Heroic Age doctors who had been qualified for months), medicine is much more specialised than 100 years ago and so the doctors still feel inexperienced. Those who over-winter now, as then, tend to be medically-screened, young and fit. Modern doctors, like their predecessors, will hopefully find their medical skills under-used and need to find other roles to keep them occupied but if a person becomes seriously ill, this disrupts the entire base and the doctor suddenly has the key role.

While early death from disease and injury was common 100 years ago, 21st century populations expect to live to well beyond three score years and ten and so, in some ways, pressures on modern doctors may be greater. Although evacuation of injured or ill casualties may be able to be arranged within hours or, at most, a few days in the Austral summer, winter evacuation is still difficult and it may take several months to evacuate a casualty from some of the bases in winter. If a person dies, the doctor may have feelings of professional inadequacy but in addition, as a member of a close-knit group, will have the same grief-feelings as the rest of the team, but must still rise above it to support the team. They are part of the group but, at times, have to be separate from it. There may be difficulties in balancing care for the individual with care for the base as a whole. Medical confidentiality means that expedition members can confide in the doctor and some base commanders see this as undermining their authority. Doctors still need to find the balance between having enough drugs and medical stores to cope with every eventuality and having to restrict the weight of the medical kit to go on an aircraft or sledge. A single-handed doctor is still on call 24 hours a day while on base but if they go into the field, the base still needs medical cover so an essential part of their work is to train others in basic and advanced first aid. The doctor is just as likely to become ill or injured as anybody else and these first aiders will also be needed if that happens.

Although medical science has made enormous progress, perhaps the main difference between Antarctic medicine then and now is improved communications. None of the expeditions I discuss had the use of aircraft and only one had any radio contact with the outside world (and that was intermittent and only for the second year of the expedition), whereas today's Antarctic resident has radio, telephone and internet communication and a doctor can seek advice easily and send photographs and X-rays via the internet, for an expert opinion.

Previous research on the history of Antarctic medicine

There are a few general papers on Antarctic medicine during the Heroic Age. Dr Des Lugg, former medical director of the Australian Antarctic Division, has written a two-part brief history of Antarctic medicine of which about two and a half pages relate to the Heroic Age.[19, 20] This only mentions nine of the expeditions.

Dr Jennifer Keys has described the medical history of South Georgia as part of an MSc in Remote Healthcare.[21] While not directly related to this topic, it is linked to the history of the Antarctic as South Georgia is usually considered as part of "Greater Antarctica" as it lies within the Antarctic convergence and several of the expeditions visited the whaling stations on the island *en route* to the Antarctic.

Many books have been written about these expeditions and these contain details of the medical problems that occurred and of the doctors. These books draw on many different accounts, diaries, and for those written within 50 years or so of an expedition, interviews. The authors will usually have done a lot of research, quote from primary sources and reference them. Virtually every book describing the expeditions comments on scurvy and its presence or absence in that expedition. A disadvantage of these books is that authors, inevitably, have to be selective on the information they quote. With books on Captain Scott, it would seem that authors choose whether to denigrate Scott as Huntford does,[22] or to praise him as does Fiennes,[23] and choose their evidence accordingly.

Secondary sources may be inaccurate. I would give, as an example, the books by Bickel. Riffenburgh argues that Bickel's book on the Australasian expedition is of limited value for many reasons, including inventing conversations for which there are no actual records.[24] In this book Bickel describes the use of ice to anaesthetise a paronychia (whitlow) before it was incised,[25] which would be logical and may well have happened, but for which there is no evidence. In his book on Shackleton's Ross Sea Party, Bickel says that Ernest Wild fractured his ankle,[26] whereas the expedition medical report says that he sprained it,[27] though there were no x-rays to refute a diagnosis of a minor fracture.

While the writers of these books on Antarctic exploration have often examined and analysed the diaries and other writings of the explorers (including the doctors) in great detail, the medical sources have usually been overlooked. For example, I am not aware of any previous reference to the lists of drugs and medical equipment supplied by Burroughs Wellcome and very few of the papers and other information from medical journals have appeared in these authors' reference lists.

Previous research and writing relevant to the individual sections, is described in the section introductions below.

The expeditions

The naming of the expeditions is sometimes a cause of confusion. Each expedition had an official name but they are often also known either by the name of the expedition leader or by the name of the ship. Thus Robert Falcon Scott's first expedition was the British National Antarctic Expedition (BNAE) but is also known as Scott's first expedition or the *Discovery* expedition (or the first *Discovery* expedition as the ship was involved in further expeditions in the 1920's which is outside the dates covered in this study). The expeditions covered are listed in Table 1. A variety of names are used: where a ship was only used once during this period, the expedition will usually be called by the ship's name with the exception of Nordenskjöld's Swedish expedition where the ship's name, the *Antarctic* would cause confusion. (The *Antarctic* had also been used on an earlier whaling expedition to the Antarctic by Henrik Bull.) The *Aurora* was used twice, by Mawson's Australasian expedition and by Shackleton's Ross Sea Party and so those names are used. Scott's second expedition (1910-3) went in the *Terra Nova*: the same ship was used to relieve Scott's *Discovery* expedition in 1904 but that relief is not normally considered a separate expedition so the 1910-3 expedition is referred to as the *Terra Nova* expedition.

However, some of the published papers may refer to, for example, the Scottish Expedition and the first and second German expeditions as these, rather than ship's names, might be easier to understand for those with a medical, rather than polar, interest.

John Lachlan Cope's expedition of 1920-22 had no ship (whaling ships dropped them off on the Antarctic Peninsula and collected them at the end of the expedition) and so this is called the Cope expedition.

I realise that in one or two of my earlier publications, I have mistakenly called the Australasian Antarctic Expedition, the Australian Antarctic Expedition. I apologise for this, especially to any New Zealanders who have been upset.

The expeditions are listed in Table 1.

Table 1. Antarctic expeditions during the Heroic Age

Expedition Leader	Ship	Expedition name	Dates	Notes
Adrien de Gerlache	*Belgica*	Belgian Antarctic Expedition	1897-9	First to overwinter
Carsten Borchgrevink	*Southern Cross*	British Antarctic Expedition	1898-1900	First to overwinter on land
Erich Von Drygalski	*Gauss*	German South Polar Expedition	1901-03	
Nils Nordenskjöld	*Antarctic*	Swedish South Polar Expedition	1901-03	
Robert Scott	*Discovery*	British National Antarctic Expedition (BNAE)	1901-04	
William Bruce	*Scotia*	Scottish National Antarctic Expedition	1902-04	
Jean Baptiste Charcot	*Français*		1903-05	
Ernest Shackleton	*Nimrod*	British Antarctic Expedition. Also known as the Furthest South Expedition	1907-9	Reached South Magnetic Pole
Jean Baptiste Charcot	*Pourquoi Pas?*		1908-10	
Robert Scott	*Terra Nova*	British Antarctic Expedition (BAE) 1910	1910-13	Reached South Pole

Roald Amundson	*Fram*	Norwegian Antarctic Expedition	1910-12	First to South Pole
Nobu Shirase	*Kainan Maru*	Japanese Antarctic Expedition	1910-12	Did not overwinter in Antarctic
Wilhelm Filchner	*Deutschland*	Second German South Polar Expedition	1911-13	
Douglas Mawson	*Aurora*	Australasian Antarctic Expedition (AAE)	1911-14	
Ernest Shackleton	*Endurance*	Imperial Transantarctic Expedition (ITAE)	1914-16	
Aeneas Mackintosh (Ross Sea Party)	*Aurora*			
John Cope	None	Imperial Antarctic Expedition or Expedition to Graham Land	1920-22	
Ernest Shackleton	*Quest*	Shackleton-Rowett Expedition	1921-2	

When comparing medical problems between expeditions, it must be remembered that the expeditions were of different sorts. Most had clearly defined scientific aims and support from national scientific bodies but others were designed to achieve “firsts”, for example: Borchgrevink being the first to spend a winter on Antarctica; Amundsen’s determination to be first to reach the South Pole; and Shackleton’s aim, on the *Endurance* expedition, to be the first to cross the continent. Scott tried to combine both and although Shackleton had little interest in science, he did realise the importance of science in getting support for his adventurous aims and his *Nimrod* expedition produced useful scientific results.

Conditions such as frostbite and snow blindness were more likely to occur on the expeditions that did a lot of sledging. These were:

- *Discovery*
- *Nimrod*
- *Terra Nova*
- *Fram*
- Australasian expedition
- Shackleton's Ross Sea Party

However, even those expeditions that were mainly ship-based did do sledging. For example, the *Gauss* expedition made two sledging trips to a mountain, Gaussberg, which was 50 miles away.

