THE GOOSE, THE GANDER, OR THE STRASBOURG PATÉ FOR ALL: MEDICAL EDUCATION, WORLD, AND THE INTERNET

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"What's good for the goose, is good for the gander"

1. INTRODUCTION: THE GOOSE AND THE GANDER

The proverb, so euphemistically stating the rules of equality seems to hold in most walks of life. Yet, despite increasingly widespread popularity among the physicians of "getting on the Net"[1], does it really hold for the Internet and medicine in its global sense?

There is no doubt the advent of the Internet introduced an unprecedented expansion of new approaches to education at all levels. Many of the traditional teaching techniques are continuously modified to suit the specific requirement of Internet-based education[2]. Simultaneously, a broad range of difficulties affecting the new teaching medium emerged[3,4] but, while the solutions are not always forthcoming with equal rapidity[3,4], the trend to employ the Internet in all aspects of medical operations is unstoppable. The future of medicine and the Internet seems so bright and inseparable that it demands new, specialized training in health and medical informatics[5].

The impact of Internet and its related industries on the economy of all advanced countries of the world is staggering[6]. In the USA, at least one third of the economical growth was related to the booming Internet business[6], with over half a trillion dollars predicted in the Year 2002[7]. Similar trends are noticeable among the rest of technologically advanced countries in Europe and in several countries of Asia, e.g., Japan, India, or South Korea[7,8,9,10]. Predictions? A billion Internet users by 2005, "business-to-business" operations reaching up to 77% of all transactions, all facilitated by the rapid spread of broadband connectivity, home-based LANs, and increasing computer/communication literacy of the consumer[11].

While the pre-existing wealth and the needs of the "First World" led to the creation of the Internet[11], its existence now increases the wealth at a rapidly increasing pace[10]. Acquisition of further wealth results in a constant improvement of the operational efficacy of the Internet[11], which enhances further growth of the wealth, etc. The "goose" profited quite well, and intends to do so even more.

What about the rest of the world? Assuming that each Internet user represents a single person, and assuming that one billion Internet users exist today rather than in 2005, over 83% of the world's population appears to have either limited or no direct benefit from the ease of "on-line" stock trading, shopping, or, for that matter, accessing the wealth of health related information available on the Net. Moreover, it also appears that, unless dramatic changes requiring concentrated international effort are made[12], the equality of Internet access is a very distant dream, and the bitter tone of the representatives of the Third World when discussing this state of affairs is unmistakably clear[13].

Unsurprisingly, when comparing the percentage of the GDP spent on health, the expenditure follows the wealth of individual countries. In 1996, USA, Switzerland, and Germany lead the statistics, with over 10% of GDP related to health expenditure, followed closely by Canada and France. The majority of the industrial nations spend between 6 and 9%[14]. Translated to US $, the amounts devoted to public health ranged from $ 4,150 (USA) to $ 570 (Greece)[15]. As interesting as these statistics may be in relation to the quality of health care provided by the individual industrial nations, they become essentially meaningless when viewed in the context of the rest of the world. There, 1.3 billion people live on less than $ 1 per day, and 4.4 billion have no access to the basic forms of sanitation[16]. Yet, it is among these people that health-care interventions on a truly colossal scale are needed. The "gander" is quite featherless. Is it then possible that the health of the gander will profit just as well from what was so amazingly good for the business life of the goose – the golden egg of the Internet?

2. MEDICINE, EDUCATION, AND THE INTERNET: RICH MAN'S TOOL, POOR MAN'S TRIFLE?

Masys stated in a recently published paper that modern medical practice, research, and education are remarkably information-intensive activities[17]. One may add that the practice of medicine, ever since the days of its "academic" foundation by Hippocrates[17], has always been based on acquisition of information (signs and symptoms of disease and methods of its cure), its systematic storage (remembering signs and symptoms and their links to the appropriate treatment), retrieval (affecting appropriate the treatment based on relevant signs and symptoms), and a lot of hope that it all would work as the theory said it should. Sometimes it did not and, even today, it still doesn't. When it does not, the fault, as often as not, rests not with the information, but rather with its inadequacy, inaccessibility, or the practitioner's capacity to implement it, i.e., training.

In today's world, medical information can be acquired in three ways: either basic or refresher formal training of physicians, nurses, technicians, health administrators, etc., self-education using publicly available hardcopy/software resources (libraries, etc.), or the Internet. Formal training is typically expensive (especially in the USA)[19] and, for the already working health professionals, it may be inaccessible due to the existing, workloads[20,21],distance[22], etc. For the workers in poor regions, access to continuing education and training may be entirely impossible simply due to the individual fiscal constraints. Public libraries provide access to a wide range of either printed resources or material stored on electronic media (CD-ROMs, video tapes, etc.) However, the immense amounts of printed text (approximately 400.000 articles a year[17]) means that only the best equipped libraries are capable of making it available to the user, and even these must make extremely judicious choices on what to select and what to pass[17]. In countries with underdeveloped structure the holdings of medical libraries often range between pathetic and ridiculous[12]. Thus, with the wealth of information it contains[22], capacity to link providers from all over the world almost instantaneously, and its overall simplicity of use, the Internet ought to be the preferential source of education and training for health care professionals anywhere in the world. While it rapidly becomes so, especially with the rapid growth of computer literacy in the industrialized world[23,24,25,26,27,28,29,30,31,32], the situation in the underdeveloped countries is strikingly less desirable.

In what is euphemistically known as the "Third World:, the access to the Internet is typically directly related to extremely inadequate infrastructure[33]. Uneven distribution (city-centered) of the access, and its cost relative to the level of local economy also pose further major obstacles[12]. In Africa, three countries (Congo, Eritrea and Somalia) still have no Internet connectivity although, despite being among the poorest in the world, all have recently announced their plans to establish the service[34]. With the exception of South Africa, the country with the highest density of Internet users and over 70 local access sites[34], the majority of African nations have their access confined to the capitals[12,34]. However, both in Africa and elsewhere, the introduction of innovative pricing policies that support Internet connectivity[12,33] and innovative applications of technology (e.g., VSAT systems, cellular telephones), may result in a perceptible and rapid lessening of the extreme "Internet poverty".

The economic burden of developing telecommunications infrastructure placed upon already impoverished countries and their populations cause a number of objections against such expenditures. Many, rightly or not, view the introduction of computers and modern information technology as elitarian toys of the urbanites[7,12]- the "Strasbourg paté" of absolutely no significance in solving the pressing problems that affect daily survival of millions of people[7,12]. Yet, while the "vaccine before VSAT" argument may ring true, it still may not be valid.

While deploring inequalities of the world, we must not forget that not all are the long-lasting consequences of colonialism, imperialistic exploitation, or indifference of the rich to the plight of the poor. Many of today's problems are inherent to the endemic cultures, to the hundreds if not thousands of years of "doing things the same way" – African tribalism and continuous problems it causes for the Africans is just one example. Current political instability, frequently egregious corruption among the local leaders, or simply sheer indifference are not the inheritance left by the British, the French, or the Germans. If this were so, the multireligion and multination India would not have emerged as a computer superpower. China would not rush in a headlong race to the technological parity with the rest of the world. Historically speaking, if the oppressive impact of a colonial power were the most debilitating factor paralyzing a nation from trying to improve its plight, there would be no United States! The power to change and the power to move ahead rests with those who need this movement most – the underdeveloped nations. The Internet is among the most powerful tools that are readily available and, if properly used, tools that may bring rapid economical development, increased wealth, and – foremostly – improvement of public health which, in itself, is one of the primary prerequisites of economic growth of the nation.

It is true that the disparity between over $ 4000 spent per capita on healthcare in the USA and $ 2 spent in many other countries of the world[35] is astronomical. It is equally true that healthcare dollars spent in the USA and other industrial countries are not always spent most efficiently: there are between 20 to 24 MRI units per 1.000.000 people in USA and Japan, but only 9-10 in Sweden and Germany[36]. Do Germans or Swedes need imaging of their ailing livers less than the Americans or the Japanese? Or Canadians who have only 2 units per million population[36]? Certainly not! The statistics reflect neither the politics nor the efficiency of health resource utilization, and the huge amount spent (theoretically) on the healthcare of each individual American does not reflect the fact that 40 million people in the USA are without health insurance and their access to medical help is, at best, rudimentary[37]. In Sweden, a country that spends only 8.6% of its GDP on its socialized national healthcare, virtually every citizen has full access to a highly sophisticated medical system. It is thus evident that it is not the amount spent but the efficiency with which it is spent that ultimately affects the level and quality of medical care. It is in this context that the postulate of spending money on basic healthcare services rather than development of the medical Internet services may be invalid.

Healthcare is not provided in vacuum, in separation from those who provide it. Dissemination of medical assistance needs people, and people need training not only to become the needed professionals, but also to maintain their skills at a constantly high level. Medicine represents one of the few areas where constant upgrading of one's knowledge, constant learning, and constant practice of skills are essential for the satisfactory and safe conduct of one's professional activities. It is clearly the lack of such training, particularly among the personnel in rural and remote regions, that leads to the large number of preventable deaths even within medically most sophisticated countries like Great Britain or the USA[38,39,40]. The recent report of the National Academy Institute of Medicine[41] indicated between 44 and 98.000 people die in the USA due to medical error, in many instances caused by incorrect diagnoses, procedures, or therapies[41,42], i.e., errors related to the inadequate training and/or maintenance of adequate levels of professional knowledge. Similar concerns were also voiced in the area of nursing[43]. With medical errors as pervasive as they are in the USA, Great Britain, or France, the countries with excellent access to some of the best teaching/training expertise in the world, it is not difficult to imagine the gravity of situation among less developed nations. Once again, the Internet provides one of the simplest and most readily available global solutions to the problem.

In their recent paper, Oshima et al.[44] stated that "The telecommunication revolution enables distance learning without frontiers in a transparent and interactive environment. Applying the Internet and other telecommunication into public health including environmental health holds the greatest promise for global health". The statement holds true as much for the industrial nations as for the developing countries with their inadequate healthcare[45], as witnessed by several editorials in the leading journals of medicine and medical education that focus their attention on the Internet as an extremely powerful medical training medium[46,47,48,49]. The concept of "virtual university in medicine"[50,51] became very alluring and is now expanded into providing extensive Internet-based medical databases to physicians in rural[52] and remote[53] regions. Using video streaming, training can be provided in the form of live lectures with the technical requirements imposed upon the participants as simple as access to a computer, a modem, and the Internet[54]. The fact that these lectures can be recorded and disseminated to the facilities without such access allows the latter to create video-libraries of the latest expert knowledge.

Development of "on line" health information libraries with multilingual accessibility[55] is another important trend introduced by the Internet and there is a rapidly growing consensus among health care professionals, irrespectively of their national origin, that the Internet provides probably the most important advance in medical education and training at all levels[45,56,57,58,59,60,61,62,63,64]. Critical for the concept of global health is the fact that the Internet provides a platform for virtually direct, and often very personal contact, among professionals of different nationalities, often separated by thousands of miles but united by the common issue[11,65,66,67]. As a direct offspring of such contacts, the scarcest of medical resources – the extremely busy expert whose practice does not allow extensive travels as a visiting lecturer – can now be brought to the global audience "on the Net", without the need of leaving the office and yet having a direct interaction with the remote trainees[66,67,68]. Thus, the continuous growth of mutual understanding and globalization of the medical community may be far more effective in reducing health care inequities than many of the ponderous political initiatives of nations emerges as a direct consequence of the advent of the Internet.

The need to implement widespread Internet healthcare access in underdeveloped countries is not a trifle whose priority pales in comparison to the urgent and unquestionably compelling need for other health-related services in these regions. Yet, many of the Internet-based training programs are directly applicable to the development of such services e.g., training in interpretation of clinical lab data[69], pulmonary medicine[70], dermatology[71,72], occupational and environmental health[73], epidemiology[74], public health[75], or nursing[76,77]. Access to these resources may have a direct impact on the low-cost development and/or improvement of local health-care related services by providing direct guidance and consultation by the leading experts of the world. There is hardly any doubt that a well-trained local nurse in contact with the rest of the world can be of a much greater benefit to the local community than several foreign aid workers, eager to help but encumbered by their limited knowledge of the local custom, language, culture, or hardships encountered during operations[78]

Complex fields such as cardiothoracic surgery[79], neurosurgery[80], pediatric[81], and orthopedic[82] surgery permeated into the Internet territory as well, and now provide a very useful educational and training resource to physicians worldwide. One of the most significant events in the development of global medical collaboration was the advent of HelthNet/Satellife (www.healthnet.org, not to be confused with healthnet.com) whose primary goal is to provide health information, electronic conferencing, and e-mail connectivity to the users in the developing countires[83]. HealthNet uses a variety of telecommunication approaches, from dedicated satellites to innovative telephone technologies and pricing schemes, that are optimized to the local conditions but also geared to maximize the contact with the rest of the world from regions where telecommunications are either unreliable or even nonexistent. HealthNet connects approximately 20.000 health care providers worldwide, and its operations resulted in very tangible medical gains in several African countries[12].

The prospects offered the medical world by the Internet are extremely alluring but the lure must not eliminate caution. Many problems still wait for a solution. In a recent survey of documents related to the treatment of diarrhea in children (a source of major concern in the underdeveloped countries), only 12% of papers supplied to World Wide Web from the traditional medical information sources (e.g., journals) conformed with the current guidelines for treatment[84]. These sobering findings underline the fact that the information on the Net is not infallible, and that the search for it ought to conform to the evidence-based rules in order to sustain adequately high quality level[85,86]. Many search engines cover only fragments of the Web (not to mention Internet)[87] making the searches a frustrating and often unrewarding experience for those with limited knowledge of appropriate techniques[88,89]. Finally, much of the information provided on the Web is written in a language that is almost inaccessible to people with less than 10th grade language comprehension skills, thereby limiting its use in the context of patient information[90]. Since the overwhelming amount of medical information on the Web is English-based, the problem caused by linguistic difficulties is particularly acute for the non-English speaking practitioners. To address theses issues the Digital Health Sciences Library published a series of recommendations addressing the issues of translation and mirroring of the information, indexing and cataloguing by the major Web search engines and the inclusion of both common and rare medical topics[91]. Yet, for those with a fairly rudimentary computer literacy and the will to master a set of relatively simple search techniques (which do not differ much from those used in the searches at the "classical" libraries), the Internet provides a very fast access to the information that, at times, may be critical to the survival of one's patient[92].

3. THE STRASBOURG PATÉ

On the 26th of February 1991 a battle between the US and Iraqi armored units was fought in the desert of Iraq. Even if simulation has been used by the Armed Forces prior to this event[93], the battle heralded the advent of DIS – Distributed Interactive Simulation. Like the Internet and many other technological developments that changed the world, the concept of computer- based simulation emerged from the needs of the military. The February battle, subsequently known as the Battle of 73 Easting, was an example of a classical clash of the armored units characterized by the speed, fluidity and a new element – the sense among the US units that they have fought this battle before[94].

Extensive training on distributed simulators prior to the deployment of the US Forces to the Persian Gulf familiarized the personnel with the operational environment: its peculiarities, demands, and the nature of the eventual combat, giving them the critical level of preparedness and even "dominance". Subsequently, the classical battle was "dissected" to its minutest detail and recreated as an electronic simulation of the event that could be viewed three-dimensionally from any vantage and at any point of time – the fourth dimension[93]. The recreation became the most recognized defense simulation so far – it also showed what DIS can do to improve performance of personnel exposed to complex, rapidly changing environments that impose strict demands on the command and control abilities of the participants[93]. These need not be soldiers or pilots. A comatose patient brought to the ER poses the same challenges to the physician, as a sight of the distant enemy to the commander in the field.

What is DIS? In its strict definition it is "a time and space-coherent synthetic representation of world environments designed to link the interactive, free-play activities of people in operational exercises"[93]. The environment is created through real time exchange of data among computationally autonomous subunits (applications) e.g., simulators, sub-simulations, instrumented equipment, etc.. All of these subunits are interconnected by means of the standard computer communication media (e.g., high speed data transfer lines, satellites, etc.) that allow the entire simulation to take place at one location or have a wide geographical distribution. The major attribute of DIS is its ability to train higher operational functions: it is not a tool whose main task is to educate in performing simple operations. Instead, it is a tool that allows to place the already trained personnel in a simulated "real life" situation, where the complex interplay of all individual and operational team skills can be honed to perfection and thus minimize the chance of fatal mistakes during actual action be it surgery, flying a jet liner, or combat.

Unsurprisingly, many characteristics of medicine are similar to warfare. In order to be effective, medical operations, whether on the scale of individual patient encounter or on the scale of international medical relief, involve several critical elements that are also present on the battlefield. There is the need for joint connectivity of systems in order for all activities to run in a smoothly and in a concerted manner. The processes involved must be timely and coordinated. The required information must be both accurate and current. The resources must be ready and available. And, finally, appropriate interventions need to be instituted. Since time is often the most critical factor, the interaction of all these elements is not linear but parallel. It also involves the key factor: human decision making process or the "actionable command and control"[93]. The latter involves assessment and evaluation, adaptation to the imposed environment, and measured response to the presenting challenge. In medicine, each new case demands from the treating physician a rapid retrieval of the relevant facts from the body of the existing knowledge that are required for the appropriate diagnosis (assessment and evaluation), initial plan of action (adaptation to the imposed environment), followed by the definitive treatment (measured response).

While the currently available medical education and training resources available on the Internet provide the information necessary for mastering each individual element of the response to medical challenge, majority are inadequate for training "real life" responses. The essential factor of time is typically missing, the stressors which are crucial for training of adequate responses[95] are missing, and so are the critical interactions with others. Yet, it is the latter that have been shown to be vital in the success or failure of treatment under emergency conditions[96,97]. Thus, the training tools available on the Net are either static or semi-static, and medical simulation is the only solution to the problem of the missing dynamic fluidity and unpredictability of the environment, stress, and the limits of time. The armed forces and civilian and aviation have already demonstrated on numerous occasions the critical relationship of adequate simulator training to the subsequent quality of performance under operational conditions[93,97,99,100].

Simulation in medicine is not a new concept[97], and very realistic (and very complex) devices are rapidly entering into routine use as a part of basic and refresher training[101]. Despite its unquestionable benefits, medical simulation is associated with two critical negative attributes: cost and non-distributable nature. Majority of simulator devices available today cost between tens and hundreds of thousands of dollars. Practically all of them, Human Patient Simulators (Fig.1) in particular, are

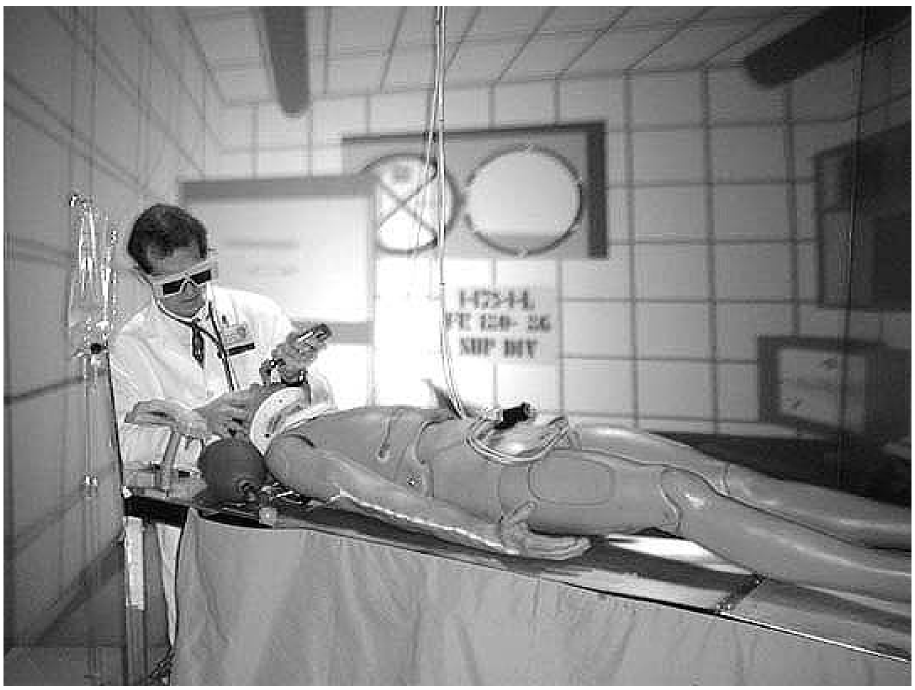

Fig. 1 *Human Patient Simulator (METI Version "B") in action. The computerized mannequin is capable of faithful reproduction of several diseases. It also responds to administration of drugs and I.V. fluids (note the saline solution in the bag attached to the pole to the left), and several procedures such as defibrillation, insertion of laryngoscope (procedure shown in the picture), catheters, etc. Here, the physician-instructor demonstrates airway management in a victim of a major accident aboard a ship. As in human patients, the vital signs correctly generated by the HPS are displayed on a monitor whose screen is seen on the right side. HPS systems are ideal for training under near "real life" conditions and, as human patients when the treatment is incorrect, can "suffer" of adverse effects or even "die". The mannequin is surrounded by the virtual reality environment (CAVE™) hence the goggles worn by the physician. The goggles allow perception of three dimensions and proper perspective.*

housed within specialized training facilities attached to hospitals or schools of medicine[97,101,102] , the majority of which are concentrated (for obvious reasons) in the financially affluent countries, e.g., USA, Germany, Switzerland, etc.[101,102] The most effective training platform – Human Patient Simulator – is today's "Strasbourg paté" of medical educators. Wonderful, mouthwatering, and available only to the most affluent few. In medicine, the "D" is missing from "DIS". Or so it would seem…

4. MEDICAL READINESