ANALYSIS AND PERSPECTIVES

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Information Technology Conduit as a Portal to Circumvent the Graveyard Shift

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Information technology (IT) with increasingly faster rates of data transfer is anticipated to continue to shape the practice of medicine in the future. Such changes in health information technology coincide with our rapidly evolving understanding of sleep deprivation and circadian disturbances and their consequent effects on health, performance of the medical provider, and the commission of medical errors. This commentary aims to update the reader of the changes in these two bodies of knowledge and explicate how they may dovetail for the mutual benefit of the patient and the provider. We will also explore some of the impediments to the transfer of health IT data and present a viewpoint of how such issues may need to be addressed and by which parties.

CONSEQUENCES OF CIRCADIAN MISALIGNMENT AND SLEEP DEPRIVATION

There are many components related to sleep that may influence performance: circadian misalignment (working at night instead of usual wake period [daytime]), sleep deprivation (due to extended period of wakefulness), and sleep inertia (latent period of time following a sleep period when vigilance is less than optimal). Both circadian misalignment and sleep deprivation can occur in the medical shift worker. With the former, the human brain has a natural urge to sleep during the hours of the graveyard shift; due to this internal circadian rhythm, brain vigilance is less than optimal during the night duration and consequently may lead to occupational errors, accidents, and injuries.[1] Moreover, learning is impaired in individuals who are attempting to learn when their sleep and wakefulness periods are out of phase with their internal biological time.[2] The unfortunate outcome in the medical field is that care providers are more likely to work extended "shift" durations (greater than 24 hours) and therefore suffer a higher likelihood for committing medical errors.[3] In a study performed on house officers following extended work hours, the performance impairment was comparable to impairment associated with a 0.04 to 0.05 gm% blood alcohol concentration, as measured by sustained attention, vigilance, and simulated driving tasks. Moreover, the house officers' ability to judge their impairment appeared to be limited.[4] Additionally, the quality of life of physicians working extended work hours in a heavy workload area of the hospital such as the intensive care unit may be compromised.[5] Rather than focusing on the single aspect of reducing the number of hours worked, a more integrated, systematic approach is needed to alter the cultural factors that contribute to tired staff and patients being placed in danger.[6]

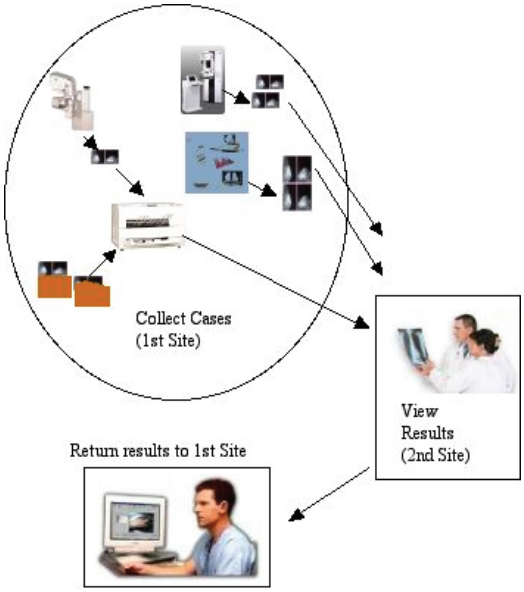
New evidence alludes to other consequences to the healthcare worker who works graveyard shifts. In December 2007, the World Health Organization's International Agency for Research of Cancer and the National Cancer Institute (U.S.) listed the graveyard shift as a probable cause of cancer, based on higher incidence of breast cancer and prostate cancer among women and men who work during night.[7] Higher rates of obesity, high triglycerides, and low concentrations of HDL were found to be more prevalent in shift workers than in day workers.[8] Recent studies conducted both in the laboratory and in population-based studies suggest that sleep deprivation may play a role in the rising prevalence of both diabetes mellitus and obesity.[9-11]

ADVANCES IN HEALTH INFORMATION TECHNOLOGY

Innovations in information technology can be applied to reduce the number of medical personnel who need to work during night hours.[12,13] Advances in computing and communications technology can enable efficient storage and rapid transmission of healthcare records such as radiology films for interpretation from health facilities experiencing nighttime in one country to physicians or radiologists in other countries where it is daytime.[14] The concordance between interpretations of radiology films across multiple international time zones can be safe; however, adequate quality assurance safeguards may need to be in place.[14] Such interpretations may serve other fields besides radiology: pathology, sleep medicine, and potentially real-time electronic monitoring of the ICU patient by conceivably more vigilant health personnel across international time zones.[15-18] The process of monitoring through the internet may circumvent the influence of circadian rhythm misalignment on night-shift workers residing in any given country. However, whether such "daytime" observers in countries experiencing daytime who observe, monitor, and make decisions involving patients in countries experiencing nighttime can translate into faster response times, fewer errors, and improved patient safety is unclear and requires further study.

