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The Future Role of Information Technology in Military Health[1]

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On technology: The press, the machine, the railway, the telegraph are premises whose thousand- year conclusion no one has yet dared to draw.

Friedrich Nietzsche (1844-1900). German philosopher[1]

On information: Information is the oxygen of the modern age. It seeps through the walls topped by barbed wire; it wafts across the electrified borders.

Ronald Reagan (b. 1911). U.S. Republican politician and president.[2]

Introduction

Through the centuries, different advances in social organization, usually associated with advances in technology, have produced profound changes in civilization. In the prehistoric era, the end of the Stone Age was marked by the move from socially isolated hunters and gatherers to communities reliant on agriculture and domestic animals. The Middle Ages continued for many years through the renaissance until the introduction of modern industrial processes and systems in the industrial revolution gave way to the industrially based society of the last two hundred years.

The term information age has been used to describe the phase we have entered where information technology has diminished geographical frontiers and rendered time, space and physical constraints less restrictive.[3] Whether the changes to society bought about by these advances constitute a revolution remains to be seen. Toffler and Toffler[4] argue that, as we leave the industrial age, the cultural and value changes, in conjunction with economic upheaval wrought by technological breakthroughs, will produce a lasting revolution. Negroponte's points out that the key difference between the industrial age and the information age is in the difference between atoms and bits. Our information is currently delivered to us in the physical form of paper and books and trade is measured as atoms although the real value is the information, not the form.

History of Information Technology

Information technology arguably had its genesis when information was first written down and stored in some manner by the Sumerians circa 3000 BC.G There was no significant progress until the 17th Century, when Oughtred developed the slide rule based on logarithmic tables developed by Napier and Gunter, and late in that century Leibniz developed his wheel that could perform mathematical calculations. Leibniz also advocated the use of the binary counting system in mechanical calculating devices.

The 19th Century saw the use of punched cards to provide instructions to various devices, including the Jacquard Loom, Charles Babbage's Analytical Machine and Herman Hollerith's (who went on to found IBM) tabulating device that was used by the United States Government to tally the results of the 1890 census.

To make the required quantum leap to allow these fledgling devices to become more than just the ideas of keen inventors, scientists and mathematicians, a new way of switching current was required. The mechanical switching devices used up to the early 1900s had clear physical limitations on potential speed. The breakthrough was made in the late 1930s with the development of vacuum tubes that led to significant increases in speed. John Anatasoffs ABC Computer and the ENIAC all purpose computer finished in 1945 were the initial first-generation computers. As an example of increased performance, ENIAC could calculate the trajectory of a missile in 30 seconds, a task which took a skilled person with a desk calculator over 20 hours.

This period also saw the first significant use of computing power to aid the military. The German mechanical coding machine ENIGMA was able to create codes that were difficult to break using the normal means available at the time. The British developed COLOSSUS, a device that contained 1,800 vacuum tubes, used binary arithmetic and was capable of reading input at the rate of 5,000 characters (5K) per second.

Transistors provided the next significant improvement in computing power and by 1957 the second generation of computers based on transistors and running assembler languages were gaining acceptance in large organisations. They were used to solve problems that involved large volumes of data. In the field of health care. there was some progress to office automation but no clinical use of the emerging technology. There was some recognition of the potential for computer-assisted decision making in medicine; however, the cost and size of computers at this time prevented widespread use. [7]

The development of integrated circuits in the 1960s followed by integrated microchips allowed hardware to advance at a rapid rate. This was in accordance with 'Moore's Law' which states 'every 18 months, processing power doubles while cost remains constant.[8]

Advances in operating systems and software matched the development of hardware and, with miniaturisation made possible by chip technology, the third and fourth generation computers appeared. The use of computers in everyday business and home life mirrored both the cost and the increasing user-friendliness of the machines, in particular office automation systems. The increasing use of personal computers in their own right did not result in significant social change. Key developments to launch the information age were made through research and development primarily funded through the United States military in the hardware and software needed to allow computers to communicate with each other over distance. This led to the development of networking protocols and standards that have allowed the vast network known as the Internet to develop.

Information Technology in the Military

The need to use information technology in warfare is well recognized. As Buckley, Francke and Milton[9] noted in 1998, 'the US Army has long recognized that technology enables new warfighting concepts and offers opportunities to develop new capabilities. The possibilities for the use of more timely, accurate and detailed information is leading to the so-called revolution in military affairs and has coined the phrase 'net-centric warfare'[10]. The United States Army has a program to study warfare in 2010 and beyond that aims to foresee what this explosion of information possibilities will do for the military. [11]

The need to project the future concerning military-technological capabilities is indeed not new. Echevarria [12] discusses the similarities that can be demonstrated between military technology salesmen from the start of the 20th Century to those at the end of that century. He points out that a key aspect is the need to sift through the diverse range of primary, supporting and enabling technologies to determine what to test and evaluate in detail (and by implication invest in).

Information Technology in Health Care

The management of clinical information in health care is still primarily in the form of atoms rather than bits. The recorded data of health care is contained in the medical record. This is still largely paper-based and includes the clinician's recording of symptoms and signs, physiological parameters and the results of investigations as well as the interpretation of the data by the clinician in the form of a provisional and differential diagnosis. Other items such as the treatment plan and specific orders and instructions are included in one form or another.

For purely clinical purposes, this paper- based system has proven relatively effective over time. Clinicians are trained to work with little or no recorded information, relying on their basic clinical skills. While the patient's medical records are 'nice to have', the reality is that, even in the best-run hospitals, records are often not available when you would like them.[13]

Current health information systems in use tend to support administration and organisational goals rather than support patient care activities. Van Bemmel et al. see computerized patient records as the key to making the transition to health information systems that support patient care.[14] A number of arguments against a computerized medical record revolve around unauthorized use of the information and security issues. Halamka describes a number of measures to ensure security of computerized medical records by a sequence of measures ranging from access protocols, data encryption, physical protections, audit processes and software measures at the servers level to ensure protection.[15] They had not detected any unauthorized access in the first six months of use.

Van Bemmel et al. argue the goals for the use of computerized patient records include support to direct patient care (information access and decision support}, assessment of quality and outcome, planning and research and education.[14]

Current Information Technology in Military Health Care

Both the United States Department of Defense and the Australian Defence Force have set up programs to introduce automated health information systems across their enterprises. In the case of the USA, there are 20 different information technology programs listed from the web site of the Office of the Secretary of Defense, Health Affairs[16]. Included in these are Composite Health Care System II (CHCSII}, the program that will lead to a computerized patient record for the dependency of the military health service (noting that this includes dependents of service people and veterans}, and the Theater Medical Information Program (TMIP). Which will deliver a health information system for the operational environment.[16]

In Australia, the Health KEYS project will deliver a: 'single, efficient and effective Health Management Solution that best meets the health information needs of health services units, providers, individuals, senior executives, commanders and line managers within the ADF' [17].

The Future

What does information technology have to offer future military health care? It is easy to be skeptical about this issue when information technology has been aggressively marketed but still the average military health professional has very few health-specific information tools. In 1998, the United States Army Medical Department conducted a seminar to discuss the possible use of telemedicine on the battlefield. They invited personnel who were serving across the echelons of care. There was some interest in the 'sexy' technology such as teleradiology systems and the like but the overwhelming need from the front line was for reliable voice communications (unpublished data}. As the 1st Brigade becomes used to operating in a digital environment with the Battle Command Support System the same results would perhaps be obtained. Having said that, I believe it is somewhat short-sighted, naive and, I would even suggest, foolish to view information technology as a distraction that will go away and to ignore its potential advantages. We do so at our own risk, perhaps summed up by Gunther Grass when he said: 'Information networks straddle the world. Nothing remains concealed. But the sheer volume of information dissolves the information. We are unable to take it all in.'[18]

In other words, if we do not look to define exactly what information is required when and where we will have so much information available that we will not be able to find the key pieces.

The Future of the ADF Health Services

The JP 2060 Study outlines the future capabilities and directions that are thought to be required for operational health support to ADF operations in the future.[19] It argues the view that to achieve the ADF Health Services vision (to achieve a world-class Military Health Service for the ADF} and mission (to optimize the health of ADF personnel}, there are five key outcomes, three of which are described as enabling and two as supporting. The enabling outcomes are a fit and healthy force. prevention of casualties and treatment of casualties. The supporting outcomes are to develop health capabilities and manage and sustain health service. What are the information requirements for these outcomes and how is this information best obtained?

Fit and Healthy Force. This outcome commences with recruiting and involves ensuring individuals are as well prepared as possible to participate in military operations. The availability of a comprehensive medical history via a computerized medical record system would have clear benefits to recruiting doctors in performing recruiting medicals. Information technology hardware is no longer an impediment to such a system and it is not unreasonable to suggest that such systems will become commonplace within a generation (technophiles would say this is an overly conservative time-frame).

Once a member is recruited, there is still potential for information technology to assist this outcome. The current approach in the ADF is for generic approaches to physical fitness training, standards and assessment. Negroponte discusses the prospects for using individualized information in a commercial sense. Physical fitness programs should likewise be tailored to an individual, based on factors such as current and past health, injuries, occupation, physical fitness level, physique and other factors. It is not difficult to accept that an automated information system, drawing data from disparate sources such as medical and personnel records and applying a predetermined algorithm to decide action required would be an effective and efficient method of producing large numbers of individualized fitness and health programs in a short period of time. Monitoring progress of a large number of individuals through their personalized program would also be more easily done with automated systems.

Casualty prevention. This outcome is concerned with identification, assessment and control of health threats that confront ADF personnel in both operational and non- operational environments. The outcome is heavily reliant on accurate and timely information. The actual threat from the environment, as well as data on potential water and food sources, should be able to be obtained from geographical information systems, communicable diseases information from the Centre for Disease Control and or local health authorities via web access and the conventional and non-conventional weapon threat from classified sources. The assumption underlying this is that the data has been collected and entered by someone, somewhere and it is available when required. To achieve this assumption someone needs to be sorting through the data available from all sources, cataloguing and indexing it much like current search engines do in order for users to retrieve what they need when they need it.

Prevention also revolves around health surveillance and casualty prevention programs. The bulk of the data for these functions are collected during clinical encounters. It is labour and time-intensive to transfer data by hand from clinical notes to other systems and this is why the ADF Health Status Report highlights the need for a health indicator data collection system as a strategic priority (accessed from www.defence.gov.au/index.html). An automated system driven by entries in a computerized health record would increase the quantity of data available. If it were able to be organised and analysed relatively easily, the resulting information would be of greater value in identifying the factors related to preventable casualties. For example, the current approach for health surveillance is to obtain data on a weekly basis. To truly identify emerging threats within a time frame that can be acted on, especially with potential non-conventional weapons or communicable diseases, requires a more frequent review of clinical presentations, focusing more on symptoms being reported than the clinician's diagnosis. This can be achieved feeding the symptoms reported in clinical encounters into a database that is continuously analysed by an automated agent looking for trends in the frequency of reporting of 'symptoms of interest'.

More futuristic in concept but perhaps closer than we realise in fact is the use of physiological monitoring systems to track the physical and mental wellbeing of each individual. Aggregated data about physical readiness (from the perspectives of fatigue, hydration, nutrition) can be provided to Commanders in order to select the task unit most appropriate for a given task. Such a monitoring system can also be used to provide remote triage capability when the individual becomes a casualty. The United States Army is working on this capability as the Warfighter Physiological Status Monitor program.[20]

Develop Health Capabilities. This outcome is related to personnel, facilities and organisations. It includes research into health-related areas as well as education and training at both the individual and collective level. Information technology and its use in education could be the subject of a paper in its own right; however, the linking of continuing education and clinical audit type programs to computerised health records in order to individualise training for the clinician based on types of cases seen and perhaps. More importantly, what they are not seeing offers more effective ongoing education than current programs. Clinical research should be fed from the clinical records from the perspective of areas to examine and also data collection to test hypotheses.

Manage and Sustain the Health System. Class 8 supplies are consumed as patients are treated. It follows that as the treatment is documented, the class 8 requirements can be calculated with reasonable accuracy. This provides for automated replenishment of stores in a timely manner (assuming that the items are physically available). Financial management is clearly amenable to automated systems; however, the potential to make better use of financial information to identify the true cost of preventable illnesses and injuries can be realised by linking the financial processes to the clinical process more effectively.

Casualty Treatment. I have saved this for last as I view it as the central outcome in terms of establishing a comprehensive, integrated and automated health information system. My view is this is where much of the data entry required by most aspects of the other outcomes enters the system and all other outcomes need a feed of data or information from the clinical encounter.

In many instances there is no reason why the member should not enter some of the relevant data. For instance, in an automated injury data collection effort, the member can enter the relevant background data while waiting to be seen or while they are having their initial ice treatment. Most of the data required here is relatively straight forward (who was in control of the activity, what happened, weather, time etc.) and often not recorded by the clinician because it has not a direct bearing on the management of the casualty in most cases. Parameters such as blood pressure, body height or weight, when collected can be automatically assessed in light of previous readings and significant trends identified.

