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- Correlates of Frequent Mental Distress among Active and Former Military Personnel
- Formation of Medical Units in Response to Epidemics in the Australian Imperial Force in Palestine 1918
- Unjustly accused? Medical authorities and army recruitment in Australia 1914-1918

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Cover Image is from the Australian War Memorial

Pictured: The 8th Sanitary Section attached to the Australian Mounted Division on parade.

Date made: January 1919

Place made: Ottoman Empire: Lebanon, Tripoli

Journal of Military and Veterans' Health

Australasian Military Medicine Association

STATEMENT OF OBJECTIVES

The Australasian Military Association is an independent, professional scientific organisation of health professionals with the objectives of:

- Promoting the study of military medicine
- Bringing together those with an interest in military medicine
- Disseminating knowledge of military medicine
- Publishing and distributing a journal in military medicine
- Promoting research in military medicine

Membership of the Association is open to doctors, dentists, nurses, pharmacists, paramedics and anyone with a professional interest in any of the disciplines of military medicine. The Association is totally independent of the Australian Defence Force.

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Inside this edition

As we move closer to the 100th anniversary of the start of the Great War, I am constantly reminded of the sacrifices made by our ancestors to fight that war. In this issue, the Journal has reprinted the HMAS Sydney's Medical Officer's log for 09 November 1914 as she battled the SMS Emden near the Cocos Islands. In keeping with this World War 1 theme, this issue has two excellent articles on the challenges of Army recruiting during the war and on the formation of medical units in response to the epidemic in the Palestine in 1918. Further articles on World War I will be published in future issues.

This issue also looks at the management of mid-facial fractures, mental distress in military personnel and the history of tuberculosis, a disease that has plagued conflict and humanitarian assistance situations, in two parts.

As Editor, I continue to look for relevant and interesting papers, both academic and operational, for future issues. I encourage all our readers to consider publishing in JMVH in your area of expertise or interest.

Dr Andy Robertson, CSC, PSM
Editor-in-Chief

Correlates of Frequent Mental Distress among Active and Former Military Personnel

Eleanor DiBiasio, Melissa A Clark and Samantha R Rosenthal

Abstract

Background: Millions of veterans living in the United States suffer from mental illness. Understanding the correlates of mental illness can help target treatment to individuals in need and prevent mental distress, leading to healthier veterans and lower healthcare costs.

Objective: To examine risk factors for mental illness among those who have served or currently serve in active duty military service in the U.S. armed forces.

Methods: Data were from the 2010 Behavioral Risk Factor Surveillance System (BRFSS). Multivariable logistic regression was used to examine the relationship between mental distress and age, race, gender, education, income, employment, time since service, marital status, number of dependent children, physical health, sleep, and emotional support among former or active duty military population.

Results: Almost 9% of respondents reported frequent mental distress (FMD). Those with FMD were more likely to be minorities, young, single and female. The unemployed and those in poor physical health also had greater odds of FMD.

Conclusion: Because individuals with physical ailments and lacking employment were most likely to report distress, physical therapy services and programs to address unemployment and poverty can have a positive impact on the mental health of veterans. Education and training programs and physical therapy offices may be excellent sites for FMD screening.

Introduction

There are currently over 20 million veterans living in the United States[1] and nearly ten percent are receiving care for mental illness.[2] In 2007, the Department of Veteran's Affairs (VA) spent over $3.5 billion dollars in mental health and substance abuse treatment for veterans[3]. That number is increasing as more veterans utilize VA mental health services.[2,4] Due to the wars in Iraq and Afghanistan, nearly 40% of veterans return home with mental health problems, the most common of which are post-traumatic stress disorder (PTSD) and depression[5]. These returning veterans add to the millions who served in the World Wars, the Korean War, Vietnam, and the Gulf War, each of which had a substantial mental health impact on its respective generation of soldiers.[6]

Despite the high prevalence of stress and mental illness, many veterans still battle their mental illness privately due to stigma of these conditions in the military and at home. Of veterans who meet the screening criteria for a mental health problem, only 38-45% express interest in receiving help and only 23-40% actually obtain professional help.[7] Understanding the correlates of mental illness among veterans can help the Veterans Administration (VA) and other veteran support organizations target mental health treatment to individuals who need it, whether they report their needs or not.

This study examines the association between potential risk factors and mental distress among current and formerly active duty military personnel using a nationally representative sample of veterans of all ages, races, incomes and backgrounds. We define "active duty" according to the U.S. Census Bureau definition:

> "Active duty military service includes full-time service, other than training, as a member of the U.S. Army, Navy, Air Force, Marine Corps, Coast Guard or as a commissioned officer of the Public Health Service or the National Oceanic and Atmospheric Administration… Active duty also applies to a person who is a cadet attending one of the five United States Military Service Academies.

> Active duty applies to service in the military Reserves or National Guard only if the person has been called up for active duty, mobilized, or deployed."[8]

The nationally representative sample provides a novel opportunity to determine the characteristics of veterans more likely to suffer from mental distress and to make recommendations to prevent and treat the condition.

Methods

Sample

The data were from the 2010 Behavioral Risk Factor Surveillance System (BRFSS), a national telephone survey administered annually by the Centers for Disease Control and Prevention (CDC). Further information about the methods of data collection and survey administration used in the BRFSS can be found elsewhere.[9]

Eligibility for the study included those who had served or were currently serving in the active duty U.S. military, or in an activated unit of the Reserves or National Guard. All BRFSS respondents were asked, "Have you ever served on active duty in the United States Armed Forces, either in the regular military or in a National Guard or military reserve unit? Active duty does not include training for the Reserves or National Guard, but DOES include activation, for example, for the Persian Gulf War." Possible responses were "yes, now on active duty;" "yes, on active duty during the past twelve months, but not now;" "yes, on active duty in the past, but not during the last 12 months;" "no, training for Reserves or National Guard only;" and "no, never served in the military." Those who reported being currently active duty, active duty in the past year, or active duty over one year ago were included in the analytic sample. Those with invalid information (i.e., those who answered 'don't know/not sure,' who refused to answer, or who had missing data) were excluded from the analytic sample, as were those who had never served in active duty forces. Also excluded was 1.9% of the eligible population with invalid information for the outcome of interest, days of poor mental health in the past month. The final analytic sample included 59,310 respondents. Henceforth the current and former active duty soldiers in the analytic sample will be referred to as "veterans."

Measures

Outcome

We used a validated Centers for Disease Control and Prevention (CDC) measure of frequent mental distress (FMD), defined as having fourteen or more days of poor mental health in the past thirty days.[10] This two-week cut-off matches diagnostic tools used by clinicians to diagnose mental health problems such as anxiety and depression.[11,12]

Potential risk factors for FMD included demographic characteristics (age, gender, race/ethnicity, marital status, education level, income, number of dependent children, and employment), as well as risk factors identified in previous literature about veterans (time since service, physical health status, days without adequate sleep in past month, and emotional support[13-16]). Age was categorized into quartiles. Race/ethnicity was operationalized so that the 'other' group included American Indian, Alaskan Native, Pacific Islander, Asian and other small minority groups. Marital status was categorized into "never married," "widowed," "separated or divorced" and "married or the member of an unmarried couple." Education was categorized as "did not finish high school," "finished high school," "some college," and "finished college." The income categories were chosen because they create four roughly equal income intervals. Because 11.0% of respondents in our analytic sample had missing information on income, we added a "missing" category to the analysis. We dichotomized respondents as employed or not employed. Homemakers, students and retirees were included as 'employed' because they are often voluntarily unemployed and involuntary unemployment has been shown to correlate more highly with mental illness than voluntary unemployment.[17,18] Finally, we categorized respondents as having either zero, one, or two or more dependent children under the age of 18 years.

Time since service, poor physical health, inadequate sleep, and lacking emotional support are all possible causes of emotional stress and psychological problems[13-16] and therefore were included as potential risk factors in the analysis. We created a three-category variable for time since service: currently active duty, active duty in the past twelve months, and active duty over twelve months ago.

Poor physical health was defined using the question, "for how many days during the past 30 days was your physical health not good?" Responses ranged from zero to thirty days. We then created two categories based on the validated CDC measure of frequent physical distress[19]: 1) no frequent physical distress (physical health not good 0-14 days) and 2) frequent physical distress (physical health not good 15 or more days).

To operationalize amount of inadequate sleep received, we used the question, "During the past 30 days, for about how many days have you felt you

did not get enough rest or sleep?" This variable was treated as continuous to compute point estimates of the average number of days without adequate sleep among those with and without frequent mental distress.

Finally, we operationalized availability of emotional support using the question, "How often do you get the social and emotional support you need?" with responses of Always, Usually, Sometimes, Rarely, or Never. We collapsed the possible responses into two categories: "Always or usually has adequate emotional support" and "sometimes, rarely or never has adequate emotional support."

Analysis

Data were weighted to adjust for non-response and non-coverage in order to obtain U.S. population estimates and to account for the complex survey design of the 2010 BRFSS. For all potential risk factors, missing and invalid observations were excluded. For all variables except income, the number of observations with invalid information was less than 10% of the total observations in the sample. Frequencies and weighted percentages were calculated for all variables (Table 1). Bivariate analyses were computed to compare the prevalence of frequent mental distress across demographic characteristics and potential risk factors. To determine if combat exposure was specifically related to frequent mental distress, we conducted a sub-analysis (N=2,556) on the relationship between combat exposure and frequent mental distress using bivariate analysis. The smaller sample size was a result of only having data on combat exposure from respondents in two states (Nebraska and Tennessee).

Multiple logistic regression was employed to characterize the relationship between potential risk factors and frequent mental distress. We obtained crude and adjusted odds ratios of frequent mental distress for all potential risk factors (Table 2). STATA version 12 was used for all analyses.[20]

Results

Overall, only 25% of the study population was under age 45, and the largest age group was those over seventy years (29%). The study sample was predominately male (92%), non-Hispanic white (78%), and married (75%). The vast majority reported completing high school or a higher level of education (96%) and almost one-third had household incomes of more than $75,000 (32%). Ninety-three percent reported being employed and 91% served more than 12 months ago, with only 5.0% active duty at the time of survey administration. Most had no dependent children (74%), and 86% percent reported good physical health. Respondents reported an average of 7.1 days of inadequate sleep (95% CI 7.0-7.3) in the past month, and most respondents had at least adequate emotional support in their lives (81%). It is worthwhile to note that our sample of current and former active duty personnel in this study is significantly older than the general U.S. civilian population. Moreover, our sample consisted of a higher proportion of males, had on average a lower reported income, and had more physical distress than non-active duty personnel who answered the BRFSS 2010, indicating that those with active duty experience in the U.S. have different distributions of demographic and health variables than the general population.

Almost 10% of the study sample reported experiencing frequent mental distress (FMD). As shown in Table 1, those with FMD were more likely to be African American, Hispanic, and non-Hispanic multiracial respondents. Results of the multivariable analysis of risk factors for frequent mental distress (Table 2) showed that younger adults and females had increased odds of FMD. Those who were widowed, less educated, and had lower incomes had higher odds of FMD. Those who were unemployed had three times the odds of FMD compared to those who were employed, and individuals in poor physical health had much greater odds of FMD than individuals with better physical health. Those with less than adequate sleep also experienced slightly higher odds of FMD than those reporting adequate sleep. Individuals who reported always or usually having adequate emotional support had decreased odds of FMD compared to those who reported sometimes, rarely or never having adequate emotional support.

Because not every active duty individual in the U.S. military participates in combat, we conducted a sub-analysis to determine if participating in active duty combat was related to frequent mental distress. We found no significant results in this regard (p=0.36).

Discussion

This study characterizes frequent mental distress among current and former active duty U.S. military personnel. Using the CDC measure of frequent mental distress (FMD), we found that almost 10% of current and former active duty soldiers have FMD. This is higher than the prevalence of FMD estimated for the general population (7.1%).[21] This is one of the largest studies to date of a random sample of veterans, and as a result our findings are highly generalizable.

Table 1: Characteristics of 2010 U.S. population of individuals who were formerly or currently active duty military*

Characteristic	Frequent Mental Distress‡ n=5,189 (8.8%)*	No Frequent Mental Distress‡ n=54,121 (91.3%)*	Total N=59,310*	p-values
Age (in quartiles)				*p<0.0001*
18-45 years	788 (34)	5,463 (24)	6,251 (25)	
46-58 years	1,368 (26)	8,244 (19)	9,612 (19)	
59-69 years	1,737 (25)	17,318 (26)	19,055 (26)	
70-99 years	1,263 (15)	22,725 (31)	23,988 (29)	
Gender				*p<0.0001*
Male	4,490 (86)	50,035 (92)	54,525 (92)	
Female	699 (14)	4,086 (7.6)	4,785 (8.1)	
Race/ethnicity				*p=0.0001*
Non-Hispanic white	4,011 (73)	45,516 (79)	49,527 (78)	
Non-Hispanic black	428 (11)	3,345 (9.9)	3,773 (10)	
Hispanic	239 (8.6)	1,787 (6.3)	2,026 (6.5)	
Non-Hispanic multiracial	176 (3.1)	999 (1.8)	1,175 (1.9)	
Other	226 (4.8)	1,550 (3.2)	1,776 (3.3)	
Education level				*p<0.0001*
Did not finish high school	483 (8.0)	2,976 (4.1)	3,459 (4.5)	
Finished high school	1,641 (29)	15,632 (28)	17,273 (28)	
Some college	1,822 (39)	15,560 (31)	17,382 (32)	
Finished college	1,228 (24)	19,804 (37)	21,032 (36)	
Income level				*p<0.0001*
<$25,000	2,107 (36)	11,076 (17)	13,183 (18)	
$25,000-$50,000	1,372 (25)	15,535 (26)	16,907 (26)	
$50,000-$75,000	577 (13)	8,640 (17)	9,217 (16)	
[3]$75,000	597 (15)	12,864 (30)	13,461 (29)	
Don't know or refused	536 (9.9)	6,006 (10)	6,542 (10)	
Employment				*p<0.0001*
Employed (or homemaker, student, retiree)	3,343 (82)	49,715 (94)	53,058 (93)	
Unemployed	483 (18)	2,182 (5.6)	2,665 (6.5)	
Marital status				*p<0.0001*
Married or member of unmarried couple	2,645 (61)	35,645 (76)	38,290 (75)	
Divorced or separated	1,421 (11)	7,967 (22)	9,388 (12)	
Widowed	648 (6.9)	6,868 (6.7)	7,516 (6.7)	
Never married	446 (9.4)	3,469 (6.3)	3,915 (6.6)	
Number of children <18 years				*p<0.0001*
0	4,232 (67)	46,924 (75)	51,156 (74)	
1	400 (10)	3,016 (9.7)	3,416 (9.8)	
2+	531 (23)	4,061 (16)	4,592 (16)	
Time since service				*p=0.2130*
Currently active duty	101 (3.8)	1,297 (5.2)	1,398 (5.0)	
Active duty past 12 months	119 (4.0)	1,242 (3.6)	1,361 (3.6)	
Active duty over 12 months ago	4,969 (92)	51,582 (91)	56,551 (91)	
Physical health status †				*p<0.0001*
No frequent physical distress	2,453 (52)	46,632 (89)	49,085 (86)	
Frequent physical distress	2,617 (48)	6,426 (11)	9,043 (14)	
Days without enough sleep in Past month? (mean in days [95%CI])	17.4 [16.8-18.0]	6.1 [5.9-6.2]	7.1 [7.0-7.3]	*p<0.0001*
Emotional support				*p<0.0001*
Sometimes, rarely or never	2,261 (43)	9,539 (16)	11,800 (19)	
Usually or always	2,567 (57)	40,951 (84)	43,518 (81)	

*unweighted totals (weighted percentages)

€ Within each covariate, the frequencies may not add up to the total number of respondents in that category (N) because of missing and/or invalid observations, which have been excluded from the table.

† Frequent physical distress defined as >14 days poor mental health in past 30 days

‡Frequent mental distress was defined as >14 days poor mental health in past 30 days

Table 2 – Crude and Adjusted Odds Ratios for Frequent Mental Distress† among 2010 US Currently or Formerly Active Duty Adults (N=58,906)

Demographic characteristics and risk factors	Odds of frequent mental distress	
	Crude OR (95% CI‡)	Adjusted OR (95% CI‡)
Age (in quartiles)		
18-45 years	1.00 (ref)	1.00 (ref)
46-58 years	1.00 (0.84-1.18)	0.79 (0.62-1.02)
59-69 years	0.68 (0.58-0.80)	0.69 (0.53-0.91)
70-99 years	0.36 (0.31-0.43)	0.38 (0.27-0.52)
Gender		
Male	0.52 (0.44-0.62)	0.56 (0.44-0.71)
Female	1.00 (ref)	1.00 (ref)
Race/ethnicity		
Non-Hispanic white	1.00 (ref)	1.00 (ref)
Non-Hispanic black	1.21 (1.00-1.46)	0.76 (0.57-1.01)
Hispanic	1.48 (1.10-2.00)	0.99 (0.63-1.54)
Non-Hispanic multi	1.85 (1.40-2.45)	0.80 (0.53-1.20)
Other	1.63 (1.16-2.30)	0.81 (0.47-1.42)
Income level		
<$25,000	4.41 (3.70-5.25)	1.83 (1.43-2.35)
<$50,000	1.95 (1.63-2.34)	1.57 (1.24-1.99)
<$75,000	1.56 (1.28-1.91)	1.42 (1.11-1.80)
³$75,000	1.00 (ref)	1.00 (ref)
Don't know or refused	1.93 (1.54-2.41)	1.53 (1.16-2.03)
Employment		
Employed (or homemaker, student, retiree)	1.00 (ref)	1.00 (ref)
Unemployed	3.68 (2.92-4.64)	2.19 (1.69-2.85)
Education level		
Did not finish high school	3.06 (2.43-3.85)	1.15 (0.87-1.51)
Finished high school	1.67 (1.43-1.95)	0.89 (0.73-1.09)
Some college	1.99 (1.73-2.29)	1.23 (1.02-1.48)
Finished college	1.00 (ref)	1.00 (ref)
Time since service		
Currently active duty	0.73 (0.51-1.04)	0.73 (0.45-1.19)
Active duty past 12 months	1.11 (0.75-1.64)	0.77 (0.51-1.19)
Active duty over 12 months ago	1.00 (ref)	1.00 (ref)
Marital status		
Married or member of unmarried couple	0.54 (0.44-0.66)	0.97 (0.72-1.33)
Divorced or separated	1.35 (1.06-1.73)	1.24 (0.87-1.78)
Widowed	0.68 (0.54-0.87)	1.51 (1.06-2.15)
Never married	1.00 (ref)	1.00 (ref)
Number of children <18 years		
0	1.00 (ref)	1.00 (ref)
1	1.14 (0.95-1.36)	0.86 (0.66-1.13)
2+	1.59 (1.32-1.92)	1.14 (0.86-1.52)
Physical health status †		
No frequent physical distress	1.00 (ref)	1.00 (ref)
Frequent physical distress	7.69 (6.81-8.68)	4.71 (3.95-5.62)
Days without enough sleep in Past month? (mean in days [95%CI])	1.09 [1.08-1.09]	1.07 [1.06-1.07]
Emotional support		
sometimes, rarely or never has adequate emotional support	1.00 (ref)	1.00 (ref)
always or usually has adequate emotional support	0.26 (0.23-0.30)	0.38 (0.32-0.45)

†Frequent mental distress defined as reporting poor mental health on 14 or more days out of the past 30 days
‡CI = confidence interval
§Frequent physical distress defined as reporting poor physical health on 14 or more days out of the past 30 days.

Current and former active duty soldiers with FMD are primarily of low income, limited education, and high unemployment. This is not a surprising finding, as it is well established that low socioeconomic status is associated with high psychiatric morbidity.[22] Improving education is one way to improve socioeconomic status because individuals who earn a post-secondary degree experience greater financial rewards than those who do not attend post-secondary school.[23] Studies of the post-World-War-II GI bills clearly established that lowering tuition costs for veterans substantially increased enrollment in post-secondary education.[24-25] Therefore, programs that increase veterans' education have the potential to reduce poverty, especially since young adults from economically disadvantaged families are more likely than others to enroll in the military.[26] We recommend an increase in programs to assist veterans in obtaining higher education, especially scholarship programs that reduce the cost of attending college for those who cannot afford it. This will have a positive impact on education, income and employment, which were three important risk factors for FMD in this study. For veterans who lack the qualifications or desire for post-secondary education, employment and economic security can still be promoted with workforce re-entry and job training programs.