Some expeditions were fully equipped and well fed (by the standards of the time) throughout their time in the Antarctic but others suffered shipwreck or were otherwise abandoned for an Antarctic winter with insufficient food, clothing and equipment. These were:

- Swedish expedition
- *Terra Nova* (Northern Party)
- *Endurance*
- Ross Sea Party

This caused specific problems. In particular, the Swedish expedition and *Terra Nova* Northern Party developed diarrhoea and urinary problems; a number of the *Endurance* expedition developed acute stress reactions after arriving on Elephant Island and the Ross Sea Party had the most severe scurvy, including the only definite scurvy death.

Structure of the thesis

This thesis is divided into three sections. Each section has its own introduction followed by a series of published papers. There is then an overall conclusion.

In section 1, I will consider the drugs and dietary supplements taken and used on the expeditions and the expeditions' links with drug companies, particularly Burroughs Wellcome. Knowledge of the drugs and dietary supplements contributes to an understanding of the diseases encountered, and the therapeutics at the end of the 19th and beginning of the 20th century.

In section 2, I will consider some of the medical problems encountered and which had a significant influence on the course of some of the expeditions. This section also includes psychological problems. Studying the treatment of these problems throws additional light onto medicine during this era. Some of the lessons learned had an influence outside the Antarctic with several doctors using their experience later. Dr Charcot advised the French army on the management of the frostbite that occurred in the trenches of the First World War,[28] and the Antarctic experience of three of the British doctors was put to use during the North Russia military campaign in 1919 where they also encountered scurvy.[29, 30] Dr Macklin wrote his MD thesis on medical aspects of this campaign, mentioning lessons learned in the Antarctic, especially in the management of frostbite.[31] Drs Macklin and Levick also used their experience in the 2nd World War.[32] Doctors Cook, Marshall, Forbes Mackay and Kohl went on further expeditions and Dr Levick founded the British Schools' Exploring Society. Scurvy and the possibility of scurvy were, perhaps, one of the major concerns of those planning expeditions, though beriberi was a more common cause of death. Snow blindness and frostbite occurred on all the expeditions with two victims of frostbite needing amputations.

As medical care was considered so vital, it is important to study the doctors who provided this care, their qualifications for being selected and their contribution to the expeditions. I do this in section 3. After the introduction, this section starts with a paper on the role of the doctor, followed by papers on the bacteriological, human science and geological research performed by the doctors. Many conducted research in bacteriology, zoology, botany and geology that a modern

medical graduate would not be qualified to do and so studying the research undertaken by the doctors may throw light on medical education at that time. The influence of geography and environment on disease has been of interest since Hippocrates' *Airs, Waters and Places*.[33] Most historical accounts of medical geography have concentrated on disease in the tropics and so Valenčius says that the other extreme offers a "potentially rich vein of research" and suggests research into the governing conceptions of cold and coldness in the European eighteenth and nineteenth centuries.[34]

Notes on the sources

All of the main expedition books were read, together with as many other books about the expeditions that could be obtained.

The on-line catalogues of the libraries and archives of the following institutions were searched and all (except the Naval Records Society) were visited to read appropriate documents.

- Scott Polar Research Institute, Cambridge
- Royal Geographical Society, London
- Wellcome Library, London
- National Archives, Kew
- Navy Records Society
- Canterbury Museum, Christchurch, New Zealand
- Library of New South Wales, Sydney
- National Library of Australia, Canberra

The following databases were searched using terms such as “medicine + Antarctic” (Antarctique, Antarktis), the names of the diseases commonly encountered such as frostbite, hypothermia, scurvy, beriberi, and the names of the doctors who went on the expeditions.

- Indexes of the following journals:
    - Cambridge University Press (publishers of *Polar Record* and *Antarctic Research*)
    - *Medical History*
    - *International Journal of Circumpolar Medicine*
    - *Polarforschung* (the German polar research journal)
    - Nursing journals archives http://rcnarchive.rcn.org.uk/
    - Medical journals archive http://www.ncbi.nlm.nih.gov/pmc/
    - *Lancet*
      archive http://www.thelancet.com/journals/lancet/issue/current?tab=past
- Bibliotheque nationale Français http://www.bnf.fr/fr/acc/x.accueil.html
- Digitalised books http://www.archive.org/

- The *Journal of the Royal Naval Medical Service* was hand searched from 1915 (when it started) to 1929 for papers by the Antarctic doctors who had been in the Royal Navy.

Personal contact was made with:

- Antarctic Heritage Trust, Christchurch, New Zealand (this was also visited)
- Institute of Naval Medicine for details of doctors who had served in the Royal Navy
- the Byrd Polar Research Center, University of Ohio, the US Library of Congress and the Dartmouth College Library (holders of Dr Frederick Cook's papers)
- Various individuals (named in the acknowledgments)

Original documents have been referred to where possible. However, many diaries have remained unpublished and are in a variety of archives throughout the world. As some expeditions were from Germany, France, Sweden, Norway and Japan and the whaling companies were often Argentinian companies staffed by Norwegians, many sources will be in other languages. In some places, therefore, quotations from the diaries published in other books are used.

The diaries were all handwritten. Some of the diaries have been transcribed and typed and Dr Wilson's diaries have been published,[35, 36] as has part of Dr Levick's diary.[37] Where typed transcripts of diaries exist, these have usually been relied on, rather than the originals. There is, of course, a risk that there may be mistakes in the transcription. If the transcription was made by the diary's writer, they can use the opportunity to add extra material. This may add additional, useful, detail but it is no longer truly a diary with thoughts recorded at the time. An example of this is Dr Marshall's description of the removal of Mackintosh's injured eye when the transcript,[38] gives more information than is recorded in his diary.[39] This extra information can only have been known by Marshall himself. This is described in section 2j.

Comments on primary sources

Official expedition book

Every expedition produced a book. This was usually said to have been written by the expedition leader though sometimes it was written by other expedition members or was ghost-written. These describe some of the medical problems that occurred but, being written by a non-medical person for non-medical readers, the details are often not adequate for analysis. Despite that, these books contain some very well written descriptions of frostbite, snow blindness and scurvy. Some of these books contain a medical report as described below. I have included the official expedition books as primary sources but there are many problems with using these as a historical record. They were usually written to defray the costs of the expedition and so were written in a way that would sell, for example by emphasising battles against adversity, though Amundsen wanted to stress the ease with which he reached the South Pole and made light of many of the difficulties that he faced. They tend to portray the expedition in a good light, and gloss over things that went wrong and the weaknesses of individuals. Information in these books is probably accurate but incomplete and usually lacks analysis. These books were often re-published several times and subsequent editions often differed from the first edition. Appendices were often omitted from later editions. For example, Mawson's book, *The Home of the Blizzard*, was originally published in two volumes in 1915,[40] but a single volume edition was published in 1930 which is shorter than the original and lacks some of the appendices of the original. The books of the Belgian, Norwegian, French, German, Swedish and Japanese expeditions have all been translated into English: I have read these in translation. However, some of the appendices have not been translated. For the French expeditions, I have, at times, checked descriptions of medical detail against the original French. Where books have been translated by others, I have used those translations. Where I quote from French publications that have not been formally translated, the translation is mine.

Books and articles written by other expedition members

Other expedition members often wrote books about the expeditions and these, naturally, tended to emphasise the role and achievements of the author, while giving an overview of the whole expedition. These are valuable as they give a different perspective from the official expedition book and may give more information about subsidiary parts of the expedition. Thus Griffith Taylor's book, *With Scott: The Silver Lining,*[41] describes his sledging journeys to study geology in more detail than is described in the official book of the *Terra Nova* expedition. When written soon after the expedition, these suffer from the same problems as the official books, though if written later they may contain some analysis.

Diaries

Unedited diaries are useful as, if the writer is honest, they describe exactly what happened as seen through their eyes. However an individual describing his thoughts at the time may make statements about another person that they might not have made if they had considered the event days or weeks later. For example on the *Nimrod* expedition Frank Wild made accusations of Dr Eric Marshall not pulling his weight. One of several similar diary entries reads: "we were all dead tired tonight, except perhaps M[arshall] who does not pull the weight of his food, the big hulking, lazy hog."[42] However, Raymond Priestley, in a paper on expedition psychology, says that the obsession on a sledging expedition that the other person is not pulling their weight, is almost universal,[43] and this still occurs.[44]

Writers of books about the expeditions sometimes seem to have an "agenda" and have used selective quotations from diaries to prove their point of view as described above.

Diaries may be written for a number of reasons. A person who intends to write a book will keep a diary but will edit it. If a diary was written with the intention of being published, it may have the drawbacks of official expedition books and books written by other expedition members. A diary that was not written for publication may not have these problems but may still paint the writer in a good light. Some of these diaries have subsequently been published, e.g. Wilson's,[35, 36] and Skelton's diaries.[45] Many diaries remain unpublished: these are spread

over a number of archives over the world and interpretation of handwriting may be difficult. I have read the unpublished diaries of the doctors and have looked at other diaries where I knew there was medical information. I have not been able to read all the diaries written by all expedition members.

Medical reports

Some of the doctors wrote medical reports following the expeditions. These vary in detail from Dr Gazert on the *Gauss* expedition whose main report ran to 55 pages,[46] with a further 31 pages on beriberi,[47] to Dr Wilson's four page article on the *Discovery* expedition.[48] It must be noted that Gazert's medical report was first published in 1914, 11 years after the end of the expedition, and so may have been written with knowledge about vitamins and the outcome of later expeditions that would not have been known to him had it been written immediately after the expedition. The reasons why some of the expeditions did not prepare medical reports are described in the paper "Human biology investigations during the heroic age of Antarctic exploration (1897-1922)" (section 4c).

Some of the doctors wrote articles on medical aspects of polar exploration or spoke at medical meetings which have been reported. These provide valuable information but must be read in context. For example Leonard Hussey was a meteorologist on the *Endurance* expedition and later became a medical student. While a student, he sailed as meteorologist on the *Quest* expedition and is sometimes described as "assistant surgeon" on that expedition. Hussey described the amputation of Blackborrow's toes on Elephant Island (described in section 2j) and says that they used up all the chloroform which meant that they could do no further surgery.[49] However, this is contradicted by Macklin's diary which not only says that he used only one eighth of the chloroform he had available,[50] but that he later recommended that a buttock abscess be drained under general anaesthesia.[51] Hussey had no medical responsibility for this case and his report was written 32 years later and so must be considered less reliable than Macklin's diary that was written at the time.

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Section 1: Drugs and equipment taken

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b) Medical supplies for the expeditions of the heroic age of Antarctic exploration: ophthalmic preparations. *Pharmaceutical Historian* 2012;42:46-50
c) Medical supplies for the expeditions of the heroic age of Antarctic exploration: injections, inhalations and suppositories. *Pharmaceutical Historian* 2013;43:28-33
d) Medical supplies for the expeditions of the heroic age of Antarctic exploration: oral medications. *Pharmaceutical Historian* 2012;42:72-7
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f) Medical supplies for the expeditions of the heroic age of Antarctic exploration: sledging cases. *Pharmaceutical Historian* 2013;43:68-72
g) Medicine in the heart of the Antarctic 1908-2001. *Emergency Medicine Journal* 2002;19:314-7
h) The relationship between the expeditions of the Heroic Age of Antarctic exploration and drug companies. *Pharmaceutical Historian* 2014;44:7-12
i) Medicinal brandy. *Resuscitation* 2011;82:951-4
j) Medical comforts during the Heroic Age of Antarctic exploration. *Polar Record*. 2013;49:110-7. (First published on line 2012)

Introduction to section 1

Previous research on drugs and equipment taken

A list of drugs taken to the Antarctic by the *Terra Nova* expedition was published as a supplement to the expedition reports,[1] but this is incomplete as it does not include the additional drugs selected by Dr Levick. An incomplete list of the drugs (and other equipment) taken on the *Nimrod* expedition has also been published by the New Zealand Antarctic Heritage Trust,[2] based on the drugs mentioned in Sir Ernest Shackleton's book and the artefacts found in his hut at Cape Royds. The lists of drugs and equipment taken on other expeditions have never been published and I do not believe that they have ever been fully described or that the use of the drugs has been discussed.

There has been internet interest in the fact that Shackleton's *Nimrod* expedition used cocaine in the form of "Forced March" tabloids.[3, 4] However, the claims made are largely sensational and have not been put into perspective as regards the circumstances in which cocaine was used, and the use of other tonics and stimulants. The use of alcohol in medicine over many centuries as a tonic, a stimulant, an antiseptic and as an anaesthetic is well known,[5] but most writing on this subject relates to an earlier time.

Much has been written on the history of Burroughs Wellcome and Co (BW&Co) and their medical chests of the type taken by many of the expeditions,[6, 7] though the emphasis is usually on their use in the tropics. BW&Co themselves described the use of these chests on a variety of expeditions including polar expeditions.[8]

Work presented in this dissertation

Most of this section consists of a series of papers on the drugs taken on the expeditions of Scott and Shackleton. After an introductory article (section 1a), ophthalmic preparations (1b), injections, suppositories and inhalations (1c) oral drugs (1d), and topical drugs (1e) are described. Alcohol was much used as a drug and so is discussed in the paper: "Medicinal brandy" (1i). Where the information is available, I also describe how the drugs were used.

Burroughs Wellcome supplied the majority of drugs and medical equipment to the *Discovery, Terra Nova* and *Endurance* expeditions and lists exist of these drugs. They also supplied drugs to the *Nimrod*, *Scotia* and Australasian expeditions and a sledging medical case to the *Fram* expedition. While the original lists of drugs of drugs supplied to these expeditions no longer seem to exist, it is likely that the drugs supplied would have been very similar to those supplied to Scott and the *Endurance* expedition. In addition to the incomplete list of drugs published as a supplement to the *Terra Nova* expedition reports,[1] I discuss the additional drugs selected by Dr Levick. The drugs taken on the *Discovery* and the *Endurance* expeditions are also discussed and I do not believe that these drugs taken have been described or discussed previously by historians. Although BW&Co's lists of drugs supplied to the *Discovery*, *Terra Nova* and *Endurance* expeditions exist, these may still be incomplete as the "patent freezing mixture" used to remove the cyst on Royds' face on the *Discovery* expedition (as described in section 2j) would seem to have been ethyl chloride but this is not mentioned on any of these lists.

The drugs taken by Shackleton on his sledging expedition towards the South Pole and based on the information in Shackleton's own book,[9] were described in 2002. This paper is reproduced in this dissertation (1g) but documents in the archives of the Canterbury Museum, Christchurch, revealed other descriptions of the contents of the sledging medical cases. Sledging drugs are discussed in a separate paper (1f). The use of cocaine and other tonics is discussed in this paper and also in section 2i. In addition, it is described how the *Discovery* expedition took some drugs from Oppenheimer, Son and Co Ltd and how some expeditions would have collected extra drugs in Australia and New Zealand.

The lack of detail into how, exactly, some of these drugs were used is frustrating to doctors and historians, as is the absence of any formal medical records relating to this period. It is possible that records were kept and have either been lost, or destroyed because of medical confidentiality. It is also likely that in some expeditions no records were kept, if the small numbers of patients were well-known to the doctor and he felt that there was no need for such records.

During this era there was much emphasis on the medical value of foods. A number of expeditions, especially the *Discovery* expedition, make reference to "medical comforts". This was mainly a military term for foods for the injured and invalids, some of which were designed to be easily digested and others were luxury foods. I am not aware of any previous descriptive paper on "medical comforts", let alone their use in the Antarctic. These are described in the paper: "Medical comforts during the Heroic Age of Antarctic exploration" (1j). The manufacturers of medical comforts often used the Antarctic links in their advertising and this is also described in this paper.

The suppliers of drugs, primarily BW&Co, also made much of their links with explorers. The relationship of BW&Co with explorers in the tropics has been described but those with Antarctic explorers, less so. These links are described in section1h. At the time most drugs were plant extracts and simple salts that could not be patented and so pharmaceutical companies had to compete by reducing manufacturing costs and by marketing. BW&Co were particularly recognised for their marketing and for their medicine cases and chests which they started to market in 1884.[10] They supplied these cases to missionaries and explorers and made much of this in their advertising with pictures of the Antarctic, pictures of the medical cases and testimonials from the doctors and expedition leaders. Section 1h shows three advertisements but there are many others that could have been shown. The market for supplying these groups was very small but the expeditions had captured the public imagination and were seen to be useful in promoting the image of the company and their products. Perhaps more importantly, BW&Co was trying to sell their products to the army where the market was very large, and there is clearly some connection between adventurous and military expeditions. The history of BW&Co has been described by Church and Tansey whose book includes a description of their advertising.[11]

There are few details of medical equipment that was carried apart from that used in monitoring health as described in section 3c and the surgical equipment supplied to the *Endurance* which is listed in appendix 2. The surgical equipment supplied to the *Terra Nova* was very similar.

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Section 2. Medical conditions occurring on the expeditions

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c) Snow blindness and other eye problems during the heroic age of Antarctic exploration. *Wilderness and Environmental Medicine*. 2012;23:77-82
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j) Surgery and anaesthesia during the heroic age of Antarctic exploration. *British Medical Journal* 2013;347:f7242
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Introduction to section 2

Previous research on medical conditions occurring on the expeditions

In a description of the medical problems facing Antarctic explorers, Dr Alexander Macklin said that the three main problems were "*Scurvy (and allied conditions)*, *frost-bite* and *snow-blindness*. *Sea-sickness* is a fourth condition which may cause disability."[1]

Scurvy occurred on the *Discovery*, *Terra Nova* and *Pourquoi Pas?* expeditions and among members of the Ross Sea Party and all the books describing these expeditions discuss the disease and how it was considered. Much has been written on the history of the disease,[2-4] and Carpenter's book which is, perhaps the most authoritative history of scurvy, specifically discusses the scurvy that occurred in the Antarctic.[2] In addition, the nutritional aspects of Scott's expeditions including scurvy as it occurred on the expedition, have been well described with a particular interest in whether Scott died of scurvy.[5-11]

The history of beriberi has been researched,[12, 13] but these publications make no mention of the disease occurring on expeditions. The idea that beriberi can occur on an Antarctic expedition is not new as it was diagnosed in two members of the *Gauss* expedition, one of whom died, and Dr Gazert (doctor to that expedition) discussed in his medical report whether other deaths in the Antarctic could have been caused by the disease.[14] However, cases of beriberi during this era are still being called "scurvy",[15, 16] and the disease in the Antarctic has not been formally studied.

Minor degrees of frostbite and snow blindness were probably the commonest medical problems that presented. A history of the treatment of frostbite,[17] makes no mention of this occurring on polar expeditions and I am not aware of any detailed description of either frostbite or of snow blindness on these expeditions. Schechter and Sarot wrote a paper on historical accounts of injuries due to cold from Assyrian and Hippocratic times to the Napoleonic era,[18] but it is often difficult to differentiate between frostbite and hypothermia in these descriptions. Modern publications on hypothermia sometimes give snippets of the history of the condition,[19, 20] but I am not aware of any full history of the disease, nor of any discussion of it occurring in the Antarctic at this time.

There is much current interest in polar psychology, and papers about this will often mention psychiatric diseases that occurred during the Heroic Age,[21] but no detailed history of psychology and psychiatric illness as it occurred during this era has been written. Papers on current Antarctic medicine such as anaesthesia and problems with alcohol,[22, 23] often use incidents from the Heroic Age as an introduction.

The illnesses of a few individuals have been studied. Douglas Mawson's illness has been much described and researched.[24-26] The cause of this is generally accepted as being vitamin A toxicity.[27] A PhD thesis on the German Expeditions has discussed the syphilis of Richard Vahsel (captain of the *Deutschland*) and the suicides related to that expedition.[29] The epilepsy of Harold Shaw (a stoker on the *Aurora* which supported Shackleton's Ross Sea Party) has been described in detail**.**[29]

Work presented in this dissertation

As the history of scurvy and its role in some of the expeditions have been well described by others, and virtually every book describing the expeditions comments on scurvy and its presence or absence in that expedition, the disease is not described in detail. The main interest in scurvy is how it was understood during this period. Some authors have been critical of expedition leaders and doctors for not being aware of the cause of the disease but the understanding of scurvy changed over the time of the expeditions with its cause being discovered and the word "vitamin" being first used during this period. "The understanding of scurvy during the heroic age of Antarctic exploration" (section 2a) gives a historical perspective, using information from all the expeditions, that has never been given before. It has often been argued that Scott and his colleagues died of the disease: this is discussed in the paper "The death of Robert Falcon Scott and colleagues" (section 2k).

In addition to the typical cases of scurvy, there was the disease that Macklin referred to when he described "scurvy (and allied conditions)".[1] This was sometimes labelled as scurvy but did not have its typical features. Charcot referred to "scorbut moderne",[31] and Cook called it "polar anaemia".[32] This was, almost certainly, beriberi and is described in the paper "'Polar anaemia':

cardiac failure during the heroic age of Antarctic exploration" (section 2b). The disease seems identical to the disease that, at the time, was called "ship beriberi". There is no previous analysis of the disease over all the Antarctic expeditions. Scurvy and beriberi could co-exist. The English translation of the book describing the *Kainan Maru* expedition was not published until after my paper was accepted. The medical report of this expedition says that while they were in Sydney, Takatori (a stoker) "came down with beriberi and nervous heart palpitations".[33] The book gives no details of the beriberi other than palpitations which are consistent with some of the symptoms described in Western explorers. Similarly, no details of the beriberi suffered by the Chinese sailors on the *Tanglin,* which delivered people and stores to Kerguelen as part of the *Gauss* expedition, are described. However, as beriberi was, mainly, a disease of the rice-eating populations of Asia, Miisho would have had no difficulty in recognizing it, whereas the Western doctors might not have recognized the disease which, they might have imagined, only occurred in Asians. It is interesting that Takatori developed the disease in Sydney. Presumably, he was eating a Japanese diet as the Western explorers had no problems with vitamin deficiency diseases except in the Antarctic or on board ship.

Fridtjof Nansen was a highly respected polar explorer and scientist whose views on scurvy probably had much influence on the polar explorers. Since my paper on scurvy was published, a paper,[34] has repeated the accusation made by Huntford that Nansen opposed Axel Holst's ideas on the cause of scurvy because Holst gave Nansen a difficult time during his doctoral viva.[35] While Nansen did oppose Holst's views that scurvy was a deficiency disease, the implication is that he did this (and might thereby have contributed to the incidence of scurvy) because of a personal vendetta. While I cannot disprove this, this is highly unlikely for several reasons. Firstly Holst qualified in 1884 and so at the time of Nansen's viva in 1888, Holst was very junior, having only been qualified for four years and he did not obtain his own doctorate until 1892. Also, Holst was working in bacteriology whereas Nansen's dissertation was on nerve cells. It is more likely that the examiner was Holst's father (also called Axel), who was a respected military surgeon or even his grandfather who had been a professor of hygiene.[36]

The paper: “Frostbite and other cold injuries during the heroic age of Antarctic exploration” (2d) describes the understanding and treatment of the disease on the polar expeditions and compares it to the modern understanding of the disease. There is further discussion on the treatment of frostbite in the paper “Medical supplies for the expeditions of the heroic age of Antarctic exploration: topical drugs” in section 1e.

Snow-blindness was well known as a result of Arctic and Alpine exploration but I am not aware that the history of the disease has been described. Snow-blindness is described in section 2c (“Snow blindness and other eye problems during the heroic age of Antarctic exploration”) and its treatment is further discussed in the paper “Medical supplies for the expeditions of the heroic age of Antarctic exploration: ophthalmic preparations” in section 1b.

Hypothermia is an obvious risk in a polar environment but, interestingly, Macklin in his paper on the medical aspects of polar exploration,[1] makes no mention of it and neither did most of the doctors in their reports and writings. While death from the cold was well-recognised, the clinical condition now described as hypothermia, was poorly described but the explorers did seem to recognise it. Many modern papers on hypothermia devote one or two sentences to the history of the disease but I am not aware of any paper fully describing the history. The paper “History of accidental hypothermia” (2e) is a general history of the disease but uses the experience of the Antarctic expeditions as a background. Knowledge of the history of the disease is important to understand why it was not described as a problem, as although it was rare, it undoubtedly occurred. I give one example in my paper. Another case almost certainly occurred on the *Discovery* expedition when Clarence Hare became lost and returned 44 hours later after wandering around. Wilson wrote:

> “… I thought the man must surely have been severely handled by the frost in these 44 hours of exposure. Imagine our amazement when we found that he hadn’t even a superficial touch of frostbite. However I decided to run no risk with him after this and put him in blankets in the magnetic observatory at a temp of 17^0 F, and lit a lamp there, which by the evening had raised the temp to freezing point and at 6 pm to 34^0 F, when I allowed him to go to his bunk in the sick bay. We took turns to sit

> with him all day, because I thought that after such cold there must be some reaction and I thought he might be delirious. Instead of that he slept the whole day. I kept him on a low diet of slops, though he was ravenously hungry … His escape is a very wonderful thing, and quite opposed to all our previous ideas about the effects of exposure." [37]

This condition was never labelled as hypothermia and does not appear to have been given any diagnostic label. The word "exposure" was, in later years, often used as a diagnostic label but Wilson describes "the effects of exposure" rather than using the word as a diagnosis. However, it is clear that he recognised the condition, if not that the cause was a lowered core body temperature.

Dental problems on the expeditions were, and still are, common and the doctors performed the dentistry. Some visiting dentists have described the dental problems that currently occur, but I am not aware of any description of dental problems during the Heroic Age. These are described in section 2f.

The isolation, confinement and 24 hour darkness that occurs during the Antarctic winter has psychological effects. These are of great interest, currently, as isolation in Antarctic bases has been used as a model for what might occur during long-distance space travel.[38] There has been a recent review on this topic,[21] but most of what has been discovered in recent psychological studies was described, albeit almost anecdotally, during the Heroic Age. This is described in the paper: "Psychology during the expeditions of the heroic age of Antarctic exploration" (2g).