As a clinician, I am also not surprised that this is also perhaps the hardest 'nut to crack'. As mentioned, my clinical training is such that I can assess and treat patients with no records available to me. Therefore, it is hard to convince me that there will be great gains in my ability to provide health care to the majority of my patients simply by providing me a computerized version of their complete health record. To expect me to record my clinical notes electronically is also going to be met with resistance. First, there is the issue of depersonalizing the consultation by having to enter data into a computer. Second, there is time. To enter clinical notes electronically requires more time than the handwritten note, simply because very few clinicians are fast keyboard operators. Handwritten consult notes can be abbreviated and formatted as the writer sees fit. Tied to this is the fact that many clinical encounter applications are optimized for data retrieval not data entry in order to allow faster and more comprehensive search and data management functions. This means they have preset formats and allow a narrow set of terms to be used. Clinicians used to writing in 'free text' in their own style and using abbreviations will resist the relatively rigid stricture of computerised health records.

A key challenge is to make the interaction between the provider and the system acceptable in terms of time, convenience and effect on the consultation process. Data entry technology perhaps holds the key, with advances in writing tablets and voice recognition software promising to overcome some of the barriers to use of computers in real-time during clinical encounters.

Doctrine and Policy Development

All the outcomes require underpinning policy and doctrine to be developed and published. Much of this is online already through the DEFWEB. The Military Health Manual is a good start at cataloguing these documents in terms of the outcomes they relate to (defweb.cbr.defence.gov.au/dpemhm/). I would suggest that this effort can be improved by the addition of a section where draft policy is published as it is being prepared and staffed to allow for interactive comment from a wider range of people than is currently possible. I believe the earlier the people who are expected to work with policy and doctrine are able to see the policy and comment, the easier to introduce and implement the changes associated with the product. The current system that relies on electronic mail is clearly faster than using conventional mail; however, even faster and more responsiveness can be achieved by a web-based system. The other advantage is that discussion can be more wide-ranging and thorough by allowing all to see comments by others. This process does take some time for users to get used to and participation is not guaranteed; however, it does provide a better chance for the 'coal face' to develop a sense of ownership in policy if they see it and have a chance to influence during development.

Information Technology in Future Military Health Care Scenarios
The following vignettes convey the author's impressions of how it could (should) be if the Defence Health Services harnesses the potential of information technology and applies it the provision of a high-quality military health care service.

In 5 Years
Scenario 1. Miss Josephine Recruit applies to join the General Reserve as a medic. The recruiting medical officer reviews her history electronically with her permission through her GP's practice. He downloads her vaccination history since birth, notes that she had juvenile asthma but has needed no medication for the last 8 years but is otherwise well.

She has an uneventful induction training period and is accepted into the RAAMC as a medic. She is issued her medical assistant training package on a CD ROM and allocated a user identification and a password to access the online test material. She returns to her unit and over the next three months works her way through the material. As she completes modules, she completes the online tests under supervision. She will continue to work through the course modules up to advanced medical assistant status.

Scenario 2. George Smith arrives at Kapooka to commence induction training. His medical record from recruiting is accessed on arrival. His immunization history was available and has been entered on his ADF electronic health record. He receives the vaccinations required to be up to date and his BMI is noted to be at the upper limit of normal. His physical training history is checked and it is noted that he struggles with running. Over the next few weeks, he presents with shin splints from running. Pack marching causes minimal symptoms. He is commenced on a swimming and cycling program by the PTIs to improve his fitness level. Over the next three weeks, his legs settle and he returns under PTI supervision to pack marching successfully. After a further 3 weeks of the swimming/cycling and pack marching, he returns to the running track. After a period of leave, he reports to his new unit - an infantry battalion. The Unit orderly room registers him as having marched in on the system and his medical record is reviewed by the health information system. This notes that he has vaccinations overdue and an alert is sent to the RAP to review his record. In doing this, his history is reviewed and the period of shin splints is drawn to the MO's attention. George is called in for review and warned of the risk if he attempts to keep pace with unit PT. He is referred to the PTis for a program to build up his exercise capacity and monitor his shins. He completes the program and resumes full PT with the Unit the next month.

10 Years
Scenario 3. LCDR Afloat is serving as the medical officer onboard the HMAS NEWSHIP in the South-West Pacific. The ship is due to arrive in port in two days time. LCDR Afloat enters a request on his shipboard system for the latest health intelligence on the port. It is stored on his terminal until the ship's communication system can send the request. The information is received later that evening and is waiting for the doctor that morning. It reveals significant new cases of arboviral illnesses in the port area. After further research through the electronic health library on the ship's network. LCDR Afloat assesses the crew is at significant risk during their port visit from the arbovirus. The ship's crew is warned to take precautions against mosquito bites in their stopover. Seven days after leaving port he enters a query into his system to check that there has been no increase in symptoms consistent with arboviral infections. The system tells him there hasn't been.