Younger veterans were also more likely to have FMD, even after controlling for time since service. Seal and colleagues found similar results in their analyses of Iraq and Afghanistan veterans,[5, 27] and suggest that due to their lower military ranks, younger veterans may have greater combat exposure leading to poor mental health outcomes. Because there is evidence that stress, such as that of combat or more generally being of lower rank, can have lifelong effects on mental health,[28] screening and treating our youngest veterans for FMD early may help prevent chronic, lifelong mental health problems.

In our sample, females in active duty service were particularly likely to suffer from FMD. This finding is consistent with other military research.[29-31] Females may be particularly at risk due to the high prevalence of sexual assault against women in the U.S. military,[32] as well as marginalization by other service members.[33] Moreover, females have about twice the risk for depression and anxiety disorders compared to males, regardless of military service history.[34] Male underreporting of mental health symptoms due to a culture of stigma may also at least partially explain the gender differences we observed.[35] As with young veterans, timely screening and treatment can prevent long-term psychological problems for females in the military. In addition, efforts to increase reporting of mental health symptoms among males may be helpful in reaching men who otherwise feel stigmatized. One way to increase reporting among men is to train primary care physicians to screen for symptoms that present more often in men than women--including irritability and risk-taking--when screening for depression.[36]

Systems to ensure emotional support for veterans returning home may also be a key method of mental illness reduction in this population. We found that having adequate emotional support was associated with lower odds of FMD. This confirms the already well-established connection between social support and mental health.[37] There are many evidence-based social support interventions to improve mental health,[38-40] including support groups, one-to-one interventions, and interventions to enhance natural networks. We recommend establishing strong support programs for service members, especially for those who are widowed.

Compared to those without FMD, rates of frequent physical distress and the number of days without sleep were higher among those with FMD. This finding is consistent with literature reporting a connection between physical health and mental wellbeing.[41-45] Physical therapy and pain management programs have been shown to improve depressive symptoms for individuals in chronic pain.[46] Physical distress was the risk factor most strongly associated with FMD in our results, therefore it is especially important that veterans have access to services addressing this issue. In addition to reducing FMD by alleviating disability and pain, these programs present a prime opportunity for mental health screenings and treatment referrals that may help veterans address other factors leading to their mental distress. Since our results show that those with frequent physical distress had over four times the odds of reporting frequent mental distress, screening for mental distress in physical therapy programs may be an effective way to identify veterans who may be experiencing FMD and refer them to appropriate services. Our finding that inadequate sleep and FMD are correlated is not particularly surprising, since FMD serves as a proxy for several mental disorders with symptoms that include sleep disturbance, including depression and PTSD.[10, 47] It is therefore difficult to determine if FMD is a cause of sleep disturbance or a result. Although our data did not allow us to examine cause-and-effect relationships, future studies should question whether, in some veterans, sleeping difficulties are resulting in preventable FMD.

In sum, education and training programs, job fairs, and physical therapy offices would be excellent sites to screen for mental distress in veteran populations,

provide information on mental health services, and refer individuals who may be suffering to appropriate services. Our results show that individuals who are likely to take advantage of employment training and physical therapy are also the individuals at highest risk for FMD. The staff that is performing the screenings should be trained to pay special attention to younger veterans and females, as they have higher odds of FMD. Another group with higher likelihood of mental distress is those who lack emotional support. These individuals may be harder to reach because they are less likely to be involved in programs and services for veterans, but are still likely to utilize basic services such as primary care or physical therapy. Future research should determine how best to reach veterans who may be socially isolated.

Our study has several limitations. First, our analyses are based on self-report data. Studies have shown that military personnel are less likely to report mental illness than the non-military population due to a culture of stigma.[48] The anonymous nature of the BRFSS may have somewhat mitigated the effect of stigma, but the true prevalence of mental distress in this population may be underestimated by our study. The self-reported nature of the BRFSS also limited our ability to study the physical health status of participants. There are clear limitations to the variable used to measure frequent physical distress because "good physical health" is a subjective term. However, we dichotomized this variable in a way that has been validated by CDC. Next, our data were cross-sectional. We cannot assume that any covariates in the final model have a causal relationship with frequent mental distress in the current and former active duty population. For example, poor physical health is likely to be highly correlated with poor mental health, so the relationships observed could be due to reverse causation or residual confounding. In addition, the BRFSS is inherently limited by low response rates, which is an indicator of potential bias in the data collected. For the 2010 BRFSS, the median response rate was between 35.8% (if unknown records are assumed eligible) and 54.60% (49). However, these rates are slightly higher than other years of the BRFSS,[50-52] and regardless of its low response rate the BRFSS is considered one of few available large, nationally representative surveys (53). Our analysis was also limited by the variables available for analysis in the BRFSS. There may be other risk factors for FMD among active and former service members that we did not include, such as housing insecurity or living with an income below the federal poverty level. Moreover, time since service and age are highly related ($p<0.001$ in chi squared), so there is likely some collinearity in our model. Therefore it is difficult to determine if younger age is a risk factor for FMD or if age acts as a proxy for time since active duty service. Further studies should determine if the association we observed between age and FMD is due primarily to vulnerability of youth or recency of combat. Next, the sampling methods of the BRFSS are limited to those with telephones. Therefore, those who are homeless, institutionalized, or who have fragile living situations are more likely to have been excluded from our sample. Finally, our sub-analysis results found that exposure to combat was not significantly related to FMD, however we were not able to analyze this relationship in our entire sample. Our sub-analysis sample size (n=2,556) was limited by the fact that only two states, Nebraska and Tennessee reported information about combat exposure in the 2010 BRFSS. This finding is supported by recent literature, which finds that suicide rates among U.S. military personnel are independent of combat exposure.[54] However, there is potential of residual confounding by combat exposure in the final adjusted model of the full sample.

Conclusion

Active duty military experience increases the risk that individuals will experience psychiatric distress.[55-56] Thus, we have a responsibility to give the best standard of care for these individuals. Our findings show that poor physical health, unemployment, low income/education, and a lack of emotional support are all associated with frequent mental distress in this population. Based on these results, we recommend that mental health resources in the Department of Veterans Affairs (VA) system be primarily targeted toward early and accurate mental health screenings, physical therapy and pain management, emotional support structures, and programs to address unemployment and poverty. It may be particularly important that younger veterans and female veterans receive these services. Future studies should examine these relationships to determine causality.

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References

1. United States Department of Veterans Affairs. Veteran Population. National Center for Veterans Analysis and Statistics. January 12, 2010. Available at http://www1.va.gov/vetdata/Veteran_Population.asp. Accessed September 26, 2013.
2. United States Government Accountability Office. VA Mental Health: Number of Veterans Receiving Care, Barriers Faced, and Efforts to Increase Access; 2011.
3. Wagner TH, Sinnott P, Siroka AM. Mental Health and Substance Use Disorder Spending in the Department of Veterans Affairs, Fiscal Years 2000-2007. Psychiatric Services. 2011;62(4):389-395.
4. OECD. Health Policies and Data. A System of Health Accounts. 2013. Available athttp://www.oecd.org/els/health-systems/asystemofhealthaccounts.htm#Data_collection. Accessed September 26, 2013.
5. Seal KH, Metzler TJ, Gima KS, Bertenthal D, Maguen S, Marmar CR. Trends and Risk Factors for Mental Health Diagnoses Among Iraq and Afghanistan Veterans using Department of Veterans Affairs Health Care, 2002-2008. Am J Public Health. 2009;99(9):1651-1658.
6. Pols H, Oak S. War and Military Mental Health. Am J Public Health. 2007;97(12):2132-2142.
7. Hoge CW, Castro CA, Messer SC, McGurk D, Cotting DI, Koffman RL. Combat Duty in Iraq and Afghanistan, Mental Health Problems, and Barriers to Care. N Engl J Med. 2004;351(1):13-22.
8. US Census Bureau. Veterans: Definitions and Concepts. May 21, 2013. Available at http://www.census.gov/hhes/veterans/about/definitions.html#Q2. Accessed February 27, 2014.
9. CDC. 2010 Health Risks in the United States: Behavioral Risk Factor Surveillance System At-a-Glance. Chronic Disease Prevention and Health Promotion. February 23, 2010. Available at http://www.cdc.gov/chronicdisease/resources/publications/AAG/brfss.htm. Accessed September 26, 2013.
10. CDC. Self-reported frequent mental distress among adults: United States 1993-2001. MMWR. 2004; 53(41): 963-966.
11. Mayo Clinic staff. Depression (major depression). Health Information. February 10, 2012. Available at http://www.mayoclinic.com/health/depression/DS00175/DSECTION=tests. Accessed September 26, 2012
12. Mayo Clinic staff. Generalized Anxiety Disorder. Health Information. September 8, 2011. Available at http://www.mayoclinic.com/health/generalized-anxiety-disorder/DS00502/DSECTION=tests-and-diagnosis
13. Harvard Medical School. Sleep and Mental Health. Harvard Mental Health Letter. July 2009. Available at http://www.health.harvard.edu/newsletters/Harvard_Mental_Health_Letter/2009/July/Sleep-and-mental-health. Accessed September 26, 2012.
14. Brown GW, Andrews B, Harris T, Adler Z, Bridge L. Social Support, Self Esteem, and Depression. Psychol Med. 1986;16(4):813-31.
15. Turner RJ, Noh S. Physical Disability and Depression: A Longitudinal Analysis. J Health Soc Behav. 1988;29(1):23-37.
16. Gade DM, Wenger JB. Combat Exposure and Mental Health: the Long-Term Effects among US Vietnam and Gulf War Veterans. Health Econ. 2011;20(4):401-416.
17. Paul KI, Moser K. Unemployment Impairs Mental Health: Meta-Analyses. J Vocat Behav. 2009;74(3):264-282.
18. Pharr JR, Moonie S, Bungum TJ. The Impact of Unemployment on Mental and Physical Health, Access to Health Care, and Health Risk Behaviors. ISRN Public Health. 2012;1-7.
19. CDC. Frequently Asked Questions. Health Related Quality of Life. March 15, 2011. Available athttp://www.cdc.gov/hrqol/faqs.htm-and-diagnosis. Accessed September 26, 2012.
20. STATA [computer program]. Version 12. College Station, TX. Statacorp; 2011
21. Brown DW, Balluz LS, Ford ES, Giles WH, Strine TW, Moriarty DG, Croft JB, Mokdad AH. Associations Between Short- and Long-Term Unemployment and Frequent Mental Distress Among a National Sample of Men and Women. J Occup Env Med. 2003;45(11):1159-1166.
22. Lorant V, Deliège D, Eaton W, Robert A, Philippot P, Ansseau M. Socioeconomic Inequalities in Depression: A Meta-Analysis. Am J Epidemiol. 2003;157(2):98-112.

23. Williams A, Swail WS. Is more better?: The impact of post-secondary education on the economic and social well-being of American society. Educational Policy Institute: American Higher Education Report Series. 2005.

24. Angrist JD. The Effect of Veterans Benefits on Education and Earnings. Industrial and Labor Relations Review. 1993;46(4):637-52.

25. Bound J, Turner M. Going to War and Going to College: Did World War II and the G.I. Bill Increase Educational Attainment for Returning Veterans? Journal of Labor Economics. 2002;20(4):784-815.

26. Lutz A. Who joins the military?: A look at race, class and immigration status. Journal of Political and Military Sociology. 2008;36(2):167-88.

27. Seal KH, Bertenthal D, Miner CR, Sen S, Marmar C. Bringing the War Back Home: Mental Health Disorders Among 103,788 US Veterans Returning From Iraq and Afghanistan Seen at Department of Veterans Affairs Facilities. Arch Intern Med. 2007;167(5):476-482.

28. Spiro A, Schnurr PP, Aldwin CM. Combat-related posttraumatic stress disorder symptoms in older men. Psychol Aging. 1994;9(1):17-26.

29. Goodman GP, DeZee KJ, Burks R, Waterman BR, Belmont PJ. Epidemiology of Psychiatric Disorders Sustained by a U.S. Army Brigade Team During the Iraq War. Gen Hosp Psychiatry. 2011;33(1):51-57

30. Hoge CW, Auchterlonie JL, Milliken CS. Mental Health Problems, use of Mental Health Services and Attrition from Military Service after Returning from Deployment to Iraq or Afghanistan. JAMA. 2006;295(9):1023-1032.

31. Kehle SM, Reddy MK, Ferrier-Auerbach AG, Erbes CR, Arbisi PA, Polusny MA. Psychiatric Diagnoses, Comorbidity, and Functioning in National Guard Troops Deployed to Iraq. J Psychiatr Res. 2011;45(1):126-132.

32. Skinner KM, Kressin N, Frayne S, Tripp TJ, Hankin CS, Miller DR, Sullivan LM. The Prevalence of Military Sexual Assault Among Female Veterans' Administration Outpatients. J Interpers Violence. 2000;15(3):291-310.

33. Booth-Kewley S, Schmied EA, Highfill-McRoy RM, Larson GE, Garland CF, Ziajko LA. Predictors of Psychiatric Disorders in Combat Veterans. BMC Psychiatry. 2013;13:130.

34. Mayo Clinic staff. Depression in women: Understanding the gender gap. Diseases and conditions: In-depth. January 19, 2013. Available at < http://www.mayoclinic.com/health/depression/MH00035>. Accessed October 28, 2013.

35. Winerman L. Helping men to help themselves. Monitor Psychol. 2005;36:57-59.

36. Harvard Medical School. Recognizing depression in men. Harvard Mental Health Letter. June 2011. Available at < http://www.health.harvard.edu/newsletters/Harvard_Mental_Health_Letter/2011/June/recognizing-depression-in-men>. Accessed October 28, 2013.

37. Kawachi I, Berkman LF. Social Ties and Mental Health. J Urban Health. 2001;78(3):458-467.

38. Mittleman MS, Ferris SH, Shulman E, Steinberg G, Ambinder A, Mackell JA, Cohen J. A Comprehensive Support Program: Effect on Depression in Spouse-Caregivers of AD Patients. Gerontologist. 1995;35:792-802.

39. Harris T, Brown GW, Robinson R. Befriending as an Intervention for Chronic Depression among Women in an Inner City. 1: Randomized Controlled Trial. Br J Psychiatry. 1999;174:219-224.

40. Brand EF, Lakey B, Berman S. A Preventive, Psychoeducational Approach to Increase Perceived Social Support. Am J Community Psychol. 1995;23:117-135

41. Paluska SA, Schwenk TL. Physical Activity and Mental Health. Sports Medicine. 2000;29(3):167-180.

42. Emerson E, Honey A, Llewellyn G. The Well-Being and Aspirations of Australian Adolescents and Young Adults with a Long-Term Health Condition, Disability or Impairment. Canberra: Australian Research Alliance for Children and Youth. Working paper.

43. Honey A, Emerson E, Llewellyn G. in press. The mental health of young people with disabilities: Impact of social conditions. Social Psychiatry and Psychiatric Epidemiology. 2011;46(1):1-10.

44. Miauton L, Narring F, Michaud PA. Chronic Illness, Life Style and Emotional Health in Adolescence: Results of a Cross-Sectional Survey on the Health of 15-20-year-olds in Switzerland. Eur J Pediatr. 2003;162(10):682-689.

45. Wolman C, Resnick MD, Harris LJ, Blum RW. Emotional Well-Being among Adolescents with and without Chronic Conditions. J Adolescent Health. 1994;15(3):199-204.

46. Maruta T. Depression Associated with Chronic Pain: Incidence, Characteristics, and Long-Term Outcome. Keio J Med. 1989;38(4):403-412.

47. Mayo Clinic staff. Post-traumatic stress disorder (PTSD). Health Information. April 8, 2011. Available at http://www.mayoclinic.com/health/post-traumatic-stress-disorder/DS00246/DSECTION=symptoms. Accessed November 7, 2013.

48. Britt TW, Greene-Shortridge TM, Castro CA. The Stigma of Mental Health Problems in the Military. Mil Med. 2007;172(2):157-61(5).

49. CDC. Behavioral risk factor surveillance system 2010 summary data quality report. May 5, 2011. Available at ftp://ftp.cdc.gov/pub/data/brfss/2010_summary_data_quality_report.pdf. Accessed February 10, 2014.

50. CDC. Behavioral risk factor surveillance system 2009 summary data quality report. February 18, 2011. Available at ftp://ftp.cdc.gov/pub/data/brfss/2009_Summary_Data_Quality_Report.pdf. Accessed February 10, 2014.

51. CDC. Behavioral risk factor surveillance system 2008 summary data quality report. February 18, 2011. Available at ftp://ftp.cdc.gov/pub/data/brfss/2008_Summary_Data_Quality_Report.pdf. Accessed February 10, 2014.

52. CDC. Behavioral risk factor surveillance system 2007 summary data quality report. March 9, 2008. Available at http://www.cdc.gov/brfss/annual_data/annual_2007.htm. Accessed February 10, 2014.

53. Powell-Griner E, Town M, Nelson DE, Kovar MG. National estimates of risks/behaviors: Behavioral Risk Factor Surveillance System and National Health Interview Survey. Proceedings of the Annual Meeting of the American Statistical Association. August 5-9, 2001. Available at http://www.amstat.org/sections/srms/proceedings/y2001/Proceed/00397.pdf. Accessed February 10, 2014.

54. LeardMann CA, Powell TM, Smith TC, Bell MR, Smith B, Boyko EJ, et al. Risk factors associated with suicide in current and former US military personnel. JAMA. 2013;310(10):1076.

55. Pflanz S. Occupational Stress and Psychiatric Illness in the Military: Investigation of the Relationship between Occupational Stress and Mental Illness among Military Mental Health Patients. Mil Med. 2001;166(6):457-462.

56. Friedman MJ. Veterans' Mental Health in the Wake of War. N Engl J Med. 2005;352(13):1287-1290.

Formation of Medical Units in Response to Epidemics in the Australian Imperial Force in Palestine 1918

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Abstract

In the closing days of the First World War, British cavalry operations defeated the Turkish Armies in Palestine. Australian Light Horse Regiments as part of the Australian Imperial Forces (AIF) were prominent in the capture of Amman, Beirut and Damascus. Epidemic infectious diseases were part of the severe desert environment faced by soldiers in the Middle East. Cholera and dysentery epidemics required reformation of medical units to emphasize mobility in an austere environment. A large epidemic of falciparum malaria coinciding with pandemic influenza shut down military operations and caused many deaths in late 1918. Three separate military medical units were formed in Egypt to address epidemic infectious diseases during mobile operations in the desert: ANZAC Field Laboratory, 5th Malaria Diagnosis Station and 7th Mobile Sanitary Section. Laboratory and preventive medicine units were critical to the military's ability to conduct operations in the Middle East in 1918 and are likely to become vital for future missions in developing countries. As was the case in 1918, military medical units may have to be acutely restructured to control infectious disease outbreaks.

Key words: Great War, malaria, influenza, military medicine

Introduction

> "Can you hope to save me one Division in the next advance and keep my men on their legs?" GEN. Edmund Allenby, Jerusalem 1918[1]

Military plans often do not survive intact when first contact occurs with the enemy, whether the enemy is human or a micro-organism. One tries to anticipate threats and the required organization to meet them, but modifications are always needed to adapt to actual circumstances. Epidemic outbreaks of infectious disease are the most obvious medical threats to military operations and are common in the Middle East. At the end of the First World War an entire British Army was forced to stop military operations just as they managed to defeat the opposing Turkish forces in Palestine.[2, 3] Simultaneous outbreaks of epidemic falciparum malaria and pandemic influenza made tens of thousands sick and killed more than 1,700 (166 Australians from a total uniformed strength approximately 17,000 in the AIF).[4, 5] Royal Australian Army Medical Corps personnel formed new medical units to address infectious disease problems they encountered during Middle Eastern operations in 1916-19. Addressing the actual question posed by Army Commander General Edmund Allenby to CAPT. Philip Manson-Bahr (shown above) required flexible, innovative thinking and rapid reorganization of existing medical units.[1] It is likely that such evolutionary behaviour will be required during future operations in developing countries, especially those disrupted by war or natural disaster.

ANZAC Field Laboratory:

> "Among the new medical units which were evolved to meet the unforeseen requirements of the war, none in the history of the Australian Medical Services is more worthy of note". COL. R. W. Downes, Canberra 1938.[2]

In August 1916 there was a cholera outbreak among troops in transit camps in the Sinai desert. Due to the potential for severe disease and mortality from cholera (the 1896 epidemic in Egypt killed more than 100,000 civilians), the commander of the Military Bacteriological Laboratory in Alexandria and formerly of the Lister Institute, LT.COL. C. J. Martin, set up a medical unit to conduct local investigations to support the anticipated need for 'diarrhoea camps'.[6] This temporary laboratory's mission was to stop cholera from crossing the Suez Canal and reaching the civilian population on the Nile. It subsequently evolved into the ANZAC Field Laboratory shown in the Egyptian desert in Figure 1.[6] Initially located at kilometer 47 along the Kantara Railway, the lab consisted of one medical officer and three other ranks, eventually growing to seven personnel drawn from the Australian Imperial

Figure 1: ANZAC Field Laboratory at Bir El Abd, Sinai, Egypt 1916; Australian War Memorial photo B02849

Force (AIF). Fortunately the cholera threat passed and the ANZAC Field Laboratory was assigned other duties to supplement the two fixed-facility Military Bacteriological Laboratories in Egypt. Assigned to the Desert Mounted Corps, the ANZAC Field Laboratory's light establishment was designed to closely follow the mounted forces. It was usually attached to a field ambulance on orders to be able to move in less than 8 hours.[7] In its first year of operations, the ANZAC Field Laboratory moved nine times covering 230 km moving across the Sinai and then north into Palestine.[7] Movement could be by train, motor vehicle (shown in Figure 2) or camel (the lab consisted of 19 camel loads).

Figure 2: ANZAC Field Laboratory loaded on wagons in Gaza, Egypt prior to movement in 1916; Australian War Memorial photo B02805

Besides diarrhoeal diseases (cholera and bacillary dysentery) the laboratory could also test for diphtheria, meningitis, sexually transmitted diseases, parasites (malaria, schistosomiasis, leishmaniasis and trypanosomiasis), tuberculosis, gas gangrene (anaerobic bacteria), enteric fever (typhoid) and typhus.[6] Separate investigations detected human diphtheria carriers, relapsing fever (a type of bacterial sepsis) and anthrax infections in horses. Dysentery had been a major medical cause of casualties at Gallipoli and most of the diarrhoea-related work of the ANZAC Field Laboratory was to detect shigellosis (bacillary dysentery). Vaccines and sera were kept by laboratories and one of the ANZAC Field Laboratory's function was to give preventive injections of horse anti-tetanus toxin to wounded troops.[8] Further reorganization occurred in 1917 while attached to the 1st Light Horse Field Ambulance. The lab was split into mobile and fixed sections (three men each). Turkish prisoners of war were examined for cholera as a means of stopping introduction into British forces. Chemical analyses were done to check drinking water supplies for bacterial contamination and residual chlorine.

The arduous task of maintaining a military force in the Jordan Valley in 1918 was assigned to Chaytor's Force, which included the ANZAC Mounted Division.[2] The Jordan Valley was generally felt to be uninhabitable during the hot, dusty summer. Once attached to the ANZAC Mounted Division in June 1918, malaria became the primary focus of the ANZAC Field Laboratory. Initially this was to support prevention measures such as mass quinine administration and engineering works to drain mosquito breeding areas. A large number of the infantry previously infected with malaria in Salonika (modern Greece) had been moved to Palestine where they became a source of infection.[9] To give a sense of the scale of these antimalarial operations, in 1918 more than 111,000 malaria slides were read by three laboratories (ANZAC laboratory in Jordan Valley, #2 Military Laboratory in Ludd and #3 Military Laboratory in Jaffa), of which about 1 in 5 were positive.[2] From 19 Sep 1918 a coordinated offensive rapidly moved more than 300,000 soldiers north, the cavalry covered up to 100 km per day. The ANZAC Field Laboratory was only partially mobile so while most of the unit stayed in Jericho, two men and two microscopes were moved forward to Amman, Jordan during the malaria epidemic of October 1918 in the 1st Australian Light Horse Brigade. The ANZAC Field Laboratory was subsequently assigned to the 5th Cavalry Division. They finished their war service attached to the Divisional Hospital which was set up on the grounds of a Turkish school as the farthest AIF unit north in Aleppo, Syria. The epidemiology of the simultaneous malaria and influenza epidemics, and the subsequent impairment of military operations, has already been described both by MAJ. Eustace Ferguson, the Laboratory Officer in Charge, and in a later historical review.[4, 7, 10]

During its greater than 2 year existence, 15 men served in the ANZAC Field Laboratory. Most were from the Royal Australian Army Medical Corps (RAAMC), but there was one Royal Army Medical Corps (RAMC) medical officer and two New Zealand Army Medical

Corps (NZAMC) other ranks. The unit's casualty list demonstrates how high a price our military medical predecessors paid to accomplish their historical mission. Two men died of falciparum malaria and three were evacuated with either malaria and/or influenza in late 1918. Four men had previously been sent to hospital for several weeks treatment and convalescence for dysentery.[7] The laboratory was under nighttime aerial bombardment while at El Arish, but suffered no combat injuries.

5th Malaria Diagnosis Station:

> "The clinical type was a very severe one, and there were many fatal cases. The diagnosis stations attached to the cavalry divisions were able to accompany them to Damascus". CAPT. Philip Manson-Bahr, London 1920.[11]

During the summer of 1918 it became apparent that although malaria could be controlled to a manageable level while on fixed lines, if and when the troops moved north into Turkish controlled territories they would be exposed to high levels of malaria transmission. In order to prepare for this eventuality, CAPT. Philip Manson-Bahr (RAMC), approached the Commanding General and requested authority to form six small mobile malaria diagnosis stations with the intention of providing rapid diagnosis and treatment to all febrile soldiers regardless of how rapidly the cavalry advanced into enemy territory. General Allenby responded with "Can you hope to save me one Division in the next advance and keep my men on their legs?"; upon receiving a positive answer he further stated to his quartermaster "Give this young officer everything he asks for". One should hope for such a decision from a senior line officer, as only when combatant officers take disease prevention seriously in order to maintain their forces in the field, will diseases such as malaria be controlled.

A Malaria Diagnosis Station originally consisted of one medical officer and two other ranks who had each received a month's special instruction on how to stain and search microscopic blood smears for malaria parasites.[11] In Figure 3 the 5th Malaria Diagnosis Station is shown with one medical officer (CAPT. Clement C. Chesterman RAMC) and four other ranks. By April 1918 these small diagnostic teams were deployed (two per Army Corps), in anticipation of a military offensive later in the year. Their equipment consisted of one wagon, two microscopes, three tables and four horses. This very light establishment was intended to allow the stations to move rapidly behind the cavalry, across a desert with few roads or railroads.[11] Besides providing current epidemiological information for public health purposes, the goal of fast and accurate diagnosis was the rapid provision of the only effective medication, quinine, usually by intramuscular injections. The alkaline nature of quinine solutions caused tremendous pain on intramuscular injection, leading some medical officers to favour intravenous quinine administration.[12]

Figure 3: Staff of 5th Malaria Diagnosis Station attached to 5th Cavalry Division at Homs, Syria in Jan 1919; front row PTE. A. J. Hardy, CAPT. C. C. Chesterman, PTE. Jeffery; back row unidentified batman and RASC driver. Australian War Memorial photo B01051

The last great cavalry battle ever started on 19 September 1918 when British infantry broke the Turkish line, followed by three cavalry divisions (largely Indian and Australian units) moving as rapidly as possible up the coast to cut off three Turkish Armies retreating north through the Jordan Valley. The 5th Malaria Diagnosis Station was attached to the Australian Mounted Division and 6th Malaria Diagnosis Station was attached to 5th Cavalry Division.[3, 11] Within a single incubation period (10-14 days), leading cavalry units had moved into Damascus and a major malaria epidemic had started. During the second week of October, more than 1,800 new malaria infections were diagnosed and pandemic influenza had broken out.[13] Military operations largely ceased as over-extended units tried to evacuate their sick (who out-numbered the battle wounded by a factor of 37) hundreds of kilometers back to military hospitals.[2, 4] The 4th Cavalry Division was the only cavalry division unsupported by a Malaria Diagnosis Station. The 4th Cavalry Division was unable to regain momentum following the twin infectious disease epidemics, and at one point it barely had sufficient men well enough to feed their horses and was unable to join the 5th Cavalry Division in their eventual movement to Homs and Aleppo, Syria.

Fortunately for the British Army the Turks had already been defeated in the first two weeks of the

Figure 4: 5th Malaria Diagnosis Station when attached to 5th Light Horse Casualty Clearing Station in Damascus, Syria Oct 1918; PTE. Hardy, PTE. Jeffery, CAPT. Chesterman (standing); Australian War Memorial photo B01070

campaign and were suffering even greater disease casualties than the Allies. The 5th Malaria Diagnosis Station laboratory set up in Damascus is shown in Figure 4; it was the first Allied laboratory unit in Damascus in October 1918 when nearly all medical arrangements collapsed due to the large number of Turkish POW casualties. CAPT. Chesterman later noted "Thousands died of the combined influenza and malaria, but we got there just in time to diagnose many hundreds of cases just at the end of the pre-patent or incubation period. Our little laboratory worked in shifts for 16 hours each day, and I went round to all the hospitals collecting blood smears. But there was a holocaust, and mass graves were filled daily."[14] The Australian 5th Malaria Diagnosis Station ended its war service in Homs, Syria. By that stage, the unit was largely working with sick prisoners of war and civilians.

Although it is arguable whether General Allenby's question had been answered correctly, rapid diagnosis and treatment did prevent a medical disaster from being even greater. The six Malaria Diagnosis Stations made over 40,000 blood examinations during their short existence, of which 11,557 contained malaria parasites. Although little could be done for soldiers with pandemic influenza, by detecting the men that were co-infected with malaria, quinine could be given in a rational, life-saving manner.[13, 15] For as yet unclear reasons, pandemic influenza appears to be synergistically lethal when it occurs in soldiers with falciparum malaria, an observation made by MAJ. N. Hamilton Fairley, who later became the Australian Army's chief malariologist during the Second World War as well as the Director of Land Headquarters Medical Research Unit, a forerunner of the Army Malaria Institute.[16, 17]

7th Mobile Sanitary Section:

> "A new feature in health control was developed in the provision of mobile sanitary sections attached to cavalry divisions." MAJ. Harvey Sutton, Brisbane 1919.[18]

Sanitary Sections were vital to maintaining troops in the field, despite their unglamorous tasks of dealing with food, water, excreta and insect infestations. The challenge facing the Sanitary Sections in Palestine in 1918 was the same as the other medical units: how to become sufficiently mobile in order to accomplish their functions within a cavalry division. The Mobile Sanitary Sections had to be formed by special order of the AIF commander in June 1916 as no such unit had ever been an organic part of a mounted formation. The 7th Mobile Sanitary Section was originally attached to the Australian New Zealand Army Corps (ANZAC) Mounted Division, whereas the 8th Mobile Sanitary Section was attached to the Australian Mounted Division. That it took a year for the 7th Mobile Sanitary Section to become truly mobile when it received its own horses, gives some indication of the lack of importance usually given to these vital administrative functions. Figure 5 shows the 8th Mobile Sanitary Section mounted as it was constituted in 1917. Although establishments varied, most Sanitary Sections consisted of about 20 men.

The hostile desert produced many practical difficulties for maintaining the health of human and animal populations in hot, dry, dusty areas. Cavalry units

Figure 5: 8th Mobile Sanitary Section attached to Australian Mounted Division circa 1917; Australian War Memorial photo B00827

produced enormous amounts of horse manure which had to be disposed of in addition to human faeces. In 1918 Egypt and Palestine presented particular problems due to the difficulties of communication and transport, which greatly complicated all preventive medicine functions. In the Sinai Desert camels were one of the few transportation options.

Latrines (5 seats in a single bench box) were devised such that they could be transported by camel.

Water was a supremely valuable resource in the desert and the entire military campaign was planned around the need to capture water sources for both men and animals. The main water source for the Desert Mounted Corps was the canal in Kantara which was fed from the Nile River. As the water in Kantara resembled dilute sewage, it was first strained, clarified by alum and followed by sand filtration under pressure. The need to chlorinate water prior to its use for drinking was also an important sanitation function, often disliked by the soldiers due to the taste of chlorine. Water was then moved via pipeline along the coast advancing with the soldiers.[2] Water delivery to the units in the field often depended on camels using specially designed rectangular metal cans holding 10-12 gallons. Mobile Sanitary Sections in the AIF became the primary construction force for water containers, latrines, incinerators and food storage facilities for the mounted divisions in the absence of sufficient engineers.[2]

Where there was adequate humidity, as in the Jordan Valley, insect pests such as flies and the Anopheline vectors of malaria were particularly problematic.[19] Flies were a constant issue in desert warfare; dysentery had been a major problem on Gallipoli and great efforts were made to avoid a repeat of the situation in Egypt. Latrines and refuse pits were covered with oil-soaked sacking to discourage fly breeding. Drying of horse manure prior to its use as road material limited some fly breeding. Temperatures often rose above 43°C which was useful for eliminating fly breeding. This all occurred prior to the synthesis of any useful chemical insecticides; formalin and arsenic were tried by the Sanitary Sections with limited success. Expert entomological advice regarding the nature and habits of insect vectors of disease was available from MAJ. Edward Austen (RAMC) who was the entomology curator at the British Museum. Using engineer and labour troops, streams were canalised and swamps drained to prevent malaria as shown in Figure 6.[3, 20] As previously stated this engineering effort was successful until offensive operations moved the battlefield north into new areas.

Masses of dead animals were the inevitable product of large cavalry units and disposing of animal carcasses, preferably by fire, was a constant effort for Mobile Sanitary Sections.[18] Fuel and building supplies remained a challenge in the near treeless desert. Delousing stations were important to prevent typhus despite the difficulties of providing washing facilities; a railroad based high-pressure steam disinfector was devised and used for entire brigades with 1,000-2,000 men accommodated over 1-2 days.[2]

Figure 6: Sanitary Section eliminating mosquito habitat by draining areas in the Jordan Valley circa 1918; Australian War Memorial photo B00228

Discussion

The Middle East has been torn by warfare for centuries. This was true for the AIF during the First World War and is also true currently with the civil war in Syria, only the largest and bloodiest of many armed conflicts in the region. It is ironic to realize that although the battle against malaria in the Middle East was won with parasite eradication occurring more than a generation ago, human conflict continues in the same towns where the AIF medical units were stationed during 1918. The ANZAC Field Laboratory redeployed to Australia from Aleppo in January 1919 and the 5th Malaria Diagnosis Station was disbanded in Homs, Syria. Australian forces may well face similar preventive medicine issues in the Middle East in the future.

Each war presents its own health problems which are often exacerbated when the conflict involves developing nations without medical or industrial infrastructure. Although our scientific predecessors did not have much to offer infectious diseases patients in the pre-antibiotic era, it is not inconceivable that a similar situation may evolve with the rapid spread of multiply drug-resistant micro-organisms. The medical officers of the Australian Imperial Force found many unfamiliar challenges when they arrived in Egypt. Over the four years of the war, RAAMC personnel evolved the best answers they could to their problems, often with little other than their ability to think. Key to their largely successful response in the face of the massive casualties created by simultaneous malaria and influenza

epidemics in 1918, was their ability to form new and flexible medical units specially adapted to the local situation. It is highly likely that such adaptations will be required during future armed conflicts.

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The opinions expressed are those of the author and do not necessarily reflect those of the Australian Defence Force or the US Department of Defense.

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References:

1. Manson-Bahr P. The march of tropical medicine during the last fifty years. Transactions of the Royal Society of Tropical Medicine & Hygiene. 1958; 52: 483-99.
2. Downes R. The campaign in Sinai and Palestine. In: Butler A, (ed.). Australian Army Medical Services in the War of 1914-1918. Melbourne: Australian War Memorial, 1938, p. 699-777.
3. Angus W. Report on malaria in the Egyptian Expeditionary Force during 1918. Cairo: Royal Army Medical Corps, 1919.
4. Shanks GD. Simultaneous epidemics of influenza and malaria in the Australian Army in Palestine in 1918. The Medical Journal of Australia. 2009; 191: 654-7.
5. Mitchell TJ and Smith GM. Medical Services: casualties and medical statistics of the Great War. London: Imperial War Museum, 1931, p.208-17.
6. Butler A. Scientific background of the Great War. In: Butler A, (ed.). The Australian Army Medical Services in the War of 1914-18. Canberra: Australian War Memorial, 1943, p. 261-7.
7. Ferguson E. ANZAC field laboratory. Aleppo, Syria: Australian War Memorial, 1919, p. 1-13.
8. Bruce D. Tetanus: analysis of one thousand cases. Transactions of the Royal Society of Tropical Medicine & Hygiene. 1917; 11: 1-53.
9. Ross R. Observations on malaria by medical officers of the Army and others. London: HMSO, 1919.
10. Ferguson E. Malaria in Palestine: experiences with a field laboratory. In: Taylor W, (ed.). Australian Medical Congress. 11th ed. Brisbane1920.
11. Manson-Bahr P. Experiences of malaria in the Egyptian Expeditionary Force. Lancet. 1920; 195: 79-85.
12. Woodcock HM. Notes and comments upon my malaria experiences while with the Egyptian Expeditionary Force, 1916-1918. Journal Royal Army Med Corps. 1920; 34: 385-483.
13. Adami J. Influenza. In: MacPhearson W, Herringham W, Elliott T and Balfour A, (eds.). Medical Services Pathology. London: HMSO, 1923, p. 413-66.
14. Chesterman C. Tropical Trail. Hunterian Society, 1966, p. 8.
15. Wenyon C. Malaria. In: MacPhearson W, Herringham W, Elliott T and Balfour A, (eds.). Medical Services Diseases of the War. London: HMSO, 1922, p. 227-93.
16. Fairley NH. The causes of death from malaria in Palestine: a study in cellular pathology. Transactions of the Royal Society of Tropical Medicine & Hygiene. 1920; 13: 121-5.
17. Sweeney T. Malaria Frontline: Australian Army research during World War II. Melbourne: Melbourne Univ Press, 2003, p.354.
18. Sutton H. The first mobile sanitary section. In: Taylor W, (ed.). Australian Medical Congress. Brisbane1920, p. 489-97.
19. Wenyon C. Prevention of malaria. In: MacPhearson W, Herringham W, Elliott T and Balfour A, (eds.). Medical Services Hygiene of the War. London: HMSO, 1923, p. 188-238.
20. Sewell EP and Macgregor ASM. An anti-malaria campaign in Palestine: an account of the preventive measures undertaken in the 21st Corps area in 1918. Journal Royal Army Med Corps. 1920; 34: 204-18.

Unjustly accused? Medical authorities and army recruitment in Australia 1914-1918

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Abstract

Throughout World One, army recruiting in Australia was subject to wartime demands, demographic constraints and political interference. Australia's small medical establishment became better in dealing with these issues, helped by the greater combat experience of the Australian Army Medical Corps. Within the political and military constraints of the day it generally responded well to changing Government and military policies at home and abroad. This was despite serious differences in opinion within the senior command of the Corps.

Key words: recruiting, World War One, Australian military, medical officers, physical standards, enlistment standards

Introduction

A comparison of these two following statements, written a generation apart, is an interesting one.

> "It may be doubted whether any feature of medical responsibility in connection with the war did more to intensify the popular contempt for a supposed lack of efficiency and alertness in the medical profession than the circumstances associated with the medical examination of recruits. The same blistering criticism has occurred in Great Britain."[1]

> "…it is fair criticism to state that the primary recruiting medical examinations were carried out under very unfavourable conditions, in pursuance of a policy that was penny wise and pound foolish."[2]

These comments invite reflection and speculation should Australia ever commit large numbers of servicemen and women to a future large scale conflict. Strategies and weapons have changed, but for the foreseeable future there will still be a requirement for recruits to be screened and made fit to deploy. To quote the official medical historian of World War One again: "It is a truism, but one of which Australia [took] account only since the second world war was imminent, that the physical standard of the soldier reflects exactly that of the community."[3] This observation brings us back to the 21st century.

This article reviews the role of Australia's military medical profession in recruiting, how it dealt with recruiting during World War One; and its response to changing policies. We also explore the tensions between the two senior medical commanders responsible for policy as they strove to maintain standards and respond to military and political pressure at home and abroad.

The Role of the army medical establishment and civilian doctors in recruiting

In the early stages of the war, medical officers on the Active List of the Australian Army Medical Corps (AAMC) were available to examine recruits. It was not long however before many of these officers themselves volunteered for active service. Their duties, as far as examining recruits were concerned, were then filled by reservists and civilian doctors, many of whom later joined the AAMC. Once the Principal Medical Officers (PMOs) of all six military districts enlisted shortly after mobilisation in 1914, this left a gap in experienced administrators in the Corps, which soon lost its most experienced officers and non-commissioned officers for service abroad.

When the original PMOs were replaced by less experienced officers, they were assisted by an advisory body which was also established in each military district to liaise between military and civilian hospitals. However most of these men were not familiar with medical examinations nor with army requirements. Consequently numbers of recruits who should not have been passed fit were accepted for service, went into training camps and were deployed.

By May 1915, army Standing Orders made it clear

that recruits from the country were to be examined by local medical officers; that recruits were not to be enlisted at rural centres but would be given rail warrants to travel to the cities or Military District HQs where all recruits, including those previously vetted in regional centres, would be medically examined and, if fit, attested. In a separate circular, "it was made clear that medical officers were entirely responsible for checking all questions on the attestation paper concerning a recruit's medical history".[4]

Until May 1916, the main role of the AAMC in Australia was associated with recruiting and providing health support to numerous training camps and facilities and (from mid 1915) of managing battle casualties when the first batch of 1,325 convalescents returned from the front. The Corps also had to recruit and train its own staff and reinforcements.

Recruiting between 1914 and 1918

It all started simply enough. In 1914 there were three army physical entry standards: for the permanent force, militia and the volunteers. In 1915 there were three medical categories applied to all recruits: A – fit for service, B – for service on the Lines of Communication only; and C – invalids for home.[5] These standards were laid down in Commonwealth Military Regulation 165. In comparison with most other countries directly involved in the fighting in France and the Middle East, Australia's population (see Table 1) was a small one, whose health was not, despite later myths, as robust as to allow slipshod standards of recruit screening. Venereal disease and poor dentition were notable features across the male civilian demographic.

As Butler pointed out, a comparatively large and quite unexpected proportion of the adult male population was unfit for military service. The fact that it was undetected and unexpected in 1914-15 would add to the immediate burden on screening recruits. Therefore recruiting during the first 18 months of the war was marked by "a progressive lowering of the physical standards (in height, weight, and chest measurement) and by increasing difficulty in complying with the reiterated demands from the Australian Imperial Force (AIF) for adherence to a high standard of fitness."[6]

In 1914 men up to 50 years old (most of whom should never have been recruited) deployed with the Australian Naval and Military Expeditionary Force to New Guinea. As medical authorities pointed out with increasing alacrity over the next five years, the long term cost to Australia by way of ongoing medical treatment, invalid compensations and pensions from poor recruit screening would be considerable (see table 2).

Table: 2 Percentage of men pensioned on medical grounds WWI

	No. men in combatant service	% of men pensioned
USA	1,390,000	55
UK	4,970,902	10
Italy	5,600,000	4
France	7,932,000	14
Germany	12,000,000	7
Australia	416,809	18

Source: Medical History War of 1914-1918, Vol II statistics. AWM 41/778.

When the 1st Australian Imperial Force (AIF) was formed in August 1914 the standards were lowered – height was reduced to 5'4" (although medical officers had discretionary powers of half an inch in a healthy recruit) and the chest measurement to 33 inches (fully expanded). Recruits with false teeth had to be able to eat without them.

In a circular of August 1914, General William Bridges (then Inspector-General of the army) issued instructions that the qualifications for enlistment of recruits in the AIF should be those laid down in Australian Military Regulations for the militia (see table 3) and that recruits must be "physically fit on medical examination." What to a soldier seemed a straight forward direction was open to wide interpretation by doctors. It was from this document that much of the subsequent confusion among and criticism of, army doctors occurred.

Table: 1 Adult Australian Population as at 3 April 1911, according to age (MD = Military District)

Age	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Total
	MD 2	MD 3	MD 1	MD 4	MD 5	MD 6	MD 1	MD 2	
15 ≤ 21	100,551	81,223	39,532	25,861	14,533	11,744	107	119	273,670
21≤ 45	316,463	229,179	121,711	75,059	72,569	32,779	1,002	358	849,120
45 ≤ 65	133,550	106,201	51,706	32,067	25,090	14,659	1,221	181	364,685

Adapted from: Official Year Book of the Commonwealth of Australia, 1901-1915, No. 9 -1916, Melbourne: McCarron, Bird & Co; 1916: 125.

Table: 3 Army Recruit requirements, 1914

	Age Limit	Height Minimum	Chest Measurement Minimum
Permanent			
Royal Australian Garrison Artillery	18 - 30	5'7"	35
Royal Australian Field Artillery – gunners	18 - 30	5'7" to 5'10"	35
Royal Australian Field Artillery – drivers	18 - 30	5'4" to 5'7"	34
Royal Australian Engineers	18 - 30	5'7"	35
Army Service Corps	18 - 30	5'7"	35
Australian Army Medical Corps	18 - 30	5'7"	35
Army Ordnance Corps	18 - 30	5'7"	35
Militia			
Australian Light Horse	18 - 35	5'6"	34
Australian Field Artillery - gunners	18 - 35	5'6"	34
Australian Field Artillery - drivers	18 - 35	5'4"	33
Australian Garrison Artillery	18 - 35	5'7"	35
Corps of Australian Engineers	18 - 35	5'6"	34
Infantry	18 - 35	5'6"	34
Australian Corps of Signallers	18 - 35	5'6"	34
Army Service Corps	18 - 35	5'6"	34
Australian Army Medical Corps	18 - 35	5'6"	34
Australian Army Veterinary Corps	18 - 45	5'4"	33
Army Ordnance Corps	18 - 45	5'6"	34
Volunteers			
Infantry	18 - 45	5'4"	33
Departmental	18 - 45	5'4"	33

Source: Enlistment and Examination of Recruits. AWM 32/91.

During the first year of the war approximately thirty-three per cent of all volunteers were rejected. The demands of war soon superseded doctrinaire standards and long established regulations and there were further easing of physical standards. "As a result of reports from ophthalmic specialists, the eyesight tests were slightly relaxed and the use of spectacles was permitted. Venereal disease was put on the same basis as dental unfitness. The age limit was increased to forty-five."[7]

This created a challenge for the army medical services and one partly of their own making. This may be explained by the absence overseas in early 1915 of its two most senior and experienced officers (General William Williams and Colonel Neville Howse VC). But there was at that time no precise procedure for medical examination, certainly not for the number of enlistees coming forward. In general, the policy was adopted of making the examining medical officer personally responsible, and of seeking his co-operation in overcoming problems detecting (and rejecting) unfit men among the recruits.

The numbers of men flocking to enlist in 1914 had exceeded the requirements for the first two contingents and for their reinforcements (3,227 men per month). After negotiations with the War Office on 20 January, 1915 Australia agreed to provide a monthly quota of reinforcements which reached 5,263. Toward the end of that year 'standing medical boards' were appointed to pass or reject all recruits about whose fitness there was doubt. As an additional precaution and to stop impersonation, repeated re-examination was ordered before soldiers deployed.

As an aside, in 1915 the procedure for medical boards for serving soldiers (i.e. not recruits) involved two medical officers, nominated by the PMO in each state. They constituted a board for medical review purposes. One Medical Officer (MO) had to belong to the hospital in which the soldier was being treated. Physicians would review medical cases and surgeons surgical cases. Where four or more soldiers were boarded at a time, MOs were paid £2/2/- .8 They were to report against three criteria:

- Whether or not they concurred with the report of the medical officer who presented the case and in how far they concurred.
- What it actually found on examining the patient, stating briefly the actual lesion or pathological condition present.
- Its *recommendations* based on its findings.

The standard reference for medical officers conducting recruit examinations in 1916 was a little eight page booklet. The categories listed were: height, chest measurement, vision, general examination, examination of limbs, general physical development; and teeth (bad teeth were no longer a reason for immediate rejection, unless the recruit presented with a chronic oral or dental condition).

General practitioners were dropped from the recruiting examination system in 1916 and in their place came a properly constituted medical board.

As the Director General of Medical Services (DGMS) General Richard Fetherston pointed out to the Defence Minister, Senator George Pearce:

> For economic working, medical boarding must be done by men who understand military routine, and who are conversant with the latest Military Orders; this knowledge cannot be acquired in a few weeks.[9]

But even with the strictest regulations there were abuses in the system. In one instance three AAMC officers had rejected a recruit whose would-be commanding officer wanted him in his unit. Therefore, the recruit obtained a private medical certificate and was officially enlisted. Subsequently he later had an epileptic fit at Broadmeadows camp in Victoria and repeated fits when he got to Egypt. The soldier had apparently suffered from this disability since infancy and had a trephine scar the size of a man's palm.[10]

During 1916 the small military dental establishment in Australia was also overwhelmed while trying to make recruits and soldiers dentally fit. It was therefore suggested in mid-April that one dental officer be attached to every infantry battalion deploying overseas. Unfortunately Fetherston had to decline the suggestion as there was not enough dental equipment in Australia; and even if there had been, the navy prohibited the use of "any form of spirit or gas flame" on ships.[11]

On 4 April 1917 a conference of representatives of all State Recruiting Committees was held at Victoria Barracks Melbourne. They discussed age limits and there was some disagreement as to the limit of 45, with military doctors arguing for the retention of the 45 year limit. This view later softened, especially for soldiers serving on the home front.

In the following year, attempts to rehabilitate recruits with sub-standard chest measurements in a trial 'deferred battalion' in Queensland were not very successful. Even support staff were unimpressed. The senior physical training instructor there noted in November 1918 that most recruits were "habitual cigarette smokers…" which had "a tendency to contract the chest and bring about improper breathing."[12]

Political and other pressures on the medical establishment

In Australia there was incredible political pressure to ease recruiting standards as the war dragged on. Even at an individual level a politician's relative, who was too short, too fat, too flat-footed or myopic to make the grade, felt himself badly done by. They wrote letters: to friends, newspapers and their local MP. Consequently, hardly a day did not go by when some self-important dignitary walked into the Melbourne office of the embattled Surgeon-General and demanded an audience.

After news of Gallipoli fiasco and the ensuing casualties reached Australia, recruiting campaigns were organised in every State. The subsequent rush (in Victoria 21,698 men turned up at recruiting centres in July 1915 alone) resulted in large numbers of troops concentrated in camps at the beginning of winter.[13] The impact on army medical staff can be imagined. In order to make good the losses of the early weeks on Gallipoli, the Commonwealth offered the War Office on 9 July double the previously agreed reinforcements for October and November, in addition to providing another infantry brigade (the 8th).

Although recruiting fell again after July 1915, the Commonwealth promised the War Office a further 50,000 men 'for active service'. The balance of troops in camp supplied the first reinforcements for these; but the commitments for future reinforcements of 11,000 per month "taxed the utmost resources of Australia (under voluntary enlistment) for the rest of the war and necessitated a series of special recruiting campaigns."[14]

In a memo of 2 July 1915, Lieutenant General Thomas Dodds, the Adjutant General, advised the Secretary of the Defence Department that the recruitment conditions "are generally known and men who do not conform to the standards are nearly always aware of the fact before applying, but feign innocence, many in fact after rejection turning up elsewhere and making the percentage of rejections greater than it would otherwise be."[15] This had affected deploying forces, and later, reinforcements. A spot check of the troopship *Euripedes*, which had stopped at Albany in November 1915 *en route* to France revealed four cases of pneumonia, seven of mumps, one tuberculosis, one malaria, one hernia and 12 men with venereal disease.[16] How was it that men with such obvious medical conditions had slipped through the net? Clearly policy and regulation were not as effective as they should have been, nor perhaps was there appropriate oversight being provided at a senior level in overworked and understaffed Military District headquarters.

As solutions were sought to maximise the effectiveness of medical assets, it was decided in 1916 to place recruits who required medical, dental or other treatment in special companies (much like our current 'rehab platoons') in recruit camps. While they were in these units they were to receive the necessary attention and would be available 24 hours a day for any medical (but not surgical) treatment

or intervention. Once medically and dentally fit they would then rejoin other units in training. But the reinforcements for the army were still constrained by physical standards (see table 4).

Table: 4 Number Medically Examined, Rejected, Passed, etc in the Call Up of October 1916

Number reported	191,610
Medically Examined	180,715
Found fit	114,322
Found Unfit	49,138

Source: A.G. Butler, The official history of the Australian Army Medical Services in the War of 1914-1918. Vol. III. Canberra: Australian War Memorial; 1943: 888.

Until the end of 1917 reinforcements for all corps and branches of the army other than the medical service arrived from Australia earmarked for particular units. After the heavy casualties of Third Ypres and the failure to send full quotas from Australia they were pooled and deployed where most required. The recruiting standard was now lowered to five feet and consideration was being given by senior medical officers in Australia to lower that height for recruits 'as long as they are strong and well built'. This approach was an option favoured by Fetherston, but not accepted by his counterpart in London, General Howse.

It was becoming clear that not all doctors were using the same procedure to examine recruits and that some medicos were using outdated protocols. [17] In that year it became an offence under the *War Precautions Regulations* for a recruit to make a false statement while undergoing a medical examination.

Unsuccessful applicants were still trying to circumvent the system by appearing at multiple recruiting centres for medicals. Fetherston, apparently acting on Government advice, therefore asked all examining officers to take the applicant's thumb prints on the attestation papers to try to stop this fraud. This was a public relations disaster for the Government as there was widespread resistance to implementing such a measure, due to its association with criminal activity.

Colonel William Giblin, Tasmania's PMO, spoke for his inter-state colleagues when he reported on 30 June 1917 that it had "been found very difficult to obtain a uniform standard of examination by the many primary examiners [GPs], few of whom have had any previous medical experience. This uniformity can only be obtained at the secondary examination. As a result, the number of recruits secondarily rejected has been large."[18] A cable from AIF HQ, London three months later explains concerns there about the physical profile of newly arrived soldiers (see table 5) about to be sent to the front.

Table: 5 Examination of AIF Reinforcements arriving in UK, 1917

	Under Age	Dentall unfit	Medically unfit
1st Military District	87	602	129
2nd Military District	105	676	39
3rd Military District	45	356	14
4th Military District	46	410	20
5th Military District	78	446	52

Source: A cable AIF HQ to Defence department, 30 September 1917. Official Historian, Enlistment and Examination of recruits. AWM 41/768.

At this time complaints were being received from England that many reinforcements had deployed from Australia without being inoculated or without any record of inoculation in their pay books. At home the situation warranted instructions from July that all recruits whose age was suspect were required to produce a birth certificate. Medical officers and civilian doctors were urged to be vigilant:

> In the past it has been found that many youths have overstated their age in order to enlist and draw pay, but when about to embark their parents have approached the department and demanded their discharge as being under age. Careful attention is also to be paid to elderly men who apply to enlist, and who represent that they are under 45 years of age, as it has been found that many such men have understated their age in the past and on joining their unit at the front have been found to be quite unfitted for service, thereby necessitating their return to Australia, without giving their country any return for the money expended on them.[19]

Following the heavy losses at the Battle of Pozieres on 29 July 1916 both the Imperial and Australian governments were concerned about how the AIF was to be kept up to fighting strength. If future casualties were on the same scale as those sustained at Pozieres (over 20,000 men), the number of volunteers coming forward would have to meet demand. It was because of this concern that Australian Prime Minister William Hughes wanted to introduce conscription.20

According to Lieutenant Colonel McIntosh the most arduous medical work arose from the 1916 War Service Proclamation, which compelled eligible men to attend a mandatory training camp and thus be part of the Citizen Military Forces. In each of the subdistricts a medical officer was assigned who acted in conjunction with a regional military registrar. Most recruits (see table 6) were examined by the Area

Table: 6 Medical Examinations in the call up by Military Districts, 1916

Mil. District	Reported	Examined	Fit	Unfit	Doubtful	Temp. unfit	% fit for Active Service
1	33,925	32,876	21,836	8,335	1,676	1,029	66
2	69,210	59,837	36,860	17,066	2,347	3,564	61
3	54,846	54,678	33,805	14,955	3,631	2,287	60
4	18,687	18,416	13,118	3,832	659	807	71
5	8,631	8,601	4,589	3,121	480	411	53
6	6,311	6,307	4,114	1,829	203	162	65

Source: A.G. Butler, The official history of the Australian Army Medical Services in the War of 1914-1918, (Vol. III), Australian War Memorial, Canberra, 1943, p. 889

Medical Officer. To eliminate any local favouritism, medicals were not conducted by local GPs or reservist medical officers but by referee medical boards. Within one week in October 1916 106,579 men were examined.21 This was despite the fact that the legality of the proclamation was questionable. Once the conscription referendum was defeated on the 28th of that month the proclamation's legality was challenged, with the result that training camps were closed down.22 Not only had this been a huge waste of medical resources but it still left the Hughes Government with the problem of how to meet the insatiable demand for men at the Western Front.

In March 1917 a senior British officer (Surgeon-General Birrell) and the Consulting Physician and Consulting Surgeon of the AIF (Colonels Harold Maudsley and Charles Ryan), advised Howse that large numbers of Australian reinforcements arriving in the depots were overage, and of very poor physique.

Howse now recommended that every new arrival be examined seven days before embarkation by competent medical officers, who should personally certify such soldier was physically and mentally sound and appeared to be within the age limit. The district commandant was held responsible for ensuring that no soldier left for deployment as a reinforcement unless he was properly classified.

Men who failed their initial board because of 'minor defects' could, at the discretion of the MO, be admitted to a military hospital for surgical intervention.23 The War Office was keen for Australia to recruit men up to 50 years, with those not fit for combat being identified for employment in logistic and other units in the rear or along the Lines of Communication. However General Birdwood and Australian army medical authorities stood firm and left the ceiling for overseas service at 45 years.24 It was believed that older Australians did not tolerate the cold European climate well and were therefore prone to contact lung and bronchial disease as well as rheumatism. There may have been some truth in this view (see table 7).

Table: 7 Percentage of recruits discharged for medical reasons 1916-17

Month	No. examined	No. Discharged	Percentage
1916			
July	870	61	7.0
August	762	52	6.8
September	2054	82	3.9
October	1925	69	3.5
November	1751	61	3.4
December	1307	36	2.7
1917			
January	663	18	2.6
February	720	25	3.4
March	738	25	3.3
April	599	19	3.1
May	607	23	3.7
June	449	19	4.2
	12,445	490	3.9

Source: Enlistment and Examination of Recruits – reports of PMOs upon medical examination of recruits, AWM 32/100

On 1 November 1917 Surgeon General Richard Fetherston advised the Secretary of the Defence Department that the practice of deploying men overseas after only a few weeks in training camps be discontinued. He suggested that all men should be kept in camp for four months before embarkation, and no one be allowed to deploy within that period. It would also provide an opportunity for medical staff to observe the men and those likely to break down would present with tell-tale signs of physical disability before they embarked. They could then be referred for discharge. However the Adjutant-General, Brigadier-General Victor Sellheim and the Minister (Senator George Pearce) disagreed with keeping men in Australia for such a long period, although they approved the need for intending recruits to provide their birth certificate. In London, much closer to the fighting, Howse estimated that 34 per 1,000 of all reinforcements arriving in England during 1917 were totally unfit for front line service in France.

The extra load being thrown onto administrative, health and logistics assets by unfit men being deployed overseas drove senior commanders to

exasperation. Referring to the additional burden, HQ AIF spelled it out for Defence officials in Melbourne:

> This means a scandalous waste of public money amounting in all to £100,000, a waste of valuable space on transports both ways, needless work on staffs here which are already working at full pressure and a taxing of the dental staff here beyond the powers of the largest staff available. The waste is almost wholly preventable by proper action in Australia.[25]

There was an obvious disconnect between the Government's priorities in meeting its obligations to Britain, the capacity of the AAMC to properly scrutinise recruits and the unwillingness of AIF HQ in London to use these 'sub-standard' recruits for combat service.