In addition to the "normal" psychological reactions that occur, a number of explorers developed frank psychiatric disease in the Antarctic. This is almost certainly more disruptive to an expedition than physical illness. In some, the illness continued after their return and a number committed suicide. There has been no analysis of this, using information from all the expeditions. This is discussed in the paper "Psychiatric illness and suicide in the heroic age of Antarctic exploration" (2h). This probably underestimates the extent of psychiatric illness as we do not have follow up information on many expedition members. It has been said that Adam Tollefsen, one of the men who was psychiatrically ill on the *Belgica* expedition, returned to Norway with his mind

permanently deranged and later committed suicide by setting fire to himself. However, other reports say that he made a full recovery.[39]

A number of explorers had alcohol problems before they went to the Antarctic and after their return, and two of the doctors are said to have abused drugs either in the Antarctic or on a later expedition. Discussion on alcohol and drug abuse cannot be separated from the social use of alcohol and this is discussed in the paper: “The use and abuse of alcohol and drugs during the heroic age of Antarctic exploration” (2i). This paper, too, almost certainly underestimates the extent of the problem due to lack of information. This paper also describes how alcohol producers used the expeditions in their advertising.

The requirement to give a general anaesthetic was rare but clearly giving such an anaesthetic on an expedition is never a minor procedure. Surgery and anaesthesia is described in section 2j and the anaesthetic and surgical equipment taken on the *Endurance* expedition is listed in appendix 2. When this paper (section 2j) was submitted to the *British Medical Journal*, it was 2,600 words long but they wanted it shortened to approximately 1,400 words. Inevitably some important information had to be removed and this section aims to give some more information on this important topic. The paper identified 11 operations performed under general anaesthesia, but at that time anaesthesia was not confined to hospital and might be done in a patient’s home. As such, its use might have been seen as more routine and therefore have gone unreported.

An example of the way in which general anaesthesia seems to have been regarded lightly is shown in Dr Archibald McLean’s description of his own dental extraction during the Australasian expedition:

> “Had hard luck this afternoon. Decided to have a tooth out. ‘Doc’ [Dr Leslie] Whetter injected ‘codrenine’ [a combination of cocaine and adrenaline] but the tooth broke & turned out to be the wrong one. So had a whiff of chloroform and the other tooth out.”[40]

This is neither mentioned in the medical report of the expedition nor referred to in the expedition leader’s diary.

On a number of occasions, surgery is mentioned without comment on anaesthesia. Thus, on Elephant Island during the *Endurance* expedition, McIlroy drained a buttock abscess",[41] and on the *Discovery*, Drs Wilson and Koettlitz drained an axillary abscess,[42] with no mention of anaesthesia. Other abscesses and infections are also described as having been operated on, or dealt with, with no description of anaesthesia.[43, 44] Presumably some form of local anaesthetic was used. On other occasions, there is even less description. Thus, when the *Terra Nova* met Amundsen's ship the *Fram*, Dr Levick wrote: "Unfortunately I didn't get to board her, as I had to operate on Rennick's eye…"[45] He did not say what operation was performed.

Almost certainly the "patent freezing mixture" used for the excision of Royd's cyst (described in section 3n) was ethyl chloride which was introduced as a local anaesthetic in the late 19th century. However, ethyl chloride is not on the list of medical equipment supplied to that (or any other) expedition.[46]

Another possible example of cryo-anaesthesia occurred on the Australasian expedition. Bickel gives a picturesque account of Douglas Mawson, the expedition leader, incising a whitlow on Ninnis' finger using a snow poultice for local anaesthesia.[47] Ninnis later died and Mawson, the sole surviving witness of this operation, mentions the surgery in both his diary and book but neither source describes how it was done. A snow poultice would be logical in the absence of other forms of anaesthesia and may well have been used (there being no shortage of this in the Antarctic) but I am not aware of any evidence that this happened.

I have found no mention of local anaesthesia being used other than the failed attempt to anaesthetise Dr McLean's tooth mentioned above and the topical use of cocaine in the eye. However, a variety of local anaesthetics were taken including cocaine, anaesthetic compound B (a mixture of cocaine $^{1}/_{5}$ grain [13 mg] and morphine $^{1}/_{50}$ grain [1.3 mg]); eucaine and novocain dental tablets. Local anaesthesia was obviously used as Dr Atkinson said of the *Terra Nova* expedition that more supplies of anaesthetic compound B would have been desirable.[48] The very low dose of morphine in "anaesthetic compound B" probably indicates the belief that opiates had some form of local action, as the morphine for systemic use was provided in ampoules of ¼ grain (16mg).

Further evidence that local anaesthesia was used comes from Gourdon who dedicates his MD thesis to Dr Paul Reclus, one of the pioneers of local anaesthesia, writing: “As the apostle of local anaesthesia is he not entitled to the gratitude of all explorers by the admirable method that is in their hands by allowing the surgeon to do his own anaesthesia, avoiding both the dangers of chloroform and the need for an assistant?”[49]

In this thesis I have used diagnostic terms as they were used at the time. However the understanding and definition of diseases changes with time and there are a number of examples of this shown in my study and so one must be careful not to assume that the diagnostic labels given at the time represent the disease that now has the same name. For example, as described in sections 2b and 2c some of what was called “scurvy” was a mixture of what we would now diagnose as scurvy and beriberi and some was probably pure beriberi. Vitamin A deficiency might also contribute to “scurvy”. At the beginning of this era, scurvy was defined by a series of symptoms and physical signs whereas it would now be defined as the disease caused by vitamin C deficiency. Beriberi was initially a disease of unknown cause, occurring in the rice-eating population of Asia: it is now defined in terms of thiamine deficiency. Another example is shown by Dr Levick who wrote in his journal: “During the last week I have been having severe occipital headaches. I believe they are gouty, due to the want of exercise…”[50] Modern medicine would never attribute recurrent headaches to gout. As noted above, hypothermia occurred and was recognised (section 2e) but not thought of as a disease as it might be today.

Apart from differences in diagnosis with time, patients define disease by its effects whereas scientists may use different criteria. Dr Wilson was diagnosed with tuberculosis while a medical student, based on the clinical features and finding mycobacteria in his sputum. However, Williams argues that because there is no evidence that he had a chest X-ray or that the organism was cultured, we cannot be certain that he did have the disease.[51] The way that disease has been understood differently over time, by different groups and with social as well as medical contributions to diagnosis, has been explored by Aronowitz who gives a number of examples of what he calls “the social construction of disease”.[52] Another concept in the understanding of disease is “splitting and lumping”. For example, a “lumping” view would imagine epilepsy

as one disease with different manifestations but a “splitting” view would have it as a number of separate diseases with common features.[53] Scurvy and beriberi can also be seen to illustrate this with seaman’s scurvy of old, caused by a deficiency diet, being able to be split into at least three separate diseases, which can co-exist, whereas Asian beriberi and ship beriberi have come to be seen as a single disease with different forms. Similarly, during this era, though in the trenches of the First World War rather than in the Antarctic, non-freezing cold injury (trench foot) was split from frostbite (see section 2d). Frostnip was also not yet a diagnosis though lumpers might still classify all three as “cold injury”.

Other medical problems also occurred including gastrointestinal symptoms especially diarrhoea on sledging expeditions,[54, 55] and when living rough, for example the *Terra Nova* Northern Party spending the winter in a snow-hole,[56] and the Swedish expedition after their shipwreck,[57] urinary symptoms,[57] carbon monoxide poisoning and hypoxia,[58, 59] sea-sickness which is described in almost every book and vitamin A toxicity. This occurred most obviously on the Australasian expedition,[22-24] but there are examples on other expeditions of men developing symptoms suggestive of mild vitamin A toxicity after eating seal liver.[60, 61] The early explorers were also interested in the absence of the common cold and of “rheumatism”. Further research deserves to be done on these topics.

The legacy of the expeditions

It is interesting to consider whether the medical knowledge obtained from one expedition was incorporated into the planning for future expeditions and thus whether Antarctic or polar medicine could be considered as becoming a separate specialty, however small. It is clear that there was some transfer of knowledge. The most obvious way that this occurred was when a doctor did a second polar expedition and could use the experience of their first expedition during their second one. For example, Dr Koettlitz had previously spent three years in the Arctic where he had encountered scurvy and so he had learned from previous polar experience. Other expedition members also went on more than one expedition and it is clear that Shackleton had a major interest in scurvy, doubtlessly because he had suffered from it during the *Discovery*

expedition. As a result, on the *Endurance* expedition his understanding of the vitamin theory was probably better than that of his doctors. The explorers would also have read the books published about earlier expeditions. Dr Wilson identified Crean's illness as the same as that from which Hanson on the *Southern Cross* expedition had died and Charcot adopted the method that Dr Cook used on the *Belgica* of treating the cardiac disease resulting from what we now believe is beriberi. This is described in section 2c. Section 1h describes how many of the drugs and medical cases were supplied by Burroughs Wellcome who sought testimonials from the expeditions for use in their advertising. It would be surprising if they did not ask for feedback on the equipment they supplied and use this in the advice they supplied to later expeditions, but there is no evidence for this.

However, expeditions did not always learn from their predecessors. Many expeditions overlapped and therefore could not learn lessons from those they overlapped with. Section 2d describes how Dr Wilson learned that the traditional treatment for frostbite of rubbing it with snow was harmful but later expeditions made the same error. Section 2a describes how the early explorers had learned that scurvy could be prevented by fresh food of all kinds but Dr Atkinson, following expert medical advice of the time, believed that it was only fruit and vegetables that would prevent scurvy. Perhaps the main problem is that many expeditions did not publish a medical report and some of the reports were very short, just appearing as appendices in books for the general public about the expedition. Other reports appeared a number of years after the expeditions. The medical reports are discussed in section 3c. The lack of learning about previous bacteriological research is discussed in section 3c. Dr Mclean admitted that before he left he had only read one of the previous four bacteriological studies and the bacteriological advisors to Charcot's second expedition appeared to have little knowledge about what was achieved on his first expedition.

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Section 3. The doctors and their research

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Introduction to section 3

Previous research on the doctors and their research

There are biographies of Drs Edward Wilson, Frederick Cook, Jean-Baptiste Charcot, Reginald Koettlitz and Alister Forbes Mackay and a few brief articles describing some of the other doctors, listed in the bibliography.

Dr Wilson is considered one of the heroes of Antarctica and there are at least three biographies written about him emphasising his role as an explorer, naturalist, artist and Christian but with little substantial about medicine. Frederick Cook is an enigma. He is praised as the hero of the *Belgica* expedition but the main emphasis is on his Arctic journeys and his relationship with Peary, followed by his fall from grace over his alleged false claims to have been first to reach the North Pole and first to climb Mount McKinley in Alaska (now Mount Denali). This was later followed by imprisonment for an alleged insurance fraud. Most literature presents him as a fallen hero but some believe that there was a conspiracy against him and there is still a Frederick Cook Society to promote him. Charcot was a major figure of exploration in the early 20th century with many trips to the Arctic as well as his two Antarctic expeditions. There are several biographies in French, one of which has been translated into English, portraying him as a great explorer but without much of substance about medicine. The biography of Koettlitz is written by a descendant and is based on private papers. It is very informative about Koettlitz's contribution to the Jackson Harmsworth Arctic Expedition but contributes little to knowledge about the *Discovery* expedition as his diary of that expedition has been lost. It is very critical of Scott but that reflects Koettlitz's views. Alister Forbes Mackay is another flawed individual who achieved fame for being in the first party to reach the South Magnetic Pole on the *Nimrod* expedition but who later developed an alcohol and drug problem and died on an Arctic expedition in 1914 (discussed in section 2i).

Albretsen, in a Norwegian paper, has very briefly described 11 of the doctors who went on Antarctic expeditions and some who went on Arctic expeditions.[1] A paper entitled "Arctic and Antarctic exploration including the contributions of physicians and effects of disease in the polar regions" only mentions three of

the physicians and they are described very superficially.[2] The biographies of Drs Cook, Charcot, Koettlitz and Wilson briefly mention their research but do not contain any critical analysis of it.

Modern papers on Antarctic microbiology often pay tribute to, and reference, the early bacteriologists of the Heroic Age,[3, 4] but the work of Drs Koettlitz and Atkinson was never published and so is not acknowledged. Dr Archibald McLean's studies on nail growth in the Antarctic have been described,[5] as they have been reproduced twice, and his results have been used as a baseline to describe changes over time, as discussed in section 4c. Campbell, in several papers, has briefly described Dr Atkinson's parasitology.[6-8] However, the work of the doctors and their researches have never been studied as a whole using information from all the expeditions of the era.

Work presented in this thesis

It is instructive to look at the experience, or rather, inexperience of the doctors by comparing their year of qualification against the date they sailed for the Antarctic.[b] While most of the 22 doctors had several years of medical experience and Dr Koettlitz had been qualified for 17 years and had spent three years in the Arctic, two doctors sailed south in the year they qualified and four others doctors travelled the year after qualification. Although Wilson sailed two years post qualification, he had only practised medicine for six months, due to illness. The main motivation for doctors applying for a first expedition would have been a sense of adventure with, for some, an interest in the science. It is quite plain that many of the doctors were appointed for reasons other than their medical abilities, either because they were competent scientists or because it was considered that they would be a good team member. Albretsen,[1] has commented on the inexperience of some of the doctors who went on polar expeditions at this time and has suggested that many were not fit enough for the extreme strain of the expeditions. He suggests that by their attention to diet,

[b] The word "surgeon" sometimes causes confusion. It usually refers to a medically qualified person with postgraduate experience and qualifications in surgery though any doctor performing a surgical procedure is the surgeon for that procedure and at the time of this study much surgery was performed by general practitioners. However, it is sometimes used in other ways. "Police surgeons" do not perform surgery. Medically qualified naval officers have "surgeon" as a prefix to their rank (eg Surgeon Lieutenant) even if they do no surgery. Whaling and expedition doctors were often called surgeons and some whaling surgeons (eg William Speirs Bruce) were not medically qualified. I will use the words surgeon and doctor interchangeably.

the doctors saved many from becoming victims of scurvy but that young doctors were not able to stand up to their expedition leaders with dire consequences. Among the examples he quotes are Dr Wilson following Scott to the South Pole and dying as a result; Dr Atkinson allowing Scott's party to go to the South Pole without adequate rations; and Drs Macklin and McIlroy allowing Shackleton to continue on the expedition on which he died. Three doctors did seem to have alcohol or drug problems (none of which are mentioned by Albretsen but which are discussed in section 2i) and on Arctic expeditions at a similar time, Dr Svendsen committed suicide and Dr Blessing became a morphine addict. However, Albretsen's coverage of the doctors is very superficial in that he discusses 17 doctors (including the Arctic doctors) in less than three pages. Some of his facts are wrong, for example saying that Dr Marshall knew Holst and Frølich's work on scurvy whereas that was not published until two months after the expedition sailed, and polar historians would dispute some of his interpretations.

The expedition doctors are shown in Table 1:

Table 1. The doctors on Antarctic Expeditions

Expedition	Dates	Doctor	Notes
Belgica	1897-9	Frederick Cook	
Southern Cross	1898-1900	Herlof Klövstat	
Gauss	1901-1903	Hans Gazert	
Swedish	1901-03	Erik Ekelöf	
Discovery	1901-04	Reginald Koettlitz, Edward Wilson	
Scotia	1902-03	JH Harvey Pirie	
Français	1903-05	Jean-Baptiste Charcot, Jean Turquet	Ernest Gourdon (the geologist) was a medical student
Nimrod	1907-9	Eric Marshall, Alistair Forbes Mackay	William Michell was ship's surgeon
Pourquoi Pas?	1908-10	Jean-Baptiste Charcot, Jacques Liouville,	Ernest Gourdon was a medical student
Terra Nova		Edward Atkinson, Edward Wilson, G Murray Levick	Levick was with Northern Party
Fram	1910-12	No doctor	
Kainan Maru	1910-12	Seizõ Miisho	Not medically qualified: a pharmacologist

Deutschland	1911-13	Ludwig Kohl, Wilhelm Goeldel	Dr Kohl left at S Georgia[9]
Australasian	1911-14	Archibald McLean, Sydney Evan Jones, Leslie Whetter	
Endurance	1914-16	Alexander Macklin, James McIlroy	
Ross Sea Party	1914-16	No doctor. John Cope (the biologist) acted as doctor	
Quest	1921-2	Alexander Macklin, James McIlroy	Leonard Hussey, the meteorologist and a medical student, is sometimes described as “assistant surgeon”

Details of the individual doctors (as far as I have been able to determine them) are shown in table 2.

Table 2. Details of the doctors on the Antarctic expeditions.

Name	Country	born		Qualified	Date of first expedition	Research (and other major activities) in Antarctic	died
Edward Atkinson	UK	1881	1906	St Thomas's Hospital, London	1910	Parasitology	1929
Jean Baptiste Charcot	France	1867	1895	Paris, Saltpêtrière	1903	Expedition leader, oceanography Bacteriology	1936
Frederick Cook	USA	1865	1890	New York	1897	Photography, anthropology	1940
Erik Ekelöf	Sweden	1875	1898	Uppsala	1901	Bacteriology	1933
Hans Gazert	Germany	1870		Munich	1901	Bacteriology	
Herlof Klövstat	Norway	1868		Kristiania	1898		1900
Wilhelm von Goeldel	Germany	?1881	1911	Berlin	1911		
Sydney Evan Jones	Australia	1887	1910	Sydney	1911		1948
Reginald Koettlitz	UK	1860	1884	Guy's Hospital, London	1901	Botany	1916
Ludwig Kohl	Germany	1884			1911		1969
G Murray Levick	UK	1877	1902	St Bartholomew's Hospital, London	1910	Photography, zoology	1956
Jacques Liouville	France	1879	1905	Paris	1908	Zoology	1960
Alistair Forbes Mackay	UK	1878	?1902	Edinburgh	1907		1914

James McIlroy	UK	1879	1904	Birmingham	1914		
Archibald McLean	Australia	1885	1910	Sydney	1911	Bacteriology, physiology	1922
Alexander Macklin	UK	1889	1912	Manchester	1914		1967
Eric Marshall	UK	1875	1906	St Bartholomew's Hospital, London	1907	cartographer	1963
William Rupert Michell	Canada	1879	1902	Toronto	1907		1966
J H Harvey Pirie	UK	1879	1902	Edinburgh	1902	Geology, bacteriology	1965
Jean Turquet	France	1867			1903	Zoology	1945
Edward Wilson	UK	1872	1899	Cambridge and St George's Hospital, London	1901	Zoology, artist	1912
Leslie Whetter	New Zealand	1888	1910	Otago	1911		1955

There was no doctor on the *Fram* but Amundsen had been a medical student and, in the words of Amundsen: “Lieutenant Gjertsen … went through a ‘lightning course’ at the hospital and the dental hospital… With surprising rapidity and apparent confidence Lieutenant Gjertsen disposed of the most complicated cases — whether invariably to the patient’s advantage is another question, which I shall leave undecided.”[10]

Shackleton’s Ross Sea Party hoped to recruit a doctor in Australia but were unable to do so because the First World War had broken out. John Lachlan Cope, a recent Cambridge biology graduate who sailed as biologist, acted as the doctor. On the *Kainan Maru* expedition, Seizõ Miisho, a pharmacologist, sailed as the medical officer. On John Cope’s expedition, only two men over-wintered and there was no doctor. The doctor on the *Gauss* expedition was Dr

Hans Gazert but the five-man Kerguelen Party of that expedition had no medical doctor though Dr Emil Werth, the biologist, had, at an earlier stage of his career, been a pharmacist and acted as doctor.

Discussion of the individual doctors would be very interesting as many made enormous contributions to the expeditions but others caused problems. I have studied the doctors and have written papers on four of them as described in the appendix. Unfortunately, space does not allow me to describe them in detail in this dissertation. Undoubtedly, the expeditions shaped some of the doctors' further careers, but as they would have been selected for being adventurous, it is difficult to attribute their achievements to Antarctic service rather than their personality. A number of the British, Australian, New Zealand, French, and German doctors served in the First World War with Drs Charcot, Atkinson, McLean and Marshall being decorated for heroism or other aspects of their war work. Drs Atkinson, Macklin and Marshall served on the Russian front and were presumably selected for this because of their Antarctic experience. Dr Charcot advised the French army on the management of frostbite. Drs Macklin and Levick also served in the Second World War with Dr Levick using his skills to train commandos. Dr Atkinson continued his parasitology and was one of the discoverers of the cause of schistosomiasis and Dr Pirie, the bacteriologist on the *Scotia* expedition, became a well-known bacteriologist and one of the discoverers of the Listeria group of bacteria. As will be noted in Table 1, four doctors served on more than one Antarctic expedition but in addition, Drs Cook, Marshall, Mackay, Kohl, Levick and Charcot went on further expeditions to other parts of the world and Dr Levick founded what became the British Schools Exploring Society. Dr Gazert founded a Red Cross Group and mountain rescue service in his native Bavaria.

Among the scientists, Dr Wilson gave up medicine to become an artist and naturalist; Dr Liouville gave up medicine, apart from service during the First World War, to become a full-time marine biologist and Dr Turquet, was by inclination a botanist. He obtained a doctorate in botany but, according to an internet source, gave it up and returned to general medical practice, when he failed to get the Chair in Colonial Botany in Paris that he had been promised.[11]

Medical students

In addition to the doctors who went on the expeditions, three other expedition members had been medical students previously but had never qualified:

- Roald Amundsen (*Belgica* and *Fram* expeditions)
- William Speirs Bruce (*Scotia* expedition)
- James Murray (*Nimrod* expedition)

Three others went while still medical students:

- John Hunter (Australasian expedition)
- Ernest Gourdon (*Français* and *Pourquoi Pas?* expeditions)
- Leonard Hussey (*Quest* expedition. He was also on the *Endurance* before he became a medical student)

John Lachlan Cope was a biology graduate from Cambridge. He may have intended studying medicine as medical students from Cambridge first did a natural science degree and then did their clinical training elsewhere. He later qualified as a doctor in 1933.

The role of the doctor on an expedition includes much more than just treating the sick and the papers in this section start with “the role of the expedition doctor: Lessons from 100 years ago” (section 3a). As the title suggests, this is, perhaps, the main area where expedition doctors today can learn from doctors during the Heroic Age.

Research done by expedition doctors

Most of the expeditions to the Antarctic during the Heroic Age were scientific expeditions. The participants were mostly young and usually had to pass a medical examination. The medical work was therefore expected to be light and the doctors who went to the Antarctic were expected to do research or take on other additional responsibilities.

Not only was the end of the 19th century a time of great change in medicine, but it was also a time of change for science. In many of the biological and earth sciences, “professional” laboratory science was developing and its practitioners

looked down on “amateur” collectors and cataloguers, before the realisation that fieldwork and laboratory study were complementary and not in opposition.[12] In zoology, the emphasis on morphology was giving way to the study of physiology, and the study of the animal kingdom as a whole was becoming too large for a single subject so zoologists needed to specialise in a particular branch of that kingdom or subjects such as physiology or embryology.[13] Bacteriology which had started as a study of the diseases of humans, animals and plants, was becoming a separate branch of science.[14]

In the 18th and early to mid-19th centuries, higher education in the life sciences was largely confined to university medical schools.[12] This led to a tradition of doctors on exploring ships acting as naturalists, or sometimes, it might be more accurate to say that the naturalist acted as ship’s surgeon. Medical education included botany and geology as many of the medicines of that age were derived from plants and minerals. Palaeontology related to both biology and geology and many of the early palaeontologists were medically qualified. By the middle of the 20th century, science was more specialised and medical education was much narrower and so very few doctors would be qualified to do good quality research in topics other than human sciences. The Heroic Age was an in-between time: professional botanists, zoologists and geologists existed but some entered those professions with a medical degree, and medical education was broad enough to enable some doctors to be recognised as experts in these subjects, and many others to have enough expertise to be useful collaborators and collectors of specimens for the professionals. Bacteriology was still largely the province of the medical profession.

Some doctors seem to have been chosen for their research abilities rather than their medical ones and on the *Français* expedition, Dr Jean Turquet was appointed as zoologist and Ernest Gourdon, a medical student, was appointed as geologist, with, it would appear, no consideration of their medical background. Others seem to have been appointed as doctors and were then given a research topic. Thus Dr Koettlitz was given the responsibility for botany, whereas he wanted to do geology.[15]

The paper: “Bacteriology during the Heroic Age of Antarctic exploration” (3b) is a historical analysis of all the bacteriology done, including that which was not published.

A history of Antarctic science dismisses the research into human biology during this time with the words “there was little that could be dignified by the name of medical research.”[16] While all the doctors monitored the health of the participants, there has been no historical analysis of this work. Dr McLean of the Australasian expedition did rather more extensive research into human physiology in that he looked at immunity, changes in bacterial flora over time and nail and hair growth. The human biological investigations performed are described in “Human biology investigations during the heroic age of Antarctic exploration (1897-1922)” (section 3c).

One doctor and a medical student acted as geologists on these expeditions and two others also had a major interest in geology. These are described in “Medical geologists during the Heroic Age of Antarctic exploration” (3d).

As noted in Table 2, other doctors did zoology, botany, and parasitology and Dr Cook carried out anthropological research in South America *en route* to the Antarctic. These researches are not described. Other doctors had roles such as dog driver, photographer and cartographer which are also not described.

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Conclusion

Conclusion

This study makes use of sources that, as far as I am aware, have never been quoted before. In particular I am not aware that Gourdon's MD thesis,[1] has ever been quoted in the English language literature. The copy in the Wellcome Library had uncut pages indicating that it had never been read in the 100 years since it had been printed. Similarly, I am unaware of any reference to Gazert's medical reports in the English language literature,[2,3] nor to Koettlitz's physiological data from the *Discovery* expedition;[4] Atkinson's medical report from the *Terra Nova* Expedition;[5] or the details of the drugs supplied to the *Discovery*, *Terra Nova* and *Endurance* that are in the Wellcome Library. Dr Wilson is well-known as an artist and books have been published of his artwork but his paintings of Dr Koettlitz's bacteriology appear to have been previously unknown.

Section 1 gives details of the drugs taken on the expeditions, which gives some insight into the therapeutics of the era. The relationship between Burroughs Wellcome and tropical explorers has been described previously but section 1h explores the relationship between the company and the polar explorers and the use of the Antarctic connection in advertising. The concept of "medicinal brandy" is not a new one and, perhaps, still lingers in the folk memory, but using the Antarctic as an example, the reasons why alcohol was being used as a medicine during that era have been described. "Medical comforts" are described which I do not believe has been previously done in the historical literature. The slow response of medical practice to the results of research is shown by the continuing use of local opiates long after it had been shown that they had no local action. While cocaine was used as a tonic, I have explained the circumstances in which it was used, which I believe does not deserve the description of Shackleton exploring the Antarctic "propelled" by cocaine.[6]

Section 2 illustrates some of the medical advances that occurred during this time, especially the discovery of vitamins and the changes in the understanding of scurvy and beriberi that caused illness and death on many of the expeditions. Section 2a illustrates that scurvy as described 100 years ago is not necessarily the disease that we now know is due to vitamin C deficiency. It also shows how it takes time for medical discoveries to become accepted: scurvy was

discovered to be a deficiency disease in 1907 but this was not generally accepted until, perhaps, 1920 and some major figures did not accept it for a further ten years. There has been much heated argument as to whether Captain Scott and his colleagues died of scurvy. There is evidence both for and against this idea and we will never know the answer but this study weighs up the evidence without taking sides. This study is not the first to suggest that beriberi occurred in the Antarctic but is the first to examine the subject in detail. The experience of the explorers themselves led to better understanding of the management of frostbite and this influenced the way frostbite was approached during the First World War.

By simple observation, explorers described the psychological problems that occur in the Antarctic which have been subsequently confirmed by formal psychological research. Similarly, it is described how a physicist gave a good description of empty field myopia long before it was described in the medical literature. Some of the significant medical problems affecting the expeditions such as the amputation of toes, the enucleation of an eye and the psychiatric problems on the *Belgica* expedition and the Australasian Antarctic Expedition have been well described in the books describing the expeditions but surgery and psychiatric illness have not previously before been described using the experience of all the expeditions. The dental problems of this era have not previously been described. Two cases of what I believe was hypothermia are described, and while the condition was recognised, it was never described in any way that would suggest hypothermia. One of these cases is used as a basis for section 2e, to discuss the history of hypothermia and why it was not recognised as a disease.

The diseases obviously affected individuals, but it is difficult to say exactly how they affected the expeditions as a whole as the expeditions' books usually try to tell a good story about overcoming adversity rather than describing the problems that resulted from it. However, it is clear that Edgar Evan's illness and Oates' frostbite contributed to the deaths of Captain Scott and his party. Disease affecting more than a single person on an expedition must, inevitably, disrupt the workings of the expedition. Examples of this would be the beriberi and psychiatric disease on the *Belgica*, scurvy on the *Discovery* and in the Ross Sea Party, beriberi on the *Français* and beriberi and scurvy on the *Pourquoi*

Pas? Vitamin A toxicity on the Australasian expedition killed Mertz and caused Mawson to be very ill but the alternative was, perhaps, death by starvation after Ninnis and the sledge with most of the food fell into a crevasse. Hayes believes that this would not have happened if he had been wearing snow shoes,[7] and so the lesson here is that preventing this accident would have saved two lives and prevented Mawson's illness. Thinking about accident prevention is now considered a medical responsibility but perhaps was not, in times past.

Section 3 includes the first list of all the doctors who took part in the expeditions of the Heroic Age. It also describes the bacteriology, human biology and geological research done by the doctors and explains how some of the doctors, were qualified to do this research. Some of the bacteriology done in the Antarctic during this era was unpublished and section 3b describes all the bacteriology that was performed. This forms the basis of modern bacteriological research on the continent. Section 3c is the first paper to fully describe the human biology studies and shows how Dr McLean can be said to have laid the foundations for later Antarctic physiological and immunological research. A number of doctors were accomplished scientists outside their medical field and Dr Wilson's fossil collection was the final piece of evidence that confirmed that the Antarctic had, at one time, been connected to South America and Africa. This study has little to tell the modern Antarctic doctor on how to treat specific diseases but the role of the doctor on an expedition (section 3a) has changed little over the past 100 years. The psychological problems described during the Heroic Age (section 2g) still occur and discussion over the social role of alcohol in the Antarctic (section 2i) continues.

There remains scope for further research. Some medical problems have not been discussed, as described in the introduction to section 2. These include gastrointestinal symptoms especially diarrhoea on sledging expeditions and when living rough, urinary symptoms, carbon monoxide poisoning and hypoxia, sea-sickness and vitamin A toxicity. This occurred most obviously on the Australasian expedition, but there are examples on other expeditions of men developing symptoms suggestive of mild vitamin A toxicity after eating seal liver. The early explorers were also interested in the absence of the common cold and of "rheumatism".

This dissertation contains little description of the individual doctors. Archives in the UK, Australia and New Zealand have been explored and the study uses sources that, as described above, I am not aware, have been used before. This exploration of the medical problems contributes to the understanding of the expeditions of the era and to medicine at the end of the 19th and beginning of the 20th century. However, further information may be available in the other countries that sent expeditions (France, Germany, Japan, Norway and Sweden) and in Argentina from where the rescue operations for the Swedish and *Endurance* expeditions were launched.

It must not be forgotten that there were other activities occurring in the Antarctic at this time and that each of these would have had medical consequences. The major activity was whaling and sealing. Medical aspects of whaling on South Georgia, have been described.[8, 9] Although not part of Antarctica, South Georgia is within the Antarctic convergence and usually considered as part of "Greater Antarctica". There were whaling deaths at Deception Island whaling station,[10] and there are whalers' graves on Signy Island, both of which are in the Antarctic, and the medical problems on South Georgia would not have differed from those that occurred further south. At the end of the *Scotia* expedition, the Scottish base became an Argentinian meteorological station called Orcadas (which still exists) and there were four deaths at this base during the time covered by this study.[11]

In addition there would have been medical problems on the ships that did not overwinter in the Antarctic and on the *Morning* and *Terra Nova* during their support of the *Discovery* The same may be true of the ships that rescued the Swedish expedition and the shipwrecked members of the *Endurance* expedition. These are very poorly described apart from a description of the epilepsy of a stoker on the *Aurora* during its support of the Ross Sea Party.[12]

Although this thesis has addressed many areas of Antarctic medicine during the Heroic Age, this remains a fertile area for further historical research. As this research covers the period 1895 to 1922, there is also scope to research the medical aspects of more recent Antarctic expeditions.

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Appendix 1

Other publications resulting from this research but not presented as part of this thesis

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GULY H. Dr. Reginald Koettlitz: Arctic and Antarctic explorer. *Journal of Medical Biography*. 2012;20:141-147.

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Appendix 2

Anaesthetic and surgical equipment supplied to the *Endurance* expedition,[1]

Anaesthetic equipment

1 chloroform mask

1 4 oz chloroform drop bottle

1 Doyen's mouth gag

12 4 oz bottles Duncan's pure chloroform

1 ½ lb Aether anaesthetic

Surgical equipment

1 Adam's saw

1 Hoffman's bone nibblers

1 Mayo self-retaining retractor

1 pair sharp pointed scissors 6"

2 pairs scissors No. 21

Suture needles straight and curved

Catgut and silk suture material

1 pocket set of trocars and cannulae

1 sinus forceps, long and elbowed.

Surgical case on loan

1 bistoury straight, metal handle

1 " curved, " "

1 " curved Button

1 " hernia, metal handle

1 cannula, tracheotomy, Fullers bivalve, silver

6 catheters, oliviary, Nos. 1,3,4,7,9, 12, solid ends

2 " silver, Nos. 3 & 5

1 " nickel, No. 8

1 director, hernia

1 elevator, double

1 pair forceps, bone

6 " " Spencer Wells

1 " " bullet extracting

2 " " dissecting

1 " " lion

2 " " bulldog

3 knives, amputating, Symes

1 needle, aneurism, metal handle

1 " Liston's " "

2 dozen needles, surgeons, assorted, in vulcanite tube

1 needle holder and wire cutter

1 probang, double

1 probe, silver, 10 inch

1 " " bullet

1 saw, moveable back, metal handle

1 " amputating, metal handle

4 scalpels, assorted

1 pair scissors, straight, blunt pointed

1 " " curved on flat, blunt pointed

1 x silk, surgeons, twisted, in carbolic solution

1 tourniquet, screw

1 trocar & cannula, Pearce's

1 " " " hydrocele

1 trephine, with handle

1 reel wire, silver, for suture

1 key

1 catgut, surgeons, in carbolic solution

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Appendix 3. Permissions to use copyrighted material

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Bibliography

The bibliography is laid out in an unconventional way as it seems more logical that all the information about an individual expedition is grouped together and that information about individual doctors is grouped together. However, where such information is contained in journals or archival material, it is also listed under those headings. The sections are:

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Alistair Forbes Mackay

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Mills L. *Men of Ice: The Lives of Alister Forbes Mackay and Cecil Henry Meares*. Whitby: Caedmon of Whitby, 2008.

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Seizõ Miisho

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I am not aware of any specific biographical information on John Lachlan Cope, Ernest Gourdon, Jean Turquet or Wilhelm von Goeldel other than as described in the expedition books listed above and snippets on the internet.

3. Archival material

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