For the last several decades, doctors in the US have looked at medical records of patients in other countries and provided

Figure 1—The integrated use of on-site medical personnel, off-site medical personnel, and computer based techniques.[37]



expert opinions through letter, fax, and telephone.[19,20] This is an example of "insourcing." More recently, medical personnel abroad have begun to look at medical records, especially radiological images.[21] This is "outsourcing," a term used for both interorganizational and transnational exchange of information (**Figure 1**). Newer technologies enable such insourcing and outsourcing to take place on a near-instantaneous basis, opening up the possibility of reducing the number of healthcare workers who need to work during the night in their respective countries.[22,23] The international exchange of medical work could be advantageous to various medical specialties and more importantly to both parties that could conceivably enter into a financial and work partnership. Partnership between such "sister" institutions, separated by multiple international time zones, is not new in the field of engineering.[24,25] With the rising economies of many countries across the globe such relationships may be of mutual financial benefits to both sister institutions and their respective patients (**Figure 1**). A hospital—be it in the North American continent or in Asia—may be able to provide radiology services 24 hours a day and 7 days per week that would consequently be rewarded with faster discharge of patients, and should theoretically achieve an improved quality of care and greater satisfaction from patients.[26] This could involve three collaborating centers, with personnel at each center working during daytime in their respective countries.

To benefit from this 24-hour model, a hospital may contract to collaborate with a hospital on the opposite side of the earth, in order to provide support during nighttime at the first hospital. Through this philosophy, radiologists could also send excess images abroad for remote diagnosis at the end of their work day (evening in the US versus morning in Australia) and have results ready to report to their patient the following morning. In the next phase, it could be a bi-directional relationship that reduces the need for night personnel at both hospitals. Ultimately, the concept of the 24-hour knowledge factory could be implemented, with three collaborating centers, each providing support during the daytime to the other two countries that are experiencing nighttime.[27] Issues of patient privacy and quality of care would need to be addressed, but in theory this paradigm provides a solution that extends the workday and reduces the need for work during the night.

FACTORS FAVORING THE 24-HOUR MEDICAL WORKSHOP

Providing healthcare at an international level can be seen as a feasible alternative to a graveyard shift because it has already been introduced to the American market. Foreign patients seek out American facilities, with the expectation that they will receive a higher quality of care in the U.S. It is becoming increasingly common for foreign patients to conveniently receive a checkup or obtain a second opinion while visiting the U.S. on a business or leisure trip.[19,28,29] Due to globalization and growing international business relationships, this influx of international patients will increase. The solution for this increased demand would have once been hiring additional help and expanding the working day; alternatively, in this 24-hour medical workshop model, U.S. and foreign doctors communicate for necessary patient information, history, and possibly details of follow-up care, laying a foundation for global telemedicine rather than straining the national market.[26,19]

Some U.S. healthcare groups that specialize in services to international patients claim that they are able to provide sophisticated healthcare due to continuous research at a cost of over $500 million each year.[19,28,29] They use technology both for advertisement and for the transmission of records. Before a referral for a foreign patient is complete, their home country doctor sends medical records, x-rays, and diagnostic reports via e-mail.[19,28,29] After completion of the treatment in the U.S., the U.S. doctors are still involved in follow-up care.

In addition to inter-country services for foreign patients, intra-country healthcare is being provided for U.S. patients. Telesurgery is a specific branch of telemedicine in which a surgeon in one location observes the procedure through a camera and offers visual and auditory support to the operating surgeon located at a different site.[30] For Americans, the cost is minimal since the procedure is conducted in a foreign institution. International telesurgery proved to be successful in two laparoscopic cases between an experienced American surgeon and a less experienced surgeon in Singapore, in which a radical nephrectomy and a varicocelectomy were performed.[31] The corresponding information technology could be video conferenced through "decentralized multipoint" technique, which could run using available telecommunications (T-1 line; maximum bandwidth of 768 kilobytes per second [Kbps]).[32] The decentralized multipoint technique refers to the video and audio data-stream not being relayed through a central point, therefore achieving higher speed of data transmission, which in turn enhances signal quality without the "bottleneck effect" faced by combined audio-video transmission.[33] However, the enhanced quality requires an increased network bandwidth. Likewise, in this case, the U.S. surgeon would administer the preoperative and post-

operative care. Though these examples discuss surgical procedures, the concept could easily be implemented for remote diagnosis and obtaining a second opinion.

Ideally, telemedicine will develop into a seamless network of available healthcare with images interpreted during daytime working hours and exchanged through network communications. Additionally, if a patient is in need of immediate results outside the bounds of their local working day, a well-rested foreign physician will be enlisted to view and interpret an image. Expanding beyond imaging, through the innovation of telesurgery, such fluid cooperation as described above would allow a patient who is unable to travel to be connected with an alert surgeon via electronic transmission.