If we take the 1st Military District (Queensland) as typical of the other states, its PMO, Lieutenant Colonel A.M. McIntosh wrote in 1917 that:

> It was apparent at an early date that the medical examinations were of very uneven quality, and numbers of men were being sent to camp who were by no means fit for active service. This was checked at first by the institution of a second medical examination on arrival in camp, and further by the establishment in Brisbane of a board of medical officers who re-examined all men before they appeared in camp.[26]

He also pointed to the long journeys many men took from remote areas, once they had been vetted by their local GP, only to be rejected at the army medical. This was the cause of some financial hardship for these recruits. So it was decided to establish army medical examination centres in twenty regional towns around the State to reduce the travel time for recruits. Despite this a number of unfit recruits still found their way into army camps. At the top of the list of causes were: heart disease, hernia, poor vision, poor dentition and varicose veins.

On 4 April 1917 at Senator Pearce's request, a conference of representatives of state recruiting committees was held in Melbourne. Among the proposals was one to raise the age limit of recruits from 45 to 50 years. Fetherston opposed the idea but agreed to give 'special consideration' to older men. Bypassing Fetherston, Pearce went direct to the War Office, which gave its approval on 25 May, although the British Cabinet disapproved. Army HQ was not obliged to heed its technical advisors, so Major General James Legge, the Chief of the General Staff (in Melbourne), agreed to the scheme and opened recruiting to men whose standard had until then been unacceptable. Fetherston and Howse were aghast and expressed their concern in unequivocal terms, but not before a number of over-age men and under-age boys had been dispatched to England.[27] On arrival, many were found to be senile or physically immature.[28]

Pearce's decision in July 1917 to maintain the age limit for recruiting to 45 years was probably in response to strenuous opposition from the General Officer Commanding, AIF, on the advice of his chief-of-staff (General Brudenell White) and with the general approval of the corps commander (General John Monash) that in the matter of physical standards, he would be guided by the advice of his technical expert – General Howse.[29] This group continued their campaign against the recruitment of youths under 18 years of age and of men over 40 years for combat deployment.

On 16 September, 1917, in response to repeated complaints from the training battalions, Colonel Douglas McWhae, the Assistant Deputy Director of Medical Services, AIF Depots in the United Kingdom, drew the attention of General Howse to "the large number of soldiers" who had arrived in August "quite unfit for any military service." The chief reason for these enlistments he found in the fact that the men had been encouraged by recruiting officials to understate their correct age, or had done so "to encourage the young men to enlist."[30] Of 4,400 reinforcements who arrived during September and October 1917, 1,700 soldiers were found dentally unfit for inclusion in drafts. They sapped resources because of the immense amount of treatment required.

By the beginning of 1918 the debate on the question of "unfit" recruits had developed into a major dispute between AIF commanders (including Howse) in London and those in Melbourne. By October Fetherston informed Howse that Prime Minister Hughes was furious because the Army Medical Corps was rejecting so many recruits in Australia. Howse remained unmoved, sure of support from HQ AIF.

In 1918 political imperatives were not helping matters, as Brigadier General George Lee, Commanding 2nd Military District (no doubt advised by Fetherston) informed the Secretary of the Defence Department:

> When a strenuous campaign is being carried on to obtain recruits it is unfortunately impossible to prevent some loss to the Department by impositions and over-keenness of people to obtain recruits, but the fact

> remains that if too stringent [medical] methods are adopted to prevent this class of thing, it is immediately stated that the efforts of the various recruiting agents are being handicapped and cold water thrown on the recruiting campaign.[31]

By 1918 recruiting standards had become such a vexed issue that the Government sought public submissions on the matter. In one such response a Mr. Edwin Spragg wrote to the Minister, Senator Pearce on 16 April, drawing to his attention the New Zealand military system then in place – special camps in which recruits were gradually brought to meet entry standards, through graduated training, swimming etc.[32] Senior Australian army doctors were unenthusiastic, mainly because of the lack of health professionals and the cost to establish such facilities.

While in Australia opportunities grew for sub-standard recruits to enter the army by lowering of standards and recruiting laxity, at the other side of the world Howse was engaged in the vigorous campaign for their return to Australia.

The next medical imperative from a recruitment perspective was an immediate consequence of the Third Battle of Ypres in the Passchendaele offensive (38,000 casualties over eight weeks). Both Fetherston and Howse did their best to support and advise their respective masters.

Senator Pearce noted on 12 January 1918 that of the soldiers returned to Australia up to the end of 1917, 10,333 had not been in any theatre of active operations.

> I have for some time been much concerned with the large percentage of rejection of A.I.F. recruits recently in England. These recruits have been medically examined three times [emphasis added] before leaving Australia so that it is extraordinary that any unsuitable men should get away. The matter is most serious in view of the shortage of recruits, and the effect on recruiting of the returned rejects is disastrous.[33]

Conclusion

War journalist Charles Bean estimated that by 1918 the AIF could only be maintained by recruiting 5,400 men each month. But after an initial rise to 4,885 in May that year the numbers steadied at about half the minimum required.[34] Had the war not ended when it did Australia could not have sustained its contribution to the war effort with both the introduction of conscription and a drastic lowering of physical recruit standards.

The professionalism of Australia's small medical establishment in dealing with recruitment issues grew during the war years, helped with the greater combat experience of many AAMC officers between 1915 and 1918. Within the political and military constraints of the day it generally responded well to changing policies and standards. Whether, after 1918, it could have continued to do so is open to debate. This is particularly the case had there been a shift from an environment in which potential recruits subverted the medical system to enlist to one in which men actively tried to evade conscription. Politics and vacillating government policy did not help matters.

The tensions between the two senior officers of the AAMC for the duration of the war did not help matters, although as we have seen, their motives were understandable given their respective combatant and home environments. Howse resolutely held his belief that a smaller fit force would achieve more in the field than a larger one diluted with unfit men. He always maintained that deploying unfit men could not 'pay'; that their enlistment was false economy. For his part, Fetherston took a more pragmatic approach, especially on standards for soldiers identified for home service only. It may be argued, given their personalities, that neither really understood the imperatives under which the other had to work.

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References

1. Butler A.G. The official history of the Australian Army Medical Services in the War of 1914-1918. Vol. III. Canberra: Australian War Memorial; 1943: 704.
2. Walker A. Australia in the War of 1939–1945. Series 5 – Medical. Vol. II. Middle East and Far East. Canberra: Australian War Memorial: 1962 reprint: 33. According to Walker the rejection figures for the full-time Services in 1938 were "navy 45 per cent, army 55 per cent and air force 43 per cent, whereas less than 4 per cent of volunteers for the militia were rejected." But he added that "…examinations were often perforce carried out by busy practitioners under the handicap of poor facilities and [in] numbers too great

to be examined in the time available." Walker, ibid.: 32.

3. Butler, op. cit.: 743.
4. Enlistment and Examination of Recruits – procedure. Australian War Memorial. Canberra. (hereafter AWM) 32/90.
5. Post recruitment and on active service there were additional categories of fitness standards which were introduced over the course of the war. From 1917 others were added, for example: B1 – unlikely to be fit in less than three months and B2 – temporarily unfit. Sub categories by 1918 included: Permanent Base, Temporary Base. Enlistment and Examination of Recruits. AWM 32/91.
6. Butler A.G. The official history of the Australian Army Medical Services in the War of 1914-1918. Vol. I. Canberra: Australian War Memorial; 1938: 524.
7. ibid. 525.
8. Official Historian, Butler A.G. Enlistment and Examination of Recruits, Standards, AWM 41/797.
9. Fetherston R. Report. 1916 18 August. AWM 41 [2].
10. Summons W. A Plea for Increased Efficiency in the Medical Examination of Recruits. Australian Military Jnl. 1915 October; 6 (4): 841.
11. AWM 27 533/45.
12. AWM 27 533/45.
13. Butler.Vol.1. 1938: 514.
14. op.cit: 515.
15. Enlistment and Examination of Recruits – rejections. AWM 32/92.
16. Enlistment and Examination of Recruits – medical examinations. AWM 32/95.
17. It was an offence under the War Precaution Regulation for any person to give false information (especially about a family history of mental health issues or epilepsy) on a medical examination. But at no time during the war were any civilian doctors charged over falsifying recruiting documents, although anecdotal evidence suggests that this practice did occur.
18. Enlistment and Examination of Recruits – reports of PMOs upon medical examination of recruits. AWM 32/100.
19. Army Circular No 168. 22 June 1917.
20. Tyquin M. Neville Howse: Australia's First Victoria Cross Winner, Melbourne: Oxford University Press, Melbourne; 1999: 87.
21. Butler A.G. The official history of the Australian Army Medical Services in the War of 1914-1918. Vol. III. Canberra: Australian War Memorial; 1943: 773.
22. There were two referenda during the war, on 28 October 1916 and 20 December 1917. Both sought authority for enlisted soldiers to serve overseas. Both referenda failed.
23. From 15 December 1917 medical conditions no longer included hernia, hammer toes, varicocele, varicose veins, haemorrhoids, fistula in ano, undescended testes or testicular hydrocele. While they were hospitalised recruits could only draw on an allowance of 10 shillings (for single men, plus an additional five shillings for married men). They were not entitled to army pay.
24. Official Historian, Butler A.G., Enlistment and Examination of Recruits, Standards. AWM 41/797.
25. Cable to Army HQ Melbourne, 11 September 1917. Official Historian, Enlistment and Examination of recruits. AWM 41/768.
26. Enlistment and Examination of Recruits – reports of PMOs upon medical examination of recruits. AWM 32/100.
27. Tyquin M. op. cit.,: 97.
28. Butler A.G. The official history of the Australian Army Medical Services in the War of 1914-1918. Vol. II. Canberra: Australian War Memorial; 1940: 847.
29. Howse had an advantage over Fetherston in that he had direct access to, and corresponded regularly with, both Birdwood and White, as well as to Lieutenant General Sir Arthur Keogh, the senior British medical officer. In Australia Fetherston not only lacked a support network but was exposed to political pressure and interference from both Federal politicians and the Governor-General.
30. Butler, Vol II. op. cit.: 473.
31. Enlistment and Examination of Recruits – procedure. AWM 32/90.
32. AWM 27 533/45.
33. Butler. Vol. II. op. cit.: 849.
34. Bean C.E.W. From Anzac to Amiens. Melbourne: Penguin; 1983: 439.

History of Tuberculosis. Part 1 - Phthisis, consumption and the White Plague

John Frith

> "A phthitic soldier is to his roommates what a glandered horse is to its stablemates." (Jean Antoine Villemin, French Army surgeon, 1865)[1]

Introduction

Tuberculosis is an infection with *Mycobacterium tuberculosis* which can occur in any organ of the body but is most well known in the lung. It has been a scourge throughout known history and may have killed more persons than any other microbial pathogen.[2] Paleopathological evidence dates back to 8000 BCE and evidence of bony tuberculosis has been found dating from the Neolithic period in 5800 BCE and in Egyptian mummies dating to 2400 BCE.[1, 3]

Tuberculosis was also known as *phthisis* and *consumption* from Hippocrates through to the 18th century[1], *the white death*[4] and *the great white plague*[5] during the 19th century, and other names which evoked the despair and horror of the disease such as *the robber of youth*[6], the *Captain of all these men of Death*[7], the *graveyard cough*[8], and the *King's-Evill*[4]. During the 18th and 19th centuries tuberculosis was epidemic in Europe and caused millions of deaths, particularly in the poorer classes of society. Tuberculosis declined after the late 19th century but remained a major public health issue as it still is today.[9]

Tuberculosis is an important disease for the military. During both World War I and World War II in the US Army, tuberculosis was the leading cause of discharge.[10] Annual incidence of tuberculosis in the military of Western countries is very low, however in the last several decades microepidemics have occurred in small close knit units on US and British Naval warships and land based units deployed overseas. Living and working in close quarters and overseas deployment to tuberculosis-endemic areas of the world such as Afghanistan, Iraq and South-East Asia remain significant risk factors for tuberculosis infection in military personnel, particularly multidrug resistant tuberculosis.[11, 12]

Descriptions of tuberculosis from antiquity

The legal text written in cuneiform on a stone pillar by Hammurabi, a Babylonian king, in the 2nd millennium BCE mentions a chronic lung disease which may have been tuberculosis, and a "wasting disease" was described in one of the earliest medical works, the Chinese *Huang Ti Nei-Ching* in the third millennium BCE. Homer's epic poem *Odyssey* from the 8th century BCE refers to "grievous consumption which took the soul from the body and caused a person to "lie in sickness .... a long time wasting away"".[1, 9, 13]

Hippocrates in *Book 1, Of the Epidemics* (410-400 BCE) described a disease of "weakness of the lung" with fever and cough which he refers to as *phthisis* (Gr. *phthiein* = to waste away). Phthisis was described as the commonest disease of the period and usually as being fatal.[1, 14]

> "Early in the beginning of spring, and through the summer, and towards winter, many of those who had been long gradually declining, took to bed with symptoms of phthisis; .... Many, and, in fact, most of them died, and of those confined to bed, I do not know of a single individual survived for any considerable time, ... Consumption was the most considerable of the diseases which then prevailed, and the only one which proved fatal to many persons. Most of them were affected by these diseases in the following manner; fevers accompanied with rigors, ... constant sweats, ... extremities very cold, and warmed with difficulty; bowels disordered, with bilious, scanty, unmixed, thin, pungent, and frequent dejections. The urine was thin, colourless, unconcocted, or thick, with a deficient sediment. Sputa small, dense, concocted, but brought up rarely and with difficulty; and in those who encountered the most violent symptoms there was no concoction at all, but they continued throughout spitting crude matters."[14]

Hippocrates recognised the predilection of the disease for young adults, "Phthisis makes its attacks chiefly between the age of eighteen and thirty five".[14] He also considered that pulmonary phthisis was a hereditary disease rather than an infectious one as it so commonly occurred throughout a whole family.[1,15]

Aretaeus of Cappadocia in the 2nd century CE in his work *De causis et signis diuturnorum morborum* described phthisis with wasting, coughing of blood and the formation of empyema[1, 4, 16] and wrote:

> "If from an abscess in the lung or a settled cough or spitting of blood, pus should develop within and the patient should spit it out, the disease is called *pyë* and *phthisis*. But if the chest or a rib suppurates and pus comes out through the lungs it is called *empyë*. If after this, the lung, consumed by the passage of the pus, has an abscess, it is called *phthoë*."[16]

Claudius Galen of Pergamum, a Greek physician to the Roman Emperor Marcus Aurelius in 174 CE, described phthisis with fever, sweating and coughing of blood stained sputum, and found tubercles in phthitic lungs that he called *phûma*. He considered it to be infectious and warned against close contact with people with the disease.[9, 16]

Early historical treatments

In the Hippocrates' era patients were nursed in temples and treated with plentiful and good food, milk, particularly asses' milk (it was thought asses were not prone to phthisis), and exercise. Galen and other physicians of his time recommended fresh air, milk, particularly human breast milk, eating wolf livers, drinking elephant urine, and sea voyages to regions with gentle favourable winds such as Egypt and Libya. Bloodletting was often done as it was for many diseases.[1, 2, 8, 9, 16] Aretaeus of Cappadocia recommended those "weak in the lungs" have a prolonged sojourn in the blessed cypress groves at Apollo's temple in Aquinum in Aratolia where the Sun God himself would heal them.[4] Pliny the Elder (23-79 CE) mentioned inhalation of stringent smoke and licking the limestone from Assos on the Troad coast; Pedacius Dioscorides, a Greek army surgeon in the service of Nero (54-68 CE) who wrote *Materia Medica*, recommended "warming drugs" such as animal fats; and Tertullian (160-225 CE) recommended butter boiled with honey.[16, 17]

Renaissance to the 19th century

In 1679 Sylvius de la Boë, an Amsterdam physician, in his work *Opera Medica*, was probably the first to use the term tubercles in phthisis of the lung which he called *tubercula glandulosa*, "glandulous tubercles", and described their progression to abscesses, ulcers, and empyema. In addition, Sylvius described the association between phthisis and a disease of the lymph glands of the neck called *scrofula*.[1, 13, 18]

Richard Morton, an English physician and physician to King James II, in his 1689 work *Phthisiologia* described the pathology of pulmonary and other forms of phthisis, tubercles of the lung, and scrofula. Both Sylvius and Morton considered phthisis was hereditary but Morton also considered it may be transmissible by intimate contact.[1,18] Morton described the severity of the disease in young people, "the Consumption of Young Men, that are in the Flower of their Age".[18]

In 1690 John Bunyan, British author of *Pilgrim's Progress*, in his work *The Life and Death of Mr. Badman* referred to consumption as *the Captain of all these men of Death*:

> "He parts from his wife – diseases attack him under captain consumption, he rots away, and dies in sinful security … Yet the captain of all these men of death that came against him to take him away, was the consumption, for it was that that brought him down to the grave."[7]

In 1702 Jean-Jacques Manget, a Genevan physician, observed at a post-mortem multiple small phthitic nodules in the lungs and organs which resembled millet seeds, later called "miliary tuberculosis".[1,5] In 1793 Matthew Baille, a Scottish pathologist who himself died from tuberculosis, described the caseous ("cheese-like") appearance of phthitic abscesses.[4] In 1803 Gaspard-Laurent Bayle of Vernet described the tubercle and its association with pulmonary and other forms of phthisis which he published in his 1810 work *Reserches sur la phthisie pulmonaire*.[17,18]

The term *consumption* was used as a lay term for phthisis in the 17th and 18th centuries, and both terms were used until the mid-19th century when the term tuberculosis was coined by Johann Lukas Schönlein and later used by Hermann Brehmer, Jean Antoine Villemin and Robert Koch.[1,15]

René Théophile Hyacinthe Laennec

René Théophile Hyacinthe Laennec (1781-1826) was a renowned French physician and medical researcher. He began his medical studies in Nantes, and then later at the École Pratique in Paris where he studied cadaver dissection in Guillame Dupuytrens' laboratory. Laennec distinguished himself as a

student, winning prizes in both medicine and surgery in 1801, and in 1802 he published his first paper on rheumatic fever and mitral stenosis. Later he served as editor of the *Journal de Médecine*. Laennec became known for his description of the tawny yellow nodules of micronodular cirrhosis of the liver (from Gr "kirrhos" = tawny yellow), now known as Laennec's cirrhosis.[19, 20]

In 1816 Laennec invented the stethoscope while working at the L'hôpital Necker in Paris, initially by rolling up his notebook, then later by constructing a hollow wooden cylinder.[4,19,20]

> "I therefore took a paper notebook, rolled it up tightly, applied one end to the pericardiac region and listened at the other. I was surprised as I was pleased to hear the heart beat much more clearly and distinctly."[4]

Laennec originally called his invention *le Cylindre*, but later called it a stethoscope, and called his auscultation method *l'auscultation médiate* ("mediate auscultation" - hearing carefully with the aided ear), or *stethoscopy*. Using a stethoscope helped preserve the modesty of female patients rather than having to have one's ear on the patient's chest or breast. Laennec's stethoscope was a revolutionary advance in clinical medicine enabling for the first time an accurate description of normal function and in diseases of the heart and lungs. In 1818 he presented his findings and research on stethoscopy of the chest to the *Académie des sciences* in Paris and in 1819 published them in his work *De l'auscultation mediate ou Traité du Diagnostic des Maladies des Poumon et du Coeur* (On Mediate Auscultation or Treatise on the Diagnosis of the Diseases of the Lungs and Heart).[15,19 20]

Laennec wrote an accurate and reliable description of many diseases of the chest such as bronchiectasis, pneumonia, pleurisy, and emphysema, as well as tuberculosis. He used his stethoscope to listen to the chests of tuberculous patients, identifying the presence of consolidation, pleurisy, and pulmonary cavitation. Correlating his patient examination with his dissection findings, Laennec described pulmonary and extra-pulmonary tubercles in detail and showed that they were the first phase of phthisis. He described how they first appeared in the lung in their "miliary" ("millet seed-like") form, progressing to larger tubercles containing "cheese-like" ("caseous") material, their breakdown into pus, and eventually forming cavities and empyema. He also described extra-pulmonary phthitic tubercles in the intestines, liver, meninges and other organs, and tuberculous infection in vertebrae which caused vertebral collapse and spinal cord paralysis that had been described by Sir Percivall Pott, a British surgeon, in 1779, known as Pott's disease. [4,15,17,19,20]

Laennec examined his patients according to the four pillars of French clinical method - inspection, palpation, percussion, and auscultation. He was a skilled dissector, relating findings at post-mortem to the patient's symptoms in life, and was hailed as "the greatest of teachers on tuberculosis".[4,9,17,19] He was the originator of the terms "auscultation" ("listening carefully"), "rhonchus" (a "whistling" or "snoring" sound), "pectoriloquy" ("the chest speaks"), "egophony" ("resonance"), and "râle" (a "rattling" sound) of which there were five types including "crépitation" (a "moist rattling"). Laennec died from tuberculosis in 1826.[19,20,21]

Scrofula – "the King's-Evill"

Scrofula is tuberculosis of the lymph glands of the neck with eventual ulceration and suppuration. Aristotle (384-322 BCE) and Cassius Felix (447 CE) were probably the first to describe scrofula.[1,22] Scrofula was also known in the 17th century as "*the King's-Evill*" because it was believed it could be cured by the King's touch. Richard Wiseman, who served as a ship's surgeon for the Dutch navy and later as a surgeon for King Charles' I army, wrote on the King's evil and its cure by the King in 1672 in his *Treatise of the King's-Evill* in the fourth book of his *Chirurgical Treatises*. It was not known then however that scrofula was related to phthisis or consumption.[18]

The belief that disease could be cured by a king's touch has its origins with Clovis of France (487-511), and later other European monarchs such as Robert the Pious, Edward the Confessor and Philip I of France.[17,22,23] The cure of scrofula by the King's touch was common after the 13th century and performed by English and French monarchs such as King Charles II, who during his 25 year reign touched 92,102 subjects.[4,9] Shakespeare in Macbeth, Act IV, Scene 3, refers to King Edward curing a "wretched crew of souls" of scrofula:

> " … strangely-visited people,
>
> All swoln and ulcerous, pitiful to the eye,
>
> The mere despair of surgery, he cures;
>
> Hanging a golden stamp about their necks,
>
> Put on with holy prayers.; and 'tis spoken,
>
> To the succeeding royalty he leaves
>
> The healing benediction … "[5]

Sylvius de la Boë, Richard Morton and René Laennec had all recognised that scrofula often occurred in

association with pulmonary phthisis, however the fact the two diseases had the one cause was not known until the 19th century.[1]

The epidemic of the 18th and 19th centuries and the romantic image of tuberculosis

By Laennec's era, tuberculosis had become epidemic in Europe where annual mortality rates were between 800 and 1,000 per 100,000 per year.[2] Between 1851 and 1910 in England and Wales four million died from tuberculosis, more than one third of those aged 15 to 34 and half of those aged 20 to 24 died[9], and tuberculosis was called *the robber of youth*.[6]

In that time it also became known as the great *white plague* and *the white death*[4,5,24], called "white" because of the extreme anaemic pallor of those affected.[4,25] The term *white plague* was used by Oliver Wendall Holmes, an American physician and writer, in 1861 in comparing the enormity of the epidemic to other severe plagues of the time.[26] Dormandy (1999) states that the term "white" may also have referred to its association with youth, innocence and even holiness.[4] Consumptive patients took on the appearance of a thin, pale, melancholy, almost delicate spirit. The wan and pallid facies of the victim was thought to be attractive and Dormandy states it gave women a "terrible beauty".[4]

The disease became romanticised in society by poets such as John Keats, Percy Bysshe Shelley, and George Lord Byron, and writers such as Edgar Allan Poe, Robert Louis Stevenson and Emily Brontë, many of whom themselves died from the disease.[2,4,27,28] Byrne (2011) refers to the romantic poetry of Keats and Shelley which "sought to find beauty in the horror and melancholy of consumption". Such poetry of the time was sometimes called "graveyard poetry". Byron once remarked to his friend, Lord Sligo, "I should like, I think, to die of consumption." When Lord Sligo asked why, Byron replied, "Because then all the women would say 'See that poor Byron - how interesting he looks in dying.'"[28]

John Keats wrote in 1819, "Youth grows pale, and spectre thin, and dies."[27] Keats died from tuberculosis in 1821 aged only 26 years. On a winter evening in 1818 when Keats was returning to his home in Hampstead Heath from London, he felt ill and immediately went to bed. He suddenly coughed blood onto his pillow and said to his friend John Arbuthnot Brown,

> " I know the colour of that blood. It is arterial blood, I cannot be deceived by its colour. It is my death warrant. I must die."[4, 5]

Edgar Allan Poe described his young wife, Virginia, who had tuberculosis as being 'delicately, morbidly angelic'. In 1842 while they were having dinner, Virginia had a sudden coughing fit and haemoptysis and Poe remarked :

> "Suddenly she stopped, clutched her throat and a wave of crimson blood ran down her breast ... It rendered her even more ethereal."[27]

Emily Brontë described the tuberculous heroine in *Wuthering Heights* as "rather thin, but young and fresh complexioned and her eyes sparkled like diamonds". Emily, her four sisters, and her brother Branwell died in young adulthood from tuberculosis, and their mother also died of tuberculosis.[2,4]

The imagery of the consumptive was also used by the writers of popular fiction of the 19th century who began the literary tradition of vampirism to describe vampires and their victims. Consequently it was sometimes thought, especially in areas of the world where such folklore abound such as New England in America and Yorkshire in northern Britain, that people seen to be suffering from what were actually symptoms of tuberculosis, the wasting and extreme pallor, were victims of vampires or were vampires themselves.[28]

There were certain social conditions that were intimately associated with the disease, linked to the industrial revolution at the time - poverty, malnutrition, and overcrowding. Conditions for the working classes were extremely poor.[8] In 1838 and 1839 in England between a quarter and a third of tradesmen and labourers died from tuberculosis compared to a sixth of "gentlemen".[5]

> "The disease picked out and killed a few Princes and it carried off more than one bejewelled, tender-hearted courtesan; but it slaughtered the poor by the million."[4]

Wealthy tuberculosis sufferers could afford to travel in search of sunny and mild climates or seek refuge in mountain sanatoria, whereas poorer people had to look after their own ill consumptive family in dark, unventilated, closed rooms, sealing their own fate to die of the same disease a few years later.[4,27]

The 19th century debate about the pathology and transmission of phthisis

From the beginning of the 19th century physicians debated in earnest two important questions about the pathological foundations of phthisis - firstly whether it was infectious, hereditary, or cancer, and secondly, whether scrofula, tubercles, and phthisis

were separate disease entities or manifestations of the one disease.

The most prominent proponents of a single entity were René Laennec and the Viennese pathologist Carl von Rokitansky. In contrast, Giovanna Battista Morgagni of Padua, and German physicians Rudolf Virchov and Johann Lukas Schönlein believed the diseases were separate entities.[1,3] This question wasn't settled until Robert Koch discovered in 1882 the *Tubercle bacillus* and that it was responsible for all forms of the disease.

By the 18th century many Italian physicians had come to believe that phthisis was infectious, although many British and American physicians at the time did not, and avoided doing autopsies on patients who had died from phthisis to protect themselves and their students.[1,3,5,29] Many others however still thought phthisis to be hereditary or due to constitutional weakness.[2,3] Another school of thought was that phthisis was related to *zymes*, chemicals that themselves did not cause diseases but acted as catalysts in causing decay within the body and could cause *zymotic fevers*.[9]

The 19th century saw several major breakthroughs in tuberculosis research that elucidated the infectious nature of the disease culminating in Robert Koch's discovery of the bacteria. In 1843 Philipp Friedrich Hermann Klencke, a German physician, successfully inoculated rabbits with material from a tubercle although he believed the disease to be cancer. In 1844 Friedrich Gustav Jakob Henle, a German pathologist, postulated that phthisis was infectious.[1,29]

The first breakthrough was in 1865 by Jean Antoine Villemin, a French military surgeon at the Army Medical School at Val-de Grâce. Villemin had observed that soldiers stationed for long times in barracks were more likely to have phthisis than soldiers in the field, and healthy army recruits from the country often became consumptive within a year or two of taking up their posts. He showed by controlled experiments that phthisis from humans, or tuberculosis as he also called it in his work *Cause et nature de la tuberculose: son inoculation de l'homme au lapin*, could be transmitted to rabbits demonstrating that the disease was infectious. Villemin thought that phthisis was similar to glanders, an infectious disease in horses.[1,2,4,5,17]

Koch's discovery in 1882 of the bacillus that caused tuberculosis provided more evidence that the disease was infectious. In his acceptance of his Nobel Prize in 1905 he alluded to the work of his colleague and a fellow bacteriologist, Carl Flügge, that bacilli in droplets from a cough could possibly transmit infection. However it wasn't until the mid-20th century that it was conclusively shown that tuberculosis was transmitted by the inhalation of contaminated air droplets.[30]

The term "tuberculosis"

Johann Lukas Schönlein, a German physician, in 1834 used the term tuberculosis in describing disease with tubercles, but did not use the term in relation to scrofula or phthisis.[1,5,15] In 1853 Hermann Brehmer, a medical graduate of the University of Berlin, used the term *tuberculosis of the lungs* in his doctoral thesis titled *De legibus ad initium atque progressum tuberculosis pulmonum spectantibus,* "On the Laws concerning the Beginning and Progress of Tuberculosis of the Lungs", in which he also referred to tuberculosis being curable in its early stages.[29,31] It appears that after this time the term tuberculosis supplanted phthisis, although consumption still remained as the lay term for the disease. Villemin used the term *tuberculose* in 1865 and in 1882 Robert Koch used the term *tuberkulose*, translated to English as *tuberculosis*, describing his discovery of the bacterium he called *Tubercle bacillus*, after which the disease was known as either tuberculosis or TB.[1,3,15,32]

Robert Koch's discovery paved the way for the development of the Pirquet and Mantoux tuberculin skin tests, Albert Calmette and Camille Guérin's BCG vaccine, Selman Waksman's streptomycin and other anti-tuberculous drugs. Tuberculosis is still a major public health problem today, in 2011, 8.7 million people were infected with tuberculosis with 1.4 million deaths, and mortality from tuberculosis has increased in recent decades with the emergence of HIV and of multi-drug resistant tuberculosis.

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References

1. Herzog H. History of tuberculosis. Respiration 1998; 65: 5-15. Available at : http://www.karger.com/Article/PDF/29220, accessed on 11.9.10.
2. Daniel TM. The history of tuberculosis. Resp Med 2006; 100: 1862-1870. Available at : http://www.resmedjournal.com/article/S0954-6111(06)00401-X/fulltext, accessed on 11.9.13.
3. Boire NA, Riedel VAA, Parrish NM, et al. Tuberculosis: from an untreatable disease in antiquity to an untreatable disease in modern times. J Anc Dis Prev Rem 2013; 1 (2): 1-11. Available at : http://www.esciencecentral.org/journals/2329-8731/2329-8731-1-106.pdf , accessed on 11.9.13.

4. Dormandy T. The White Death: A History of Tuberculosis. London: The Hambledon Press, 1999, p. xiv, 2, 4, 13, 34-36, 73-84, 92-94, 101-104, 129-137, 147, 392.
5. Dubos R, Dubos J. The White Plague: Tuberculosis, Man and Society. Boston; Little, Brown & Co., 1952, p. 7, 10, 13-14, 70-73, 91, 98, 203.
6. Segen JC. The Dictionary of Modern Medicine. Park Ridge, NJ; Parthenon, 1992, p. 783.
7. Bunyan J. The Life and Death of Mr. Badman. Acacia John Bunyan Online Library. 2013. Available at : http://acacia.pair.com/Acacia.John.Bunyan/Sermons.Allegories/Life.Death.Badman/XVIII.html , accessed on 18.10.13
8. National Institute of Health (U.S.) Tuberculosis (TB). 2010. Available at : http://www.niaid.nih.gov/topics/tuberculosis/Understanding/history/pages/historical/ , accessed on 18.10.13.
9. Bynum H. Spitting Blood. Oxford; Oxford University Press, 2012, p. 13, 17, 18, 33-39, 56-62, 104, 106-107, 110.
10. Long ER. Tuberculosis in World War I. In : Hays SB (Editor-in-chief). Preventive Medicine in World War II. Vol IV. Communicable Diseases. Washington, DC; Office of the Surgeon General, Department of the Army, 1958. Available at : http://history.amedd.army.mil/booksdocs/wwii/PM4/CH14.Tuberculosis.htm, accessed on 13.9.13.
11. Mancuso JD. Tuberculosis trends in the U.S. Armed Forces, active component. Medical Surveillance Monthly Report 2013; 20 (5): 4-8. Available at : http://www.afhsc.mil/viewMSMR?file=2013/v20_n05.pdf, accessed on 13.9.13.
12. O'Shea MK, Wilson D. Tuberculosis and the military. J R Army Med Corps 2013; 159 (3): 190-199. Available at : http://jramc.bmj.com/content/159/3/190.full, accessed on 2.10.13.
13. Schreiber W, Mathys FK. Infectio. Basle, Switzerland: Editione Roche, 1987, p. 181-193.
14. Hippocrates (460-370 BCE). Book 1 – Of the Epidemics. In : Adams F (translator). The Genuine Works of Hippocrates. London: The Sydenham Society, 1849. [Facsimile edition, The Classics of Medicine Library, Alabama, 1985, p. 352-354.]
15. Daniel TM. Pioneers in Medicine and their Impact on Tuberculosis. Rochester, NY; University of Rochester Press, 2000, p. 4, 29, 46-48, 50-51, 74-76.
16. Pease AS. Some remarks on the diagnosis and treatment of tuberculosis in antiquity. Isis 1940; 31 (2): 380-393. Available at : http://www.jstor.org/discover/10.2307/225758?uid=3737536&uid=2&uid=4&sid=21102645880757, accessed on 11.9.13
17. Garrison FH. An Introduction to the History of Medicine. Philadelphia & London: W B Saunders & Co., 1921, p. 109, 288, 411-413, 616.
18. Major RH. Classic Descriptions of Disease. Springfield, USA: Charles C Thomas, 1932, p. 49-56, 56-57, 58-61, 61-62.
19. Roguin A. René Théophile Hyacinthe Laënnec (1781-1826): the man behind the stethoscope. Clin Med Res 2006; 4 (3): 230-235. Available at : http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1570491/pdf/0040230.pdf, accessed on 11.9.13.
20. Nuland SB. Doctors: The Illustrated History of Medical Pioneers. New York: Black Dog & Leventhal Publishers, 1988, p. 193-227.
21. Nixon JA. Classification of adventitious sounds. [Letter] BMJ 16 April 1938, p. 170. Available at : http://europepmc.org/articles/PMC2086242/pdf/brmedj04272-0043a.pdf , accessed on 19.10.13.
22. Barlow F. The King's Evil. English Historical Reviews (1980). XCV (CCCLXXIV): 3-27. Available at : http://ehr.oxfordjournals.org/content/XCV/CCCLXXIV/3.full.pdf+html, accessed on 17.9.13.
23. Goddard PR. The King's Evil. West of England Medical Journal 2013; 112 (2): Article 3 (e-journal). Available at : file:///C:/Documents%20and%20Settings/Owner/My%20Documents/Downloads/3)_The_Kings_Evil_The_Royal_Touch_for_Scrofula.pdf , accessed on 20.5.14.
24. Robert Koch and Tuberculosis. NobelPrize.org. 21 September 2003. Available at : http://www.nobelprize.org/educational/medicine/tuberculosis/readmore.html, accessed on 11.9.13.
25. Dobson M. Disease. London: Quercus, 2007.

26. Murray JF. The White Plague: down, and out, or up and coming? Am Rev Respir Dis 1989; 140 (6): 1788-1795. Available at : http://www.atsjournals.org/doi/abs/10.1164/ajrccm/140.6.1788?journalCode=arrd , accessed on 18.10.13.
27. Evans R. The White Plague. 2012. Available at : http://www.gresham.ac.uk/lectures-and-events/the-white-plague , accessed on 11.9.13.
28. Byrne K. Tuberculosis and the Victorian Literary Imagination. Cambridge; Cambridge University Press, 2011, p. 21, 94, 126.
29. Daniel TM. Hermann Brehmer and the origins of tuberculosis sanatoria. In J Tuberc Lung Dis 2011; 15 (2): 161-162. Available at : http://docstore.ingenta.com/cgi-bin/ds_deliver/1/u/d/ISIS/75571322.1/iuatld/ijtld/2011/00000015/00000002/art00004/6E4641630974685013799183848 91BF294582C383B.pdf?link=http://www.ingentaconnect.com/error/delivery&format=pdf , accessed on 11.9.13.
30. Daniel TM. Pioneers in Medicine and Their Impact on Tuberculosis. Suffolk, UK; University of Rochester Press, 2000, p. 7-8.
31. Knopf SA. Hermann Brehmer, and the Semi-centennial Celebration of Brehmer's Sanitorium for the Treatment of Consumptives; the first Institution of its Kind. New York Medical Journal and Philadelphia Medical Journal, 2 July 1904. Charlestown, SC; Bibliolife Reproduction.
32. Sakula A. Robert Koch: centenary of the discovery of the tubercle bacillus, 1882. Thorax 1982; 37: 246-251. Available at : http://thorax.bmj.com/content/37/4/246.full.pdf , accessed on 11.9.1

History of Tuberculosis. Part 2 - the Sanatoria and the Discoveries of the Tubercle Bacillus

John Frith

> "If the importance of a disease for mankind is measured by the number of fatalities it causes, then tuberculosis must be considered much more important than those most feared infectious diseases, plague, cholera and the like. One in seven of all human beings dies from tuberculosis." (Robert Koch, in his address to the Berlin Physiological Society, 24th March 1882)[1]

Introduction

Tuberculosis was epidemic in Europe and America in the 18th and 19th centuries, and by the mid 18th century in London and Hamburg, the mortality rates were as high as 1000 per 100,000 per year.[2] The disease had a predilection for young people and was called the *robber of youth*[3], and also for the poorer classes, who were disadvantaged by malnutrition, overcrowding and poor living and working conditions and who died by the millions over those two centuries.[4, 5]

The ravages of the disease spurred many scientists to find the cause and the cure. Sanatoria were developed in the mid 19th century where patients lived in open alpine or seaside air with good and ample food, but they were not effective at curing the disease and most still died from it.[2, 6] Scientists and physicians also argued whether phthisis, scrofula and tubercular disease were separate entities or the one disease, and whether they were hereditary, cancer or infectious diseases. In 1865 Jean Antoine Villemin, a French military surgeon, showed by experiments in animals that phthisis was infectious. [2, 5, 6]. The second major breakthrough was the discovery in 1882 by Hermann Heinrich Robert Koch of the cause of tuberculosis – a bacillus he called Tubercle bacillus and which was later renamed Mycobacterium tuberculosis.[2, 6, 7]

Robert Koch's discovery of the tubercle bacillus in 1882

In 1882 Robert Koch, a German physician and one of the founders of bacteriology, discovered the bacillus that caused tuberculosis. Koch used material from cases of pulmonary, extra-pulmonary and meningeal tubercular disease as well as cases of scrofula. For staining Koch used methylene-blue in a solution of caustic potash. Culture of the bacteria was difficult, he eventually used a medium of coagulated bovine serum developed by John Tyndall, a British microbiologist. Koch then successfully inoculated bacteria from the culture to infect laboratory animals, thus fulfilling the postulates of infectious disease developed by his mentor from Göttingen, Friedrich Gustav Jakob Henle, and which he and Henle later modified to become the Henle-Koch postulates. Koch used his technique to demonstrate the presence of the bacillus in all forms of human and animal tuberculosis proving unequivocally not only that the bacillus was the cause, but the many different forms of tuberculosis were manifestations of the one disease entity.[2, 6, 7, 8, 9, 10]

Koch delivered his findings in a lecture to the Berlin Physiological Society at the Charité Hospital in Berlin on 24th March 1882 under the title *Die Ätiologie der Tuberkulose*, "The Aetiology of Tuberculosis".[1,6] The audience of Koch's lecture listened in silence and awe and admiration to what must have been an extraordinarily enlightening presentation, afterwards the audience rose to look at Koch's cultures and microscope slides of the bacillus. Paul Ehrlich, then assistant bacteriologist to Professor Friedrich von Frerichs at the Charité Hospital, Berlin, and who later discovered Salvarsan and became the founder of immunology and chemotherapeutics, was present at the lecture and remarked, "I hold that evening to be the most important experience of my scientific life."[11]

On 10 April 1882 Koch published his lecture in the *Berliner Medicinische Wochenschrift*, and sent a copy to John Tyndall who in turn published Koch's essential findings in a letter to *The Times* on 22 April 1882. The letter was subsequently reprinted in the *New York Times*, the *New York Tribune* and other newspapers around the world, and within a short time Koch had gained fame in discovering the cause of a scourge that had affected humankind since recorded history.[7]

In 1890 he obtained a concentrated filtrate of liquid cultures of tubercle bacilli which he called *tuberculin* and which he believed was to be an effective vaccine for tuberculosis, however after some years of trying, Koch found this not to be so. In 1907 a Viennese paediatrician, Clemens Freiherr von Pirquet, used cutaneous scratch tests of tuberculin, the Pirquet test, to diagnose children with 'latent tuberculosis', a term which he introduced. Charles Mantoux, a French physician, in 1908 used tuberculin intradermally, the Mantoux test, which replaced Pirquet's test. In the 1930's Florence B. Seibert and Esmond R. Long, two American biochemists, developed a tuberculin purified protein derivative, PPD, which did not produce as many false negative results as 'Koch's substance'. Koch was awarded the Nobel Prize in 1905 for his work on tuberculosis. He died in 1910 in Baden-Baden from heart disease.[2,6,7]

Koch initially called his bacillus *Tubercle bacillus* and after the publication of his 1882 lecture, it became popularly known as *Koch's bacillus* and tuberculosis became known as *Koch's disease*.[7] The bacillus was officially renamed *Bacterium tuberculosis* by Friedrich Wilhelm Zopf in 1883, changed to *Bacillus tuberculosis* by Edward Emmanuel Klein in 1884, and to *Mycobacterium tuberculosis* by K.B. Lehman and R. Neumann in 1896 after considering it to belong to a new genus, *Mycobacterium*.[12]

Staining of the bacillus and acid- alcohol fast bacilli

Mycobacterium tuberculosis, as with other Mycobacteria, has a cell wall consisting of glycolipids and lipids which makes the bacteria resistant to chemicals and enzymes, a property which made staining of the bacterium difficult. Koch initially used methylene-blue in an alkaline solution and Bismark brown as a counterstain. In a paper following his address to the Berlin Physiological Society in 1882 Koch remarked :

> "Under the microscope the structures of the animal tissues, such as the nucleus and its breakdown products are brown, while the tubercle bacteria are a beautiful blue."[13]

Inspired by Koch's lecture, Paul Ehrlich began working on a better method of staining. He used aniline water, fuschin and gentian-violet, applied nitric acid and alcohol to decolourise the background tissue, and heated the slide. He then applied a blue background counterstain which showed up the bacilli which were stained red.[7, 10]

Later in 1882 Franz Ziehl introduced carbol fuschin instead of aniline and Friedrich Neelson substituted sulphuric acid for nitric acid which stained the bacillus a brighter red. This was known as the Ziehl-Neelson (ZN) stain. The lipid bacterium cell wall of the bacillus has the property of resisting decolourisation by acid and alcohol and so was known as the acid-alcohol-fast bacillus, AAFB, or acid-fast bacillus, AFB.[7, 10]

The tuberculosis sanatorium

Fresh air, nutritious food and exercise had been proscribed for phthisis throughout history including by Hippocrates and Aretaeus of Cappadocia. Around the middle of the 19th century, Hermann Brehmer, a German physician, proposed sanatorium treatment (called 'phthisiotherapy'), an 'immune' place where a person could be cured with the aid of fresh rarefied alpine air, plentiful nutritious food, mountain walks, and mountain water douches. Brehmer found such a place in 1857 in a valley in the Sudeten Mountains in Silesia and founded his sanatorium, *Heilanstalt* ("healing place"), in the village of Göbersdorf. Brehmer's treatment included walks on mountain trails to a waterfall where the patient stood underneath a cold mountain stream, the 'forest douche' or *Walddusche*, which he supervised personally to counter any objections to the icy water that his patients might give. In the sanatorium his patients were given nutritious food and milk, Hungarian wine with dinner, and French cognac at bedtime. Brehmer published his treatment in 1857 in his work *Die Chronische Lungenschwindsucht und Tuberkulose der Lunge: Ihre Ursache und ihr Heilung, "The Laws and Healing of Chronic Tuberculosis of the Lung*".[2, 6, 14, 15]

Towards the end of the 19th century sanatoria were also built for the poorer classes. They were much less salubrious with plainer food, and the patients had to work and do their own housekeeping. For those who still could not afford a sanatorium, improvisations were made in their home with the patient sleeping outside or in a small outdoor bungalow rugged up against the weather. Rooms in sanatoria were sometimes ventilated with stringent airs – creosote, turpentine and eucalyptus.[4] Tuberculosis sanatoria became an important treatment in many countries well into the 20th century and many urban hospitals had open air wards as sanatoria. Sanatoria treatment was often beneficial for patients with minimal disease, but many with severe infection still died.[2, 6]

Other treatments were still being sought, and Paul Ehrlich's discovery in 1909 that syphilis could be cured with an arsphenamine spurred others on to find a chemotherapeutic agent for tuberculosis. Edward Trudeau, medical superintendant of a sanatorium at Adirondack Cottage on Saranac Lake, New York, and who died of tuberculosis in 1916,

stated in a letter posthumously published in the *British Journal of Tuberculosis*:

> "My faith in the possibilities of chemotherapy for tuberculosis is based simply on what Ehrlich has demonstrated as possible in syphilis – namely, that a chemical compound could be discovered which killed the germ without injuring the cell ... I see no reason why what has been accomplished in the treatment of syphilis should not be attained in tuberculosis."[16]

Pneumothorax and other surgical treatments

From the late 1880's, sanatoria treatment was supplemented by surgical treatment and collapse therapy, or pneumothorax therapy. The benefit of lung collapse was first suggested in 1771 by Edmond Claude Bourru, librarian, Faculté de Médicine in Paris. In 1885 Edouard Bernard de Cérenville, a Swiss surgeon, and in 1890 Max Schede, a German surgeon, performed thoracoplasty, unilateral partial rib resection to reduce thoracic cavity volume and collapse tuberculous cavities, the principle being to allow them to heal and prevent spread of infection. In 1888 Carlo Forlanini, an Italian physician of Pavia, Lombardy, created the first artificial pneumothorax by collapsing the lung and filling the pleural cavity with nitrogen. Other forms of surgical treatment were used such as lobectomy and segmentectomy, but were commonly complicated by the spread of the infection, fistulas and empyema. In the 1940's the space created by surgical pneumothorax was filled with oil ('oleothorax'). After the introduction of streptomycin in 1945 and other anti-tuberculous drugs, all forms of surgical treatment were abandoned in favour of drug treatment.[2,6]

The development of the X-ray (the Röntgenogram)

An important contribution to the diagnosis and control of tuberculosis was the discovery in 1895 of X-rays by Wilhelm Konrad von Röntgen. While experimenting with a Crooke's cathode ray tube Röntgen produced a radiation that could produce shadows of metal objects on a photographic plate. Röntgen's technique of utilising these rays to show the body's skeleton with images he called Röntgenograms (he initially called them X-rays but was convinced by his colleagues to change the name) was able to be applied to looking in more detail at internal organs and was very effective at showing tuberculosis in the lung in its various stages, especially the Ghon focus and the apical cavitation and calcification. X-ray screening was introduced for military recruits during World War I and then for the general population through to World War II where it was again used to screen military recruits. Its efficacy in population screening was found to be very low and was ceased in the 1950's, however it still remained a cheap means of individual diagnostic screening and together with the tuberculin skin sensitivity test played a very significant role in controlling the disease. Röntgen was awarded the Nobel Prize in 1901 for his work.[2,6,9]

The Bacille Calmette-Guérin (BCG) vaccine

In 1900 two French bacteriologists and *Pastoriens*, Albert Calmette and Camille Guérin, began their research for an antituberculosis vaccine at the Pasteur Institute in Lille. By 1908, by successive sub-culturing a virulent strain of *Mycobacterium bovis* (previously supplied to them by Edmond Nocard, a French veterinarian and microbiologist) on a medium containing ox bile, they were able to produce a non-virulent strain which they formulated into a live attenuated vaccine. By 1919 Calmette and Guérin showed the effectiveness of their vaccine in animals and called their vaccine Bacille Bilie Calmette-Guérin, later abbreviated to Bacille Calmette-Guérin or BCG. In 1921 the first human administration of BCG was performed by two French physicians, Benjamin Weille-Hallé and Raymond Turpin, at the Charité Hospital, Paris, using an oral vaccine. The vaccine was given to an infant born of a mother who died from tuberculosis shortly after giving birth, the child survived and did not contract the disease. The vaccine soon became popular throughout Europe and over the next seven years over one hundred thousand children were immunised.[2,4,6,17]

In 1930 popular confidence in the vaccine was greatly affected when in Lübeck in Germany 250 children were given a BCG vaccine that had been accidently contaminated by virulent tubercle bacilli, 73 of the children died in the first year from tuberculosis infection and a further 135 were infected but recovered.[6,17] World War II was followed by a resurgence of tuberculosis throughout Europe and Asia and in 1948 UNICEF undertook a tuberculosis control program of tuberculin testing and BCG vaccination in children and many countries followed suit.[2] Routine vaccination was discontinued in the 1970's but is still used in many countries with a high prevalence of tuberculosis to prevent childhood tuberculous meningitis and miliary disease, and for health care and military personnel and other people at high risk of exposure to tuberculosis.[18]

The development of streptomycin and other anti-tuberculous drugs

Tuberculosis was resistant to the sulphonamides of the 1930's and to penicillin of the 1940's. In 1940 Selman Waksman, a Ukrainian born American microbiologist working at Rutgers University with funding from chemical company Mercke & Co., isolated actinomycin from *actinomycetes* fungi and in 1942 streptothricin, but these were too toxic to use. In 1943 Waksman and his colleagues Albert Schatz and Elizabeth Bugie obtained streptomycin from *Streptomyces griseus* which was found to be very effective against tuberculosis and much less toxic, and became a standard treatment by 1945. Waksman was awarded the Nobel Prize in 1952 for the discovery. Waksman also coined the term "antibiotic" in 1941 after his discovery of actinomycin.[2,4,6,8,10]

In 1943 Jorgen Lehmann, a Swedish physician, developed para-aminosalicylic acid (PAS) and in 1945 Gerhard Domagk, a German bacteriologist, developed thiosemicarbazone, both also very effective. Since then other anti-tuberculosis antibiotics have been developed such as isoniazid, rifampicin, ethambutol, and pyrazinamide, and more recently, viomycin and ciprofloxacin which are used in drug resistant infections.[2, 6]

Tuberculosis and AIDS

In the 1980's and 1990's the incidence of tuberculosis surged as a major opportunistic infection in people with HIV infection and AIDS related to their immune system impairment. WHO estimates that in 2012 there were 8.6 million new cases of tuberculosis, of which 1.1 million had HIV co-infection, and 1.3 million died from tuberculosis. The largest number of new cases of tuberculosis occurred in Asia, accounting for 60% of new cases. Sub-Saharan Africa had the highest rate per population with over 260 new cases per 100,000.[19, 20, 21]

The risk of developing tuberculosis is estimated to be between 12-20 times greater in people living with HIV than those without HIV infection. Worldwide 15% of patients with tuberculosis have HIV co-infection, and up to 50-80% have HIV co-infection in parts of sub-Saharan Africa. Tuberculosis is the leading cause of death in people with HIV infection and AIDS, 1 in 3 people with AIDS die from tuberculosis.[21, 22] The incidence of HIV-related tuberculosis has declined in developed countries due to effective anti-TB and anti-HIV treatment, but remains a significant health problem in many developing countries.

Drug resistant tuberculosis

In recent decades multidrug resistant tuberculosis (MDR-TB), tuberculosis which does not respond to at least isoniazid and rifampicin, has emerged and is present in most countries. In 2012 WHO estimated there to be 450,000 cases worldwide, most of which were in India, China and the Russian Federation, and 10% had extensively drug resistant tuberculosis (XDR-TB). MDR-TB is on the rise in many countries, but an international initiative financed by UNITAID is currently making progress in improving access in participating countries to diagnostic services for tuberculosis and HIV, and especially to diagnosis of MDR-TB.[19, 20, 23, 24]

Tuberculosis and the military

Tuberculosis was a major problem in soldiers of the Crimean War of 1853-1856. Florence Nightingale in her paper *On Army Sanitary Reform under the Late Lord Herbert* read at the *Congrés International de Bienfaisance* on 13 June 1862 remarked :

> "After the Crimean War, it was found that the death rate among soldiers from consumption alone and its cognate diseases (the monstrous product of breathing foul air) exceeded the death rate from all causes among the civil population."[25]

Tuberculosis as a medicomilitary problem became more apparent during World War I. Both the Allies and the Germans screened their military recruits for tuberculosis using chest radiographs, however many were still enlisted with latent or active tuberculosis. Before the war ended, 2,000 soldiers had died of tuberculosis in the US Army and was the leading cause of discharge.[2, 25] After World War I the US Army established the Fitzsimons Army Hospital in Denver, Colorado, to cope with the large number of returning Army and Navy veterans with tuberculosis.

Tuberculosis declined in incidence between the two world wars due to better case finding, early diagnosis, and better conditions of living, although X-ray screening was used again during World War II. During the years 1942 to 1945 there were 3,099 soldiers discharged from the US Army for tuberculosis, just over half of all discharges. In one half of those discharges the disease had already been present on enlistment. [26] In 1943 the Valley Forge Hospital was established in Phoenixville, Pennsylvania, to treat returning US military personnel including those with tuberculosis. Following the introduction of streptomycin and other anti-tuberculous drugs, the worldwide prevalence of tuberculosis declined and remained low until its resurgence with HIV in the 1980's.

In the last several decades microepidemics have occurred in small close knit units on US and British Naval ships and land based units deployed overseas. In 1998 an outbreak of 21 cases of active tuberculosis occurred among the ship's sailors and the marine expeditionary unit on a US amphibious ship.[27] In 2006 a small outbreak occurred on HMS Ocean, several naval personnel had active tuberculosis and 80 cases of latent infection were identified.[28] In 2006 a sailor on USS Ronald Reagan was diagnosed with active pulmonary tuberculosis and 139 sailors and 1 civilian were identified with new latent tuberculosis.[29]

Overall incidence of tuberculosis in Western militaries is currently low but is higher in militaries of other countries such as South Korea and the Russian Federation. Mancuso & Aaron[28] in an analysis of US active military personnel from 1998 to 2012 found that the average annual incidence rate of pulmonary tuberculosis was only 0.6 per 100,000, which was one fifth of the incidence in the US general population. The rate declined from 1.5 per 100,000 in 1998 to 0.35 per 100,000 in 2012. In health care personnel in 2012 the rate was 0.46 per 100,000, an increased risk of 28%, however this was not statistically significant. Interestingly, and reminiscent of the early 20th century experiences, the most common factor associated with diagnosis during military service was latent infection at the time of enlistment. Military personnel are still at significant risk of acquiring tuberculosis infection because of living and working in close quarters and deployment in regions with a high prevalence of tuberculosis such as Afghanistan, Iraq and South-East Asia, and are particularly at risk of exposure to multidrug resistant tuberculosis (MDR-TB).[27, 30, 31]

Tuberculosis has been a severe health problem throughout recorded human history, and probably for many thousands of years before that. It has been known by many names including phthisis, consumption, the "white plague" and "the robber of youth". The disease had been romanticised in the 19th century by people such as John Keats, Edgar Allen Poe and Emily Brontë. The nature, cause and cure of the disease had eluded the scientific and medical community until the discoveries by eminent scientists such as René Laennec, Jean Antoine Villemin, Robert Koch and Selman Waksman. Tuberculosis never-the-less remains a significant public health problem worldwide, especially with the emergence of multidrug resistant tuberculosis, and also remains an important medicomilitary issue.

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References

1. Robert Koch and Tuberculosis. NobelPrize.org. 21 September 2003. Available at : http://www.nobelprize.org/educational/medicine/tuberculosis/readmore.html, accessed on 11.9.13.
2. Daniel TM. The history of tuberculosis. Resp Med 2006; 100: 1862-1870. Available at : http://www.resmedjournal.com/article/S0954-6111(06)00401-X/fulltext, accessed on 11.9.13.
3. Segen JC. The Dictionary of Modern Medicine. Park Ridge, NJ; Parthenon, 1992, p. 783.
4. Bynum H. Spitting Blood. Oxford: Oxford University Press, 2012, p. 109-115, 128-145, 166, 175-187, 190-196.
5. Dormandy T. The White Death: A History of Tuberculosis. London: The Hambledon press, 1999, p. 54-57, 73-84.
6. Herzog H. History of tuberculosis. Respiration 1998; 65: 5-15. Available at : http://www.karger.com/Article/PDF/29220, accessed on 11.9.10.
7. Sakula A. Robert Koch: centenary of the discovery of the tubercle bacillus, 1882. Thorax 1982; 37: 246-251. Available at : http://thorax.bmj.com/content/37/4/246.full.pdf , accessed on 11.9.13.
8. Daniel TM. Pioneers in Medicine and their Impact on Tuberculosis. Rochester, NY; University of Rochester Press, 2000, p. 74-76, 179.
9. Garrison F H. An Introduction to the History of Medicine. Philadelphia & London: W B Saunders & Co., 1921, p. 578-590, 721.
10. Boire NA, Riedel VAA, Parrish NM, et al. Tuberculosis: from an untreatable disease in antiquity to an untreatable disease in modern times. J Anc Dis Prev Rem 2013; 1 (2): 1-11. Available at : http://www.esciencecentral.org/journals/2329-8731/2329-8731-1-106.pdf , accessed on 11.9.13.
11. Brock TD. Robert Koch. A life in medicine and bacteriology. New York: Springer-Verlag, 1988, page 129.
12. UniProt Taxonomy. Mycobacterium tuberculosis. 2013. Available at : http://www.uniprot.org/taxonomy/1773, accessed on 11.9.13.

13. National Institute of Health (U.S.) Tuberculosis (TB). 2010. Available at : http://www.niaid.nih.gov/topics/tuberculosis/Understanding/history/pages/historical/ , accessed on 18.10.13.
14. Daniel TM. Hermann Brehmer and the origins of tuberculosis sanatoria. Int J Tuberc Lung Dis 2011; 15 (2): 161-162. Available at : http://docstore.ingenta.com/cgi-bin/ds_deliver/1/u/d/ISIS/75571322.1/iuatld/ijtld/2011/00000015/00000002/art00004/6E4641630974685013799183848 91BF294582C383B.pdf?link=http://www.ingentaconnect.com/error/delivery&format=pdf , accessed on 11.9.13.
15. Kinghorn HM. Hermann Brehmer. Trans Am Climatol Clin Assoc 1921; 37: 193-210. Available at : http://europepmc.org/articles/PMC2307432/pdf/tacca200003-0222.pdf , accessed on 11.9.13.
16. Trudeau EL. Relative immunity in tuberculosis and the use of tuberculin. Br J Tuberc 1916; 10: 29-30. Available at : http://ac.els-cdn.com/S0366085016800149/1-s2.0-S0366085016800149-main.pdf?_tid=d4ea0b70-23e9-11e3-bd63-00000aab0f01&acdnat=1379897476_57f5328534c5819d162afb08d9b14d0b , accessed on 23.9.13.
17. Luca S, Mihaescu, T. History of BCG vaccine. Maedica (Buchar.) 2013; 8 (1): 53-58. Available at : http://www.ncbi.nih.gov/pmc/articles/PMC3749764 , accessed on 1.5.14.
18. Centers for Disease Control and Prevention. BCG Vaccine. 2011. Available at : http://www.cdc.gov/tb/publications/factsheets/prevention/bcg.htm , accessed on 1.5.14.
19. World Health Organisation. WHO Global Tuberculosis Report 2012. Available at : http://www.who.int/tb/publications/factsheet_global.pdf , accessed on 26.9.13.
20. World Health Organisation. Tuberculosis. Fact sheet No. 104. 2014. Available at : http://www.who.int/mediacentre/factsheets/fs104/en/ , accessed on 1.5.14.
21. World Health Organisation. Tuberculosis and HIV. 2014. Available at : http://www.who.int/hiv/topics/tb/en/ accessed on 1.5.14.
22. Leutkemeyer A. Tuberculosis and HIV. University of California, San Francisco. Available at : http://www.hivinsite.ucsf.edu/InSite?page=kb-05-01-06#S3X , accessed on 1.5.14.
23. World Health Organisation. Progress in diagnosing multidrug-resistant tuberculosis. 2014. Available at http://www.who.int/medicacentre/news/releases/2014/tb-day/en/ , accessed on 1.5.14.
24. Matteelli A, Centis R, D'Ambrosio L, et al. Multidrug-resistant tuberculosis today. Bulletin of the World Health Organisation 2012; 90: 78, available at http://www.who.int/bulletin/volumes/90/2/11-097360/en/, accessed on 1.5.14.
25. Warren P. The Evolution of the Sanatorium: the First Half-Century, 1854-1904. Can Bull Med Hist 2006; 23 (2): 457-470. Available at : http://www.cbmh.ca/index.php/cbmh/article/viewFile/1239/1230 , accessed on 11.9.13.
26. Long ER. Tuberculosis in World War I. In : Hays SB (Editor-in-chief). Preventive Medicine in World War II. Vol IV. Communicable Diseases. Washington, DC; Office of the Surgeon General, Department of the Army, 1958. Available at : http://history.amedd.army.mil/booksdocs/wwii/PM4/CH14.Tuberculosis.htm, accessed on 13.9.13.
27. LaMar JE, Malakooti MA. Tuberculosis outbreak investigation of a U.S. Navy amphibious ship crew and Marine expeditionary unit aboard, 1998. [Abstract] Mil Med 2003; 168 (7): 523-527. Available at : http://www.ncbi.nlm.nih.gov/pubmed/12901459 , accessed on 2.10.13.
28. O'Shea MK, Wilson D. Tuberculosis and the military. J R Army Med Corps 2013; 159 (3): 190-199. Available at : http://jramc.bmj.com/content/159/3/190.full, accessed on 2.10.13.
29. Buff AM, Deshpande SJ, Harrington TA, et al. Investigation of Mycobacterium tuberculosis infection transmission aboard the U.S.S. Ronald Reagan, 2006. Mil Med 2008; 173 (6): 588-593. Available at : http://www.redorbit.com/news/health/1478948/investigation_of_mycobacterium_tuberculosis_transmission_aboard_the_uss_ronald_reagan/ , accessed on 2.10.2013.
30. Mancuso JD, Aaron CL. Tuberculosis trends in the U.S. Armed Forces, active component. Medical Surveillance Monthly Report 2013; 20 (5): 4-8. Available at : http://www.afhsc.mil/viewMSMR?file=2013/v20_n05.pdf , accessed on 13.9.13.
31. Freier G, Wright A, Nelson G, et al. Multidrug-resistant tuberculosis in military recruits. Emerg Inf Dis 2006; 12 (5): 760-762. Available at : http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3374445/pdf/05-0708.pdf , accessed on 13.9.13.

Excerpt from HMAS Sydney I Medical Officer's log during action with SMS Emden 09 November 1914

Surgeon Captain Leonard Darby

At 7.30 a.m. rumour went around the ship that a strange War ship was at the entrance to Cocos Islands 50 miles distant. Soon this was confirmed and though we had had many false alarms previously, I went to the Sick Bay and gave instructions to S.B.S. Mullins to get everything below and prepare for action.

The stations for the surgical party are, the fore and after ammunition for the stretcher bearer and two theatres, one for each Surgeon and his assistants, are prepared in well separated stoker's bathrooms which are situated in the tube running up the centre of the ship. The bathrooms are 10ft x 8 ft x 7 ft in size and are supplied with hot and cold water also they contain lockers in which dressings can be stowed. Though not quite below the water line they are well protected above by two decks and on the sides by armour and coalbunkers.

One of the bathrooms I have appropriated during the war and it is permanently rigged out as an action theatre with operating table instruments and dressings stored there for immediate use. Unfortunately, only two days before the action I had everything taken up to the Sick Bay and had the bathroom painted out intending to return to it on this very day when the paint was dry. Before the action began at 9.30 there was only time to get things down below without proper stowing so that there was confusion and one could not put one's hands on things as quickly as would have happened at any other time. The No ii action theatre is not kept ready but is hurriedly fitted out with a Sick Bay mess table as an operating table and with stores which are taken aft along the tube from No 1 theatre.

Adjacent to these stations are six other bathrooms which are hurriedly cleaned up as well as possible under the circumstances and which are very useful as clearing stations and as shelter places for the wounded brought below.

In addition to the water supply in the bathrooms, we had an emergency supply of boiled water in the Captain's and the ward-room galleys which situated further aft along the tube. It was fortunate this was so as ten minutes after our guns had been firing the water came through the bathroom taps black muddy and useless.

On sighting smoke on the horizon I went round the guns and to the fire control stations to see that the first aid bags were correct - thence to the Sick Bay to see if anything useful had been left behind and before I was able to get below our guns had opened fire at 11,000 yards.

The Emden soon hit us and within 5 to 10 minutes the first wounded wounded (sic) Man was brought below to me by members of an unengaged gun's crew, the stretcher party having ordered not to go on deck during the action unless directly ordered. Most of the wounded were got below by man-handling which was found to be quicker and less awkward.

The first man was Meldrum 0.S. R.A.N. He was in the after control when two shells entered it and he sustained a fractured (R) leg and 13 other wounds. He was in great agony so I gave morphia and ordered Mullins S.B.S. to attend to the wounds and quickly apply a splint for by this time a constant stream of wounded men requiring urgent attention were being brought down to the theatres. The second case was Sharp A.B. R.N. shot through the chest and bleeding freely, with the apex of the heart beating through a gaping hole in the chest, loud inrush of air into the chest and air hunger being marked. Pads were rapidly applied to the wounds with tight bandages and a large dose of morphia was given.

Before this case was attended to Gascoyne A.B. R AN. was brought down. He had various shell wounds in the (R) leg, thigh and buttock and his (R) eye had been pierced at the same time by a small fragment of shell. Lynch P.O. RN. and Bell AB. R.AN. were carried below immediately after having both been struck down by a bursting shell at an unengaged gun. These two men were very badly wounded and the former was in terrible agony. He had been shot through the abdomen, (L) hypogastrium, the fragment emerging in the (R) Lumbar region leaving 6 inches of omentum hanging out of a hole near the (R) kidney.

In addition patient was burnt from head to foot. Bell was shot through the base of the heart and soon

died. I hurriedly administered large doses of morphia and attended to first dressings.

Meantime two more men Horne AB. RAN. and Williamson O.S. RA.N. had been brought down and all available space near No 1 theatre was taken up so I gave orders to the stretcher parties, some of whom had arrived to give first aid, to convey the wounded who were temporarily dressed to the Wardroom and place them on beds and blankets taken from the cabins.

Horne was wounded at the same gun as Lynch and Bell and was wounded badly in both feet the left being almost shot away. Williamson was at the after control and had a large gaping wound in the (R) thigh and severe bums of face hands and forearms from our cordite which caught fire.

Whilst these men were being attended to I received a message from the Captain to send for a wounded man on the upper bridge. The forward stretcher party was sent up to bring down this man. Soon after this all the wounded with the exception of Bell A.B. who had died within ten minutes of corning down, had been removed to the Wardroom and laid upon the beds on the deck. This place was only protected by thin armour but room had to be made near the theatres for probable fresh cases and this was the only available space. Fortunately no damage was done to this part of the ship and now the Emden was not so dangerous.

Another case, Green A.B. R.A.N. who had been wounded in the (L) thigh and (R) arm was soon dressed and taken to the Wardroom. We were now clear round No 1 theatre so I went aft to see the wounded in the Wardroom on my way passing Surg. Todd's station. He had all this time been equally busy and had been handicapped by the fact that on four occasions his S.B.A. had fainted. He had attended to Lieut. Hampden R.N. wounds in both calves and (R) thigh with severe haemorrhage, Crosby A.B. R.A.N. slight wound in (L) knee, Kinniburgh 0.S. R.A.N. severe cordite burns of face hands and forearms, Butcher 0.S. R.A.N. wound in (L) kidney and Harvey P.O. R.N. shock and injury to (L) knee.

After visiting the Ward Room I returned to No 1 theatre and found that the stretcher party had returned from the upper bridge with the above mentioned wounded man. It had been a difficult place to get at, however with the aid of a Neil-Robertson folding stretcher it had been achieved with no great loss of time. This stretcher by the way was found to be most useful and well adapted to a ship of this class with steep stairways and narrow passages and hatchways.

The wounded man was Hoy A.B. R.N. he was working the range finder on the fore bridge when it was struck by a shell which did not explode. His left leg had been shot away at its juncture with the body and was a horrible sight. He had lost a tremendous amount of blood and was almost dead on arrival below. I sent for Surg Todd and got the patient's clothes cut away rapidly and had him placed on the operating table. We then administered one pint of Normal Saline subcutaneously and started to trim up the stump which consisted of a ragged end of skin fascia, muscles, nerves and vessels, longer posteriorly than anteriorly. There was scarcely enough flap left to cover the stump. After making a few cuts in clearing away the ragged ends the patient died.

He had been wounded some time and the haemorrhage had stopped when he arrived below, but, it was hopeless from the outset and he must have lost a fatal amount of blood in a few seconds during a hot period of the engagement when nothing could be done for him. This was the last of our wounded excepting two slight cases Stevenson Ord. Sig R.A.N. small fragment in (L) forearm and Hooper A.B. R.A.N. slight wound of (L) leg. These cases were attended to some hours later.

Cease fire sounded at 11.15 a.m. after we has been working two solid hours in a very confined atmosphere and a temperature of 110 (degrees) F. The strain had been tremendous and S.B.S. Mullins who had done wonderfully well with me started off to faint but a drink of brandy saved him and I was very glad of a similar drink at the time.

Our clothes were saturated with blood and perspiration and altogether it had been a terrific two hours of high tension. We had been ably assisted by the first aid party and especially Tillbrook Off. Std R.A.N., Holley M.A.A. R.N, Paymaster Norton R.A.N. and Chaplain Little R.A.N.

'I'he Wardroom now contained eleven (11) cases and most of them were restless and groaning in agony. The initial dose of morphia, in no case less than Gr 1/2 had been of slight value and I have good reason to suppose that the solution in the Ampoules supplied had deteriorated. Fresh doses of Morphia were administered and iced water, soda water and brandy to various cases as thought fit. The initial lotion used for wet-dressings and cleaning was Hydroxy Perchlor, mainly because it was convenient, in strength of one tabloid to 1 ½ pints of water. The Picric Acid dressings in the first aid bags were found most useful in the case of burns.

During the action the space below seemed like a mad inferno. The "tube" was full of men belonging to the ammunition and fire parties and at the best of times there is little room here so the constant

supply of wounded men was considerably hindered. All this time we knew not how the fight was going we could only hear the shouts for ammunition and the continued rapid fire of our guns. At one time we heeled over and the operating table with Hoy upon it took charge. It seemed as though we had been hit but it was only a sudden alteration of course as we soon discovered.

Our constant attention was now taken up by two cases, Lynch and Sharp. Normal saline was administered in the first case subcutaneously because no vein could be found and in the second case into the Median Basilic by means of a needle through the skin. Wounds were redressed and all methods of reducing shock tried. Lynch was hopeless from the first and died two hours after being wounded after going through much pain. Sharp somewhat improved after the saline but air hunger was pronounced and he complained of constriction round the chest and tried to tear off his bandages. There was oozing of blood from his wounds and his pulse was very weak.

The other cases were not quite so urgent but many were in considerable pain and all that could be done was temporary until operative interference could be carried out. The Wardroom was hurriedly rigged up as a hospital and lotions, dressings and instruments were placed handy. The first aid party did excellent work now in looking after the wants of the wounded.

The actual extent of the injuries could not be definitely made out until the cases were under anaesthesia. As soon as the sick berth staff could be spared I gave orders for the Sickbay to be rigged up as an operating theatre with all despatch. This entailed an enormous amount of work on account of the state of the recent site of activities and of the Sickbay which was flooded with water from the fire mains. The muddle below was unavoidable owing to lack of space and the speed with which one had to work so it took some time to sort out things and have them conveyed back to and arranged in the Sickbay.

Besides this there were many interruptions due to requirements of the cases and all through the afternoon and evening German sailors were being picked out of the water some of them in a very collapsed condition. One man had been in the shark-infested sea for nine hours and he was brought after some trouble. Another man was rather badly wounded in the leg and belly.

It was found impossible to do any surgery (operative) until the following day for numerous reasons nor was it considered advisable on account of the condition of the wounded. The Sickbay staff were too exhausted to get the theatre ready with instruments and dressings sterilised for the first day and none of us including Surg Todd and myself was in a fit state to undertake operations until we had rested especially as we saw there was a solid time in front of us. Until midnight we were attending to the wants of the patients - changing dressings, giving hypodermic injections, passing catheters etc. The two S.B. ratings were sent to bed at 10 p.m. thoroughly exhausted and Surg Todd and myself took four-hourly watches from midnight. The first aid party and volunteer nurses under Tillbrook (Off. Std) and Holley (M.A.A.) were told off into watches to do the nursing.

Correction of Midfacial Fractures using a Dentofacial traction appliance

Lt Col DC Tong RNZAMC & Col MD Williams L/RAMC

Abstract

The management of midfacial fractures during the First World War was problematic due to limited diagnostic resources and operative techniques. We present a well-documented use of a dentofacial traction appliance to manage severe midfacial injuries sustained in combat during the First World War.

Introduction

The First World War produced a range of combat-related injuries that severely challenged the resources and technical abilities of medical services at the time. The surgical sub-specialties that evolved in response to this "new age" of warfare included thoracic surgery, orthopaedic surgery, neurosurgery and plastic/maxillofacial surgery.[1,2]. Units specialising in face and jaw surgery, as it was known then, typically comprised of a plastic surgeon, a dental surgeon and a dental technician and the close relationship between these areas of expertise reflected the complex and challenging nature of managing such injuries. Fractures of the mandible were managed primarily with intraoral appliances utilising the existing dentition to stabilise the fracture segments once occlusal reduction had been achieved. Such appliances were also used to treat continuity defects of the mandible allowing the correct anatomical relationship to be maintained between treatment episodes and preventing wound contracture.

Fractures of the midfacial skeleton were more problematic due to the relatively primitive state of diagnostic imaging and the limited means to anatomically reduce the fractures and provide rigid fixation for healing. There were also concerns in surgically exposing such fractures and the perceived risk of infection. We present a unique historical illustration of the use of a traction device utilising an intraoral appliance and distraction screws to correct a midfacial deformity resulting from a combat related injury.

History and Examination Findings

Soldier WC (aged mid-twenties) sustained a perforating gunshot wound through both cheeks and a shrapnel (sic.) wound to the right cheek in February 1917.[3] WC was admitted under the NZ section (Major HP Pickerill, OC) at the Queen's Hospital in Sidcup in November 1917 and his examination findings at that time were summarised as follows: "…the whole of the upper face had fallen backwards, the nose was sunken and depressed, the maxilla was too far back by three quarters of an inch, as judged by the hiatus between upper and lower teeth, zygomas had united but were in malposition and bulging outwards; there was also a long scar and an unsightly swelling on the right cheek".[4] It was also noted that WC was deaf in the right ear, had lost most of the sight from his right eye and was in a septic condition. No attempt had been made to control the facial fractures.

Due to his poor general condition extensive surgery was deferred and the decision was made to correct the facial fractures using a dental appliance instead, which could be used as a traction device to bring the fracture segments into better anatomical alignment. It is unclear from the case notes if the fracture sites were opened surgically but the maxilla was "reset" and brought forward in order to re-establish premorbid dental occlusion and reduce the acquired antero-posterior discrepancy between the maxilla and mandible. The patient wore this traction appliance for approximately six months after which the appliance was removed and the maxilla immobilised against the mandible using double gunning splints[3]. Minor surgeries to correct nasal bone projection and scar revision were performed during the period of bony healing and by December 1918 the splints were removed. Pickerill reported that the patient was able to eat a regular diet and there was an overall improvement in his psychosocial condition.

The Traction Appliance

Pickerill pays a rare tribute to the expertise of his dental surgeon colleague Major Rishworth, who along with Captain Turner (NZ Dental Corps), provided the fracture management of this patient. The appliance itself consisted of cast splints which were cemented onto the upper and lower dentition. The maxillary splint had a pair of short vertical arms

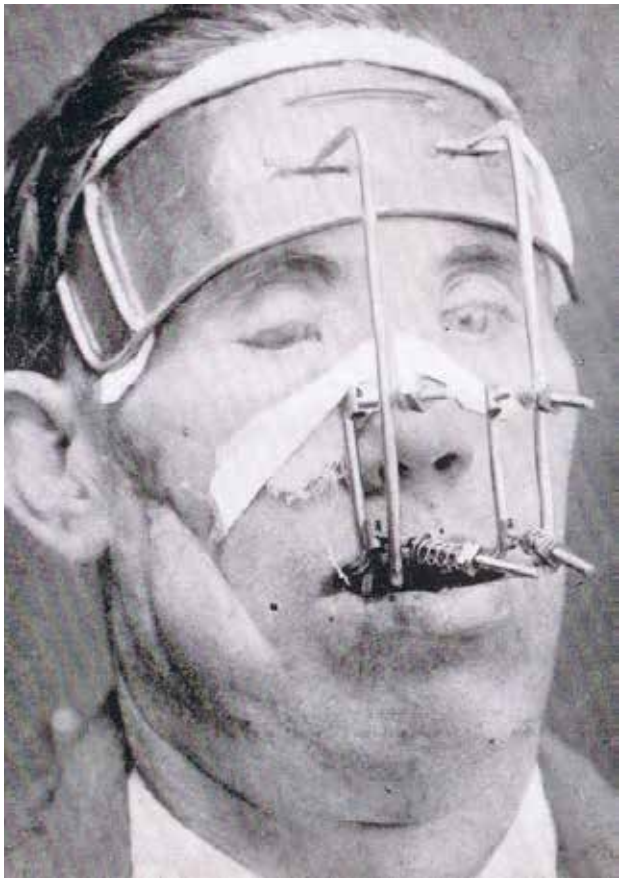

Figure 1. Photograph of the patient and traction appliance in situ (original photograph quality is poor).

Figure 3.Late post-operative photograph of patient showing improved maxillary position and scar revision. Residual enophthalmos of the right eye remains.

that extended outwards on either side of the nose, while the mandibular splint had two longer arms extending up to a metal plate which rested onto the forehead and secured by bandages (Figure 1). The maxilla was gradually pulled forward by tightening a set of screws which were spring loaded to give slight tension during the distraction of the maxilla. The screws could be replaced over time as the length of the threads became too short and this was accomplished by simply removing the threaded screw by means of a housing into which the head of the screw was slotted (Figure 2). The technical expertise, innovative design and art can be fully appreciated when the appliance is closely examined.

Figure 2. Photograph showing the dental traction appliance with spring mechanisms and threaded screws. The craftsmanship involved in making such a device is particularly noteworthy.

Discussion

This patient exemplified the problems of casualties with facial fractures presenting late to face and jaw units. This may have been due to a number of factors including the tactical environment, delays in medical evacuation, poor general condition of the patient and a lack of appreciation of the surgical needs of the patient.

The pattern of injury of this patient highlights the difficulty in managing midfacial injuries at a time when open reduction and internal fixation was not possible. The only possibility given the poor general state of the patient was to gradually distract the fractures using a dental appliance and what Pickerill termed an "orthodontic" method[4] but what would now be considered as dentofacial orthopaedics. Pickerill was qualified in both dentistry and medicine

and possessed a better appreciation of orthodontic principles than some of his surgical colleagues. The innovative use of an external traction device combined with an intraoral appliance is of particular significance as the concept of gradually moving separate bony segments into position over time using a screw-traction appliance has been reincarnated for craniomaxillofacial use today in the guise of distraction osteogenesis devices for the surgical management of congenital craniofacial deformities. Figure 3 shows a post-treatment photograph with a general improvement in facial appearance. There is still a degree of right enophthalmos and an impression of a flattened midface but given the limited treatment options at the time, the results are very satisfactory. Presenting historical case material is often difficult due to incomplete or missing background information. However, this case study presents a rare combination of written notes, photographs and archival material - in this case the appliance itself.

Acknowledgements

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References

1. Cope Z (1959). The Royal College of Surgeons of England – A History. Springfield: Charles C Thomas, p185.
2. Simpson D, David D (2004). World War 1: the genesis of craniomaxillofacial surgery? ANZ Journal of Surgery 74: 71-77.
3. Archival Material from the Rhind Collection. Surgical case notes from the NZ Section at Sidcup School of Dentistry Archives, University of Otago, Dunedin
4. Pickerill HP (1918). Orthodontics in war surgery. NZ Dental Journal 14: 140-141

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