Scenario 4. Australia is involved in peace support operations in an area of the world that has recently undergone a bloody civil war. There were numerous unconfirmed reports of use of non-conventional weapons during the conflict, with both parties known to have access to chemical and biological munitions and delivery systems. Monitoring has not revealed any grossly contaminated areas. The health surveillance system is checking for symptoms such as tiredness, malaise and lethargy occurring in geographical clusters. An area is identified where is an association between serving in that area and presentation within 24 hours feeling tired, washed out and a range of non-specific symptoms. Further investigation reveals this area had been contaminated by persistent chemical agents within the previous 12 months. Patients with symptoms were counselled and a long-term monitoring system was put in place.

Scenario 5. Simultaneously with Scenario 4, Australia has small contingents serving in operations elsewhere. Their food and water sources are all centrally procured and distributed from Australia. The health surveillance system alerts HQ AST that there is a rise in gastrointestinal illness in each theatre. Investigations reveal a contaminated batch of water as the source of the problem and within 12 hours of the first cases, the batch is withdrawn.

20 Years

Scenario 6. Members who served in Scenario 4 are claiming that all people who served have similar symptoms and they must have all been exposed. In reviewing their service history and medical records, it is clear that the members identified as being exposed in Scenario 4 have one constellation of symptoms, those from other areas have a different set and those who served in both areas have a mix. The people affected are clearly identifiable from their electronic record and their situation, including management options are sent electronically to their primary care provider as well as to the individual where possible.

Scenario 7. An infantry section is patrolling an urban area on a peace enforcement mission. They are each equipped with body-worn computers, physiological monitors, GPS and radios. The medic with the patrol (now SGT Recruit from Scenario 1) has visibility of where each of her section is as well as the ability to check their vital signs at any time. The aggregated picture of the section's physical and mental status is being fed to the section commander and up the chain of command. As they cross a street, they take fire from two directions. The section all receives an alert from the system that two members have been hit by bullets. The medic can see where they are located and her system indicates that both are still alive, one with a chest wound, the other with a leg wound. SGT Recruit contacts them by radio and confirms they are still able to talk and gets a description of their wounds. The chest wound patient was wearing ballistic protection however the bullet was deflected at an edge and entered the side of his chest. It seems to be a graze, and certainly, his vital signs indicate a minimal injury. The patient with the leg wound reports significant arterial bleeding and this is reinforced by his BP that is reported to be 100/60 according to his status monitor. The medic conveys the situation to the section commander and gets the all-clear to proceed. SGT Medic directs first aiders to dress the chest wound while she attends the member with the leg wounds.

The casevac requests are compiled by the Section 2IC's system after interrogating the section commander and the medic's systems, and the Commander and the medic review the message. The message is sent as soon as the two of them have reviewed and approved it. At the same time the medic's system is preparing to send stores consumed report based on the medications used by her and the dressings and fluids etc. administered. The patients current status, including a description of injuries, treatment and location are checked by the AME team as they travel to the scene. Once in the air and heading to the level 3 facility, the relevant details are sent via the AECC to the triage officer at the Joint Force Health Support Unit who will receive the two patients. The surgical teams are warned out and as the operating rooms are clear they are prepared to do the initial wound surgery on arrival.

Conclusion

The information revolution is characterized by rapid development in information and communications technology. Even though the all-important bandwidth availability may become less of a factor by technology, there will still be finite limits of how much information can be moved at once, and as technology increases the limit, the amount of information we want to move will increase.

Watson and Crick perhaps started the next age in 1953 when they unravelled the structure of DNA. This has led to work on the identification of the human genome and perhaps the start of what might be called the 'genome age'. Further progress in this area will unlock perhaps the most basic data element of all - the genetic coding for individuals. The possibilities that arise from this may perhaps be the subject of an AMMA Annual essay in the years to come.

On information: Information can tell us everything. It has all the answers. But they are answers to questions we have not asked, and which doubtless don't even arise.

On computers: Computer science only indicates the retrospective omnipotence of our technologies. In other words, an infinite capacity to process data (but only data - i.e. the already given) and in no sense a new vision. With that science, we are entering an era of exhaustivity, which is also an era of exhaustion.[21]

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