Morbidity and mortality on RAN ships

Commander Mike O'Connor, MB BS(Hons), MD, DCH, DDU, FRCOG, FRANZCOG, RANR and Commander Mark Parrish, MB BCh(Hons), FRACGP, MRCGP, DipOccMed, MHA, RANR

Abstract

- ***Objectives:*** To determine the level of morbidity and mortality in seagoing sailors in Royal Australian Navy (RAN) ships, and compare this with data from other navies.
- ***Methods:*** All available ship's medical journals and their statistical annexes (PM293 forms) from major fleet units were obtained for the period 1991–2003. Data on deaths, common types of morbidity and medical evacuations were extracted and related to manning levels and sea time for each 6-month period. A log of RAN ships' communications to the Deputy Fleet Medical Officer from August 1999 to November 2000 was used to determine the spectrum of illness arising in minor and major fleet units. A log of medical evacuations from Persian Gulf deployments for the period July 2001 to February 2003 was also analysed.
- ***Results:*** Medical evacuation rates reached a maximum of two per major fleet unit per annum, although there was significant variability between ships and within each ship. Rates of medical evacuation from Gulf deployments were similar to rates from the US Navy and Royal Navy where a medical officer was carried. Rates of common surgical emergencies at sea were below Australian age-related averages. These rates were considerably lower than those reported in Royal Navy Polaris submarines.
- ***Conclusions:*** The current policy of deploying RAN ships with medical officer support is probably useful in terms of reducing medical evacuations and providing better diagnosis of acute conditions. The use of diagnostic algorithms and telemedicine is of secondary importance to the clinical skills of a ship's medical officer. Data collection on episodes of serious morbidity and medical evacuations needs some revision.

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MEDICAL SUPPORT AT SEA for Royal Australian Navy (RAN) operations is provided by ships' medical teams of varied competencies and strengths. These teams range from a solo medical sailor with the support of a Ship's Medical Emergency Team to a fully equipped Surgical Support Team of surgeons, anaesthetists, intensive care physicians, theatre nurses and medical sailors, as in the Primary Casualty Receiving Facility of the RAN's two heavy landing ships. Commonly, a frigate or destroyer will be provided with a ship's medical officer when deploying overseas; at least, there will be one medical officer within a task group. The ship's medical officer usually has limited experience in surgery and anaesthesia, and occasionally may be faced with an acute surgical emergency in mid-ocean, with expert surgical help thousands of kilometres away. Even if the officer has the confidence and ability to perform emergency surgery, there is often no skilled anaesthetic support nearby. Evacuation by helicopter from the ship is only possible if the ship is within flying range of the aircraft (usually about 400 nautical miles). Submarines and smaller surface ships lacking a landing facility for helicopters pose an additional set of logistical problems for medical retrieval.

The fitness of sailors at sea is assured by high pre-deployment standards of health (including a requirement that female sailors are not pregnant), but such checks cannot prevent unforeseen accidents and

Commander Mike O'Connor *is Vice President of the Royal Australian College of Obstetricians and Gynaecologists and chairs the Chapter of Military Obstetrics and Gynaecology. He has been a consultant obstetrician and gynaecologist to the RAN since 1982. He has appointments at St George public and private hospitals in Sydney and is chairman of the Division of Obstetrics and Gynaecology at St George Private Hospital. He has served on HMAS* Stalwart, *HMAS* Tobruk *and HMAS* Manoora, *the last being as support for pregnant refugees during the Tampa crisis in 2001. He has also served in Bougainville and East Timor.*

Commander Mark Parrish *has served in the Royal Navy and the Royal Australian Navy from the Antarctic to the Arabian Gulf. He was responsible for establishing and deploying with the Primary Casualty Reception Facility aboard HMAS* Manoora *and* Kanimbla *and, on leaving the Navy, has managed public and private hospitals.*

Department of Obstetrics and Gynaecology, St George Hospital, Kogarah, NSW.
Mike O'Connor, MB BS(Hons), MD, DCH, DDU, FRCOG, FRANZCOG, Consultant obstetrician and gynaecologist, RAN.
School of Underwater Medicine, HMAS Penguin, Balmoral, NSW.
Mark J Parrish, MB BCh(Hons), FRACGP, MRCGP, DipOccMed,MHA,
Correspondence: CMDR M O'Connor, Department of Obstetrics and Gynaecology, St George Hospital, PO Box 185, Kogarah, NSW 2217.
celticdr@bigpond.net.au