LIMITATIONS ON TELEMEDICINE

Due to the need for physicality and human contact in many aspects of the medical profession, it is unlikely that the work will be completely outsourced; however, both outsourcing and insourcing are favorable in instances where reduced physician working hours equate to fewer medical errors. From this perspective, the exchange of responsibility to ensure that an alert physician completes interpretation of patient data during daytime hours presents an ideal solution for both the patient and physician.

The reading of x-rays of U.S. patients by radiologists in foreign countries has attracted significant attention in the media.[21] Levy and Yu[35] conducted a survey on how widespread this practice is and found that there are fewer than 20 radiologists doing such work in India. Although this practice of remote diagnosis may be inaccurately portrayed as solely an off-shoring phenomenon, in reality, work in this field is being insourced into the United States as well, based on instances in which U.S. doctors look at radiological images and other medical records of patients in foreign countries.[28,29]

Additionally, the electronic transfer of medical images is not limited to international exchange, but is also transforming stateside rural healthcare systems. The above concept of onsite and offsite tasks was extended in 2002 to include the notion of computer-based decision support for the area of mammography, which could both reduce demands on the physician to work overnight and oversight in diagnosis.[36,37] This technique can also reduce the incidence of false positives and false negatives.[38-42] The proposed technology envisaged a vision of "Image Anywhere," with a network of mammography screening centers across the country, and the image being analyzed by computers and radiologists located hundreds of miles away. This architecture can be readily adopted for use in dentistry, CT colonography, bone cancer detection, and auxiliary applications. There are multiple reasons to advocate this framework due to the overall increase in quality of care. Radiologists and physicians would experience enhanced productivity, and patients would benefit from improved access to mammography centers, greater quality of mammogram interpretations, decreased incidence of error (both false positives and false negatives), and lower mammogram costs.[40] Thus, the expanded use of human and computer-aided remote diagnosis can potentially lead to improvements, both on an intra-country and inter-country basis.

RELEVANT PRIVACY, SECURITY, AND LEGAL ISSUES

With growing concern for the danger of sleep-deprived physicians, the U.S. legislature proposed that working hours be restricted to 80 per week and that the maximum continuous shift be limited to 24 hours.[43] If the work previously completed by overscheduled physicians could be shared more efficiently across healthcare facilities, the lost time at work would not directly result in halted results; not to mention that potential cost savings are estimated at $77.8 billion dollars per annum for the U.S. alone.[44] Information technology could complement Congress's campaign to reduce physician hours and create an efficient model of continuous work; however, the collaboration of individuals across state and national boundaries raises additional legal issues. For instance, who can be sued for medical malpractice, and under which set of laws? How should the medical charges be divided? What complications will this add in terms of seeking payment from insurance companies? Also, social and policy-related concerns, such as quality control and the intensity of workflow, must be taken into consideration.

The creation of systems that transcend geopolitical boundaries requires closer coordination among relevant organizations. Today, an out-of-state radiologist may issue an initial opinion for a patient in the U.S., but the final diagnosis must be authorized by a radiologist licensed to the practice in the concerned state of the U.S. (in most cases). Note that Canada certifies radiologists at the national level. In the case of the U.S., only a handful of federal and military organizations have licensure laws that enable them to render services independent of state and national boundaries. As such, one needs to conceive new higher-order mechanisms for resolving matters that transcend traditional boundaries and for regulating the international medical arena.[36]

If one goes back in history, one finds that rules originated at the village level. As travel became easier, multiple layers of laws emerged. A resident of Waltham is today governed by four sets of regulations promulgated by the City of Waltham, Middlesex County, Commonwealth of Massachusetts, and the U.S., respectively. Now a fifth layer is needed to address issues that transcend national boundaries, as is happening in Europe under the aegis of the European Economic Community. Ideally, for the medical arena, the fifth layer should be at the global level. The logical agency may be the World Health Organization; it could interact with the World Trade Organization and the World Intellectual Property Organization as needed to establish new mechanisms to facilitate medical tasks performed on a transnational basis. In the interim, the U.S. should consider adopting the growing set of medical applications that will enhance the ability to provide healthcare that favors the health of both physician and patient.

The risk of health problems, such as cancer and cardiovascular disorders, in medical professionals working the graveyard shift provides an initial incentive to seek an alternative working model.[7,45] When coupled with errors in patient care that could be committed in hours of the night, the argument for telemedicine is strengthened.[4,1] There is no doubt that the quality of work will need to be constantly monitored and privacy concerns resolved, but in the interest of meeting the demands of an evolving global medical environment, telemedicine and remote diagnosis could be the solution.

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DISCLOSURE STATEMENT

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