1: Comparison of morbidity rates during Persian Gulf deployments and during refits

Ship	Refit/Gulf	Man days	Morbidity/1000 man days
Melbourne	Refit	31 255	0.416
Sydney	Refit	35 748	0.531
Westralia	Refit	8 733	0.344
Westralia	Refit	11 370	0.616
Westralia	Refit	14 600	0.205
Westralia	Refit	12 775	1.018
Mean refit morbidity rate			**0.522**
Adelaide	Gulf	133 180	0.291
Adelaide	Gulf	26 400	0.038
Anzac	Gulf	20 640	0.048
Anzac	Gulf	30 960	0.019
Arunta	Gulf	9 515	0.210
Arunta	Gulf	30 960	0.065
Canberra	Gulf	33 000	0.030
Kanimbla	Gulf	43 680	0.023
Kanimbla	Gulf	52 500	0.095
Manoora	Gulf	29 640	0.574
Manoora	Gulf	9 000	0.333
Melbourne	Gulf	18 564	1.023
Melbourne	Gulf	20 111	3.083
Melbourne	Gulf	11 934	3.184
Melbourne	Gulf	20 610	0.049
Newcastle	Gulf	33 000	0.061
Newcastle	Gulf	29 700	0.135
Sydney	Gulf	13 608	1.837
Sydney	Gulf	30 240	0.198
Sydney	Gulf	26 400	0.038
Sydney	Gulf	26 400	0.076
Mean at-sea morbidity rate			**0.543**

unpredictable acute surgical emergencies from arising at sea. These include complications of early pregnancy and a range of gynaecological emergencies. Acute medical and surgical emergencies requiring prompt medical care for sailors of both sexes include appendicitis, cholecystitis, peptic ulceration and haematemesis, pneumothorax, asthma, severe sea sickness, decompression sickness, marine envenomation, fractures, and intracranial haemorrhage after head injury. Male sailors are at risk of testicular torsion and acute epididymo-orchitis. Because diagnostic facilities are limited in fleet units, maximum use of basic clinical skills is required. Diagnosis of the condition may at best be narrowed to a shortlist of possibilities. As a general principle, surgical procedures at sea in units not equipped with operating theatres should only be undertaken as a last resort.

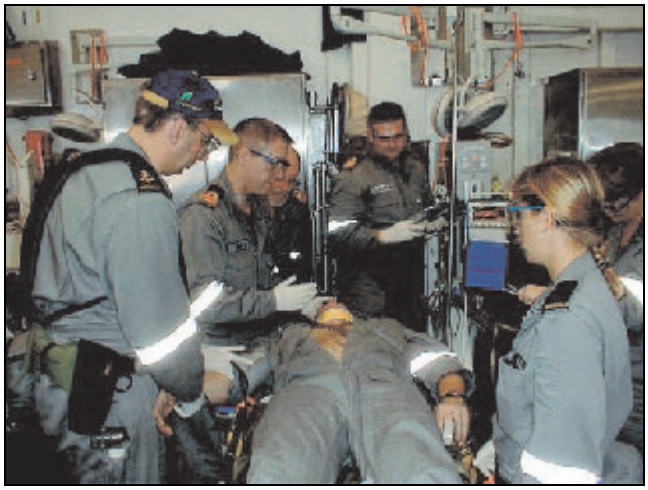
The level of surgical and medical emergencies at sea in RAN ships is not well recorded. This is important information for health planners to provide adequate support for sailors at sea, including allocation of appropriately trained ships' medical officers. This study aimed to determine the level of morbidity and mortality in seagoing sailors in RAN ships and compare this with data from other navies.

Methods

All available 6-monthly medical journals for RAN ships were obtained from Maritime Headquarters. These included records from 14 major fleet units spanning 124 periods, mostly of 6 months' duration, between 1991 and 2003. The crew complement and record of sea time were obtained from each period to derive a figure for "man sea days" (acknowledging that up to 20% of some crews were female).

Form PM293 is a statistical form that is part of the ship's medical journal kept by all major fleet units. It is completed for every 6-month period and details levels of crew morbidity, vaccinations performed, public health education provided by sick-bay staff, a record of drugs of addiction used and health inspections conducted. Minor fleet units, such as patrol boats, minehunters, landing craft and submarines, are not required to collect such data.

The level of morbidity during each 6-month period was determined from the four categories recorded on Form PM293, including crew members admitted to the sick-list aboard, those admitted to naval hospitals, those landed ashore sick, and those admitted to non-



Treating a patient in the triage area, HMAS *Manoora*.

naval hospitals. Specific data on serious morbidity were extracted from the ships' medical journals where these were available.

Data on all medical evacuations undertaken were also obtained from PM293 forms and from a medical evacuation database held by Headquarters Australian Theatre and covering 13 deployments to the Persian Gulf from July 2001 to February 2003.

It was not possible to separate episodes of morbidity that occurred at sea from those occurring alongside. However, the ships' activity levels were available, and these allowed some comparison of morbidity rates to be made, morbidity rates in times of low seagoing activity such as refits were compared with morbidity rates in times of high operational activity such as Persian Gulf deployments (Operation Slipper, Operation Damask). The latter involved minimal periods alongside.

In addition, the log of all communications between major and minor fleet units and the Deputy Fleet Medical Officer over an 18-month period was analysed to determine the spectrum of medical and surgical emergencies occurring at sea from August 1999 to November 2000.

Statistical analysis included the Pearson correlation coefficient and the Mann–Whitney *U* test.

Results

Analysis of medical journals

A total of 1 797 631 man sea days were available for study. This represented data from a total of 134 data sheets on 14 RAN ships. These ships included two guided missile destroyers (HMAS *Brisbane*, *Perth*) with crew complements of about 330, two heavy amphibious landing ships (HMAS *Kanimbla*, *Manoora*) with crew complements of 250–350, six FFG frigates (HMAS *Adelaide*, *Canberra*, *Darwin*, *Melbourne*, *Newcastle*, *Sydney*) with crew complements of about 200, two supply ships (HMAS *Success*, *Westralia*) with crews of about 230 and 100, respectively, and two Anzac class frigates (HMAS *Anzac*, *Arunta*) with crews of about 175 sailors.

In a 6-month period, the number of sea days ranged from zero (6-month refit) to 151 (median, 120 days; mean, 69.5 days). The number of man sea days for a 6-month period ranged from zero to 30 240 (mean, 13 318; median, 26 400). The rate of morbidity (total sick) ranged from zero to 18 per 10 000 man sea days (median, 16 per 10 000 man sea days; mean, 15 per 10 000 man sea days). The rate of acute surgical emergencies was 1 per 40 000 man sea days, and the rate of acute medical emergencies was 1 per 18 000 man sea days. This gives a combined rate of acute emergencies of 1 per 12 400 man sea days. There was poor correlation between the number of total sick per 6 months and the number of man sea days (Pearson correlation coefficient, 0.271).

For the 14 ships, there were 65 medical evacuations recorded, spanning some 54 ship sea years, or about 1.2 evacuations per sea year for the whole study group.

The rate of morbidity at sea during Persian Gulf deployments (21 separate deployments in nine ships) was not significantly different from morbidity rates during refits (Box 1): the mean morbidity rate for Gulf deployments was 0.54 per 1000 man sea days (95% CI, 0.11–0.98 per 1000 man sea days) compared with 0.52 per 1000 man refit days (95% CI, 0.23–0.82 per 1000 man refit days; $P = 0.06$).

The rates of specific illnesses are summarised in Box 2. These include four members with smoke inhalation, all of whom died on HMAS *Westralia* in 1998.

Analysis of communication logs

In an alternative attempt to determine the frequency of certain illnesses on RAN vessels at sea, the telephone log of the RAN Deputy Fleet Medical Officer was analysed. This comprised 44 communications over 15 months (Box 3). Fifteen of these calls concerned casualties beyond the Australian coastline. Eighteen of the 44 calls concerned casualties in minor fleet units. Twenty-one of the casualties required medical evacuation. A ship's medical officer made 14 of the 44 calls.

2: Rates of specific types of morbidity

Condition	Number	Rate per 100 000 man sea days	Frequency in man sea days
Fractures	20	1.1126	1 per 89 882
Psychiatric illness	19	1.0569	1 per 94 612
Appendicitis	7	0.03894	1 per 256 804
Obstetric and gynaecological	6	0.3338	1 per 299 605
Smoke inhalation*	4	0.2225	1 per 449 408
Burns	2	0.1113	1 per 898 816
Peptic ulcer	2	0.1113	1 per 898 816
Central nervous system haemorrhage	2	0.1113	1 per 898 816
Calculus–renal	1	0.0556	1 per 1 797 631
Inguinal herniorrhaphy	1	0.0556	1 per 1 797 631
Testicular torsion	1	0.0556	1 per 1 797 631

* These four patients were in the *Westralia* fire and were the only fatalities during the study period.

Of the remaining 30 calls, medics made nine, petty officer coxswains (responsible for basic medical care in minor fleet units) made 11, and officers and other ranks made 10.

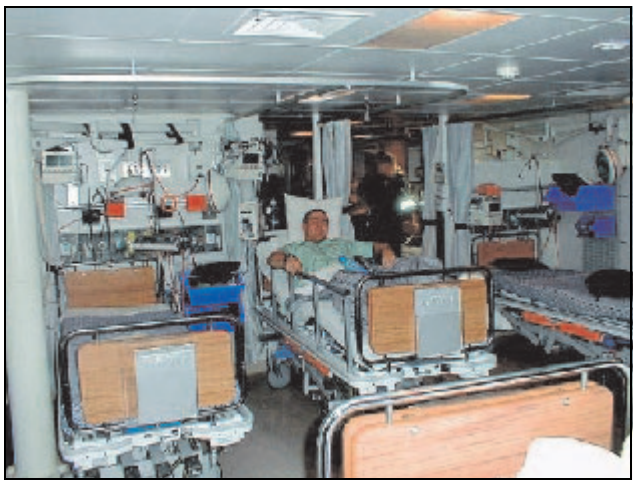
Nine of the 44 calls related to orthopaedic injuries and two involved psychiatric illness. The acute obstetric case related to an unauthorised boat arrival (UBA) on Ashmore Reef. The woman, who had a history of three previous caesarean sections, was transferred in suspected labour to a patrol boat. In addition, a petty officer coxswain saw another UBA immigrant at 24 weeks' gestation with headaches. Another UBA presented to the crew of a patrol boat with a secondary postpartum haemorrhage. She was treated conservatively with antibiotics after communication between a ship's medical officer on the patrol boat and a gynaecologist. There were two consultations regarding severe seasickness in the period August 1999 to November 2000.

Medical evacuation of an injured soldier from HMAS Tobruk.

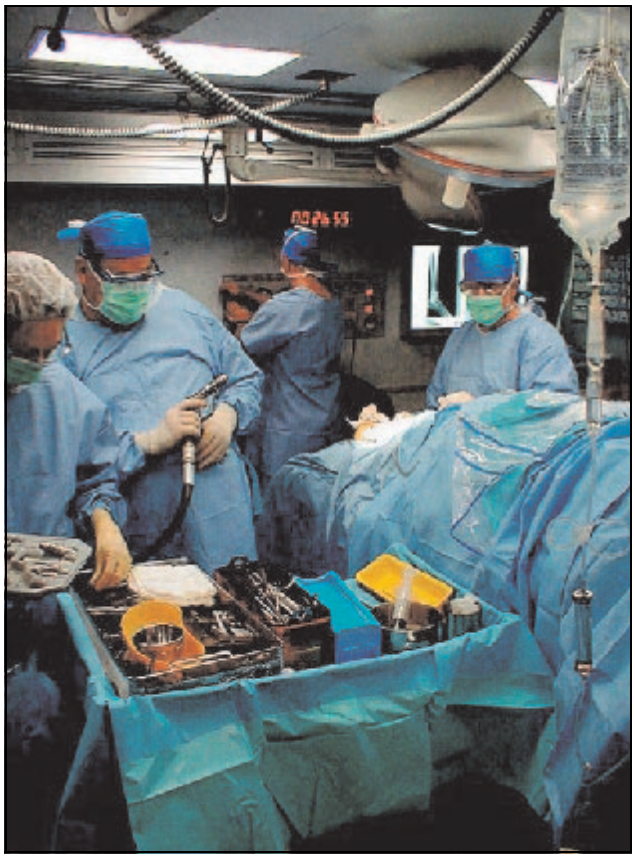
Discussion

Morbidity and mortality at sea in the period 1991 to 2003 were low, with only four fatalities (in a single accident). There was no significant difference in the morbidity rates between ships involved in high operational activity (Gulf deployments).

The deaths of four sailors on board HMAS *Westralia* in an engine room fire accounted for the only seagoing deaths for the whole study period. In 1998, the mortality in the RAN was 4 per 10 000 members per year. This compares with 10 per 10 000 members in the Army in 1998 and 4 per 10 000 members in the Royal Australian Air Force (RAAF). Between 1994 and 1998, accidents represented 66% of all RAN deaths, 71% of Army deaths and 48% of RAAF deaths. The overall mortality in the Australian Defence Force was 6–7 per 10 000 members, of whom 32% died from natural causes, 27% from motor vehicle accidents and 17% from suicide.[1]



Patient in the high dependency unit, HMAS Manoora.



Orthopaedic surgery aboard HMAS Manoora.

While the traditional concept of the ship's medical officer is that of a person capable of performing emergency surgery, such as appendicectomy, at sea, the necessity to do so is minimal (eg, only seven cases of appendicitis and two cases of peptic ulcer were reported by the 14 ships over the study period, spanning nearly 55 years of accumulated sea time). The commonest option was to evacuate acute emergency patients (21/44 cases in the Deputy Fleet Medical Officer's log) and clearly the availability of shipborne helicopters has meant that most casualties can be transferred either to a shore-based facility or to a capital ship with better medical facilities.

The RAN has chosen to evacuate people with acute surgical and medical conditions from seagoing ships wherever possible. Other navies have chosen to operate on relatively large numbers of sailors at sea (eg, the Soviet whaling fleet based in Antarctic waters operated on 1800 personnel, including more than 200 women, over a 12-year period).[2] Like their merchant marine counterpart, the Soviet Navy also chose to treat sailors at sea surgically, reporting 1000 such operations, including 205 appendicectomies. These operations were occasionally performed under ether/oxygen anaesthesia in frontline surface ships, but in submarines local anaesthesia, especially using a novocaine right perinephric block, was preferred.[3] Apart from appendicectomies, perforated ulcers, abdominal cavity trauma and injuries to extremities were all treated at sea by the Soviet Navy.[4]

The US Navy performed 684 operations aboard ships of the Atlantic Fleet over a 3-year period from 1994 to 1996, reporting surgical morbidity rates far lower than those of a shore-based navy surgical facility.[5] The series included 84 appendicectomies, 150 inguinal herniorrhaphies and 171 vasectomies. More recent publications describe laparoscopic hernia repairs aboard the USS *Abraham Lincoln* in the Pacific Ocean,[6] and using intercontinental telemonitoring systems to link consulting surgeons in Maryland and California to the ship's operating theatres (Battlegroup Telemedicine).[7] The Royal Navy has followed a more

3: Casualties at sea recorded in the Deputy Fleet Medical Officer's telephone log

Condition	Number	%
Acute surgical emergency	7	16%
Acute medical emergency	9	20%
Acute obstetric emergency	1	1%
Subacute surgical	5	11%
Subacute medical	21	48%

Moving a patient to the operating room, HMAS Manoora.

conservative path, although surgery at sea on aircraft carriers such as HMS *Ark Royal* was practised, particularly to keep the medical department at maximum efficiency.[8] For Royal Navy submarines, the treatment of acute surgical conditions is necessarily conservative — in 100 Polaris patrols of average duration of 50 days, 20 submariners with appendicitis were treated surgically, with only one requiring emergency medical evacuation (because of portal pyaemia).[9] One hundred and six surgical emergencies were described in that article, giving a rate of one surgical patient per 7944 man sea days. This figure is similar to estimates made in a study of US submarines.[10] It suggests that one surgical emergency can be expected on an average patrol of 8500 man sea days.

Our data suggest that the rate of acute medical emergencies in the RAN is slightly better than in the Polaris patrols. In real terms, it would mean that a 6-month deployment to the Persian Gulf could involve one to two acute medical or surgical emergencies, depending on the crew numbers.

However, it should be emphasised that the data extracted from PM293 forms were suspected of being incomplete in a significant number of cases. Revision of the data collection form is strongly recommended.

A study in the US Navy of 354 surface ships, 42 Pacific Fleet submarines and 54 military transport ships reported that, in 62% of cases where a medical communication was made, the patient was subsequently evacuated from the ship.[11] Twenty-eight per cent of these medical evacuations were deemed avoidable if a system of sophisticated telemedicine had been available. This would include transmission of radiographs, imaging studies, and voice communication between sickbay staff and shore-based facilities. In 22% of these evacuations, the shipboard diagnosis was significantly different from the final diagnosis (eg, "fracture" versus contusion, "appendicitis" versus gastrointestinal upset). Overall, it was estimated that the average US Navy ship initiates two medical evacuations per year. The rate of evacuations from ships whose medical departments were staffed only by an independent duty corpsman was more than double that of ships staffed by a physician (3.5 per 1000 patient visits versus 1.5 per 1000 patient visits). This was thought to be a problem resulting from poorer diagnoses by independent duty corpsmen. The solution proposed was to introduce clinical algorithms for the diagnosis and treatment of common acute conditions, such as appendicitis and infectious diseases. These were subsequently developed.[12]

The high rate of RAN medical evacuations described in the Deputy Fleet Medical Officer's log (48% of 44 cases) may reflect the fact that 40% of calls were from minor fleet units lacking a medical officer. Although the data may be incomplete, the low number of medical evacuations reported in the 14 major fleet units in our study (65 evacuations over 54 ship sea years) agrees with findings reported by Mark and Hodge when describing advice given by radio to masters of merchant ships in the Southern and Indian oceans:[13] 48 patients with spontaneous illness were discussed (7 surgical, 41 medical), including 27 injuries at sea. In only 12% of cases was there a need for the ship to change course significantly — most illnesses were diagnosed and treated on board. However, the paramedical qualifications of the merchant seaman making the call may be less than those of RAN-trained medics, who might be expected to seek advice about simple conditions less frequently than their merchant service colleagues.

Pregnancy emergencies are uncommon in service-women at sea. However, the involvement of major and minor fleet units in the apprehension and transportation of UBAs since August 2001 has required RAN ships to deal with pregnancy complications (including hyper-emesis, confinement and postpartum haemorrhage) arising in civilians at sea,.

The transport of UBAs and contact with new strains of microorganisms have led to an increase in communicable diseases in RAN crews (eg, an epidemic of adenovirus conjunctivitis).

The rate of appendicitis is 26.3 per 10 000 men aged 15–24 years per annum in the Australian population,[14] and, in 1998, in the RAAF was 24 per 10 000 per annum).[1] Therefore, in our sample of a seagoing population of 3140 sailors in 14 ships, one might

expect up to eight cases of appendicitis per year. Peptic ulcers could also be expected to occur in greater numbers, with rates in the Australian population aged 15–24 years of 39.8 per 10 000 per annum for women and 17.7 per 10 000 per annum for men. The rates for peptic ulcer escalate in the 25–34 years age group: 82.2 per 10 000 per annum for women and 66.0 per 10 000 per annum for men.[14] One might therefore have expected to see 20 or more cases in our study instead of only two. In the RAAF, gastrointestinal tract endoscopies were the second commonest operative procedure in 1998 (1.4 per 10 000 members per annum).[1] Hospital admission rates for digestive system diseases rank first in the Australian population generally (3.5 per 10 000 population per annum) and in the RAN (4.31 per 10 000 members per annum).[1]

Mental disorders occur in the general Australian population at a rate of 106 per 10 000 per annum.[14] There were 19 cases of psychiatric illness detected in sailors on RAN ships in this study, giving a rate of 0.1 per 10 000 man sea days, or 1 per 259 man sea years. One might have expected 33 cases for our 3140 sailors. The overall rate for mental disorders in the RAN in 1998–99 was 180 per 10 000 per annum (1 per 55 sailors and substantially higher than the overall Australian incidence), compared with 69 per 10 000 per annum for the Army and 72 per 10 000 per annum for RAAF personnel.[1] Part of the unusually high incidence in the RAN is due to the impracticality of treating people with such illnesses as outpatients, so many are admitted to RAN hospitals for more intensive treatment ashore. In civilian life, many patients would never be admitted because of the ready availability of outpatient care by psychiatrists. At sea, the treatment of subacute mental illness may well be deferred until the ship is again alongside for longer periods, such as during refits.

The rate of acute trauma was 0.2 per 10 000 man sea days. It is important to note that ship maintenance ranks 11th in the top 15 causes of workplace injuries to ADF members,[1] and in 1998 accounted for 111 casualties in the RAN.

The rates of disease aboard Navy ships in peace time have been recognised as higher than those in time of war.[15] For example, the rate of illness aboard Royal Navy aircraft carriers during the Second World War was 9.55 per 10 000 man days (compared with 11.44 per 10 000 man days in peacetime), and was progressively higher in smaller ships such as cruisers (10.81 per 10 000 man days in wartime; 15.71 per 10 000 man days in peacetime). There was a similar finding in the Vietnam War.[16] The wartime figures for smaller Royal Navy ships are higher than our own figure of 6.92 per 10 000 man sea days for RAN ships involved in Persian Gulf deployments. One explanation given for these lower rates in combat and in larger ships is the reduced time spent in port.[15] Presumably this led to reduced exposure to infectious diseases. One epidemic of gastroenteritis recorded in the ship's medical journal of an RAN guided missile frigate involved 34 sailors. It was traced back to a single source, who acquired the infection in a navy townhouse development ashore.

Another recent factor that may increase morbidity rates at sea has been the introduction of female crew, who appear to have higher rates of illness. Several studies have described the much greater use of ships' medical departments by female sailors in the Royal Navy and the US Navy — threefold greater and ninefold greater, respectively.[17,18] The implication of this finding for the staffing of a ship's medical department could be significant: it has been calculated that replacing just 10% of a ship's all-male crew with female sailors would lead to a doubling in the medical workload.[17]

Conclusion

We have reviewed the morbidity and mortality rates in an unselected sample of major RAN fleet units. The actual rates of medical evacuation appear to compare more than favourably with those of other navies, and the rate of morbidity for many conditions at sea seems lower than might be expected from both Australian population and ADF data. This may be due, in part, to poorer recognition and recording by sickbay medics and, if so, diagnosis and management might be improved by the introduction of better facilities for telemedicine and computer-assisted diagnostic and therapeutic algorithms.

Acknowledgement

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Book review

A personal history

The Royal Australian Army Medical Corps, 1945–1975

Colin M Gurner. Cheltenham and Richmond: Kingston Digital, and Abbott Inc, 2003. ISBN 0 646 42115 8

A COMPREHENSIVE HISTORY of the Royal Australian Army Medical Corps (RAAMC) marking its centenary was written by Michael Tyquin and published in 2003.[1] Now, Major General (Retd) Colin Gurner, AO, CBE, KStJ, ED, QHP, (Director-General, Army Medical Services, 1967–1975; Joint Services Medical Advisor, 1975–1977; and Surgeon-General, Australian Defence Force, 1977–1979) has written a uniquely personal account of the RAAMC, 1945–1975, which covers the period of the Korean and Vietnam wars. Its value lies in being a primary source of Australian military history written by a senior Australian Army officer at the centre of the action at this time, and it is therefore a precious document. This is despite General Gurner stating in the preface that it is an "unofficial" history prepared from his personal records and recollections.

For a book of 137 pages, it packs in an enormous amount of fascinating information, covering the early post-World War II period; the redevelopment of the Citizen Military Forces (CMF), 1948–1975; the Army Medical Directorate, 1948–1960; the development of the School of Army Health; the expansion of the CMF and the development of Australian Regular Army (ARA) medical units, 1951–1960; the Army Health Benefits Scheme; the recruitment of ARA Medical Officers; the impact of wars on the Directorate; and the Clyne and Gurner eras.

There are many fascinating photographs depicting the major military medical figures of this period, including General Gurner. Several appendices provide brief but informative biographies of great Australian soldier–doctors, including Refshauge, Hanson, Johnston, Glyn White, James, Coates and Dunlop. General Gurner's involvement in the Order of St John and the St John Ambulance is also described.

Fortunately, General Gurner presented me with a signed copy of this privately published book, otherwise I would probably not have encountered it. For those who have caught the "history bug", but also for those who want to find out how the RAAMC has arrived at its current stage of development, this little book is highly recommended. It should be held in all ADF libraries.

Jeffrey V Rosenfeld
Editor, *ADF Health*

1. Tyquin M. Little by little: a centenary history of the Royal Australian Army Medical Corps. Sydney: Australian Military History Publications, 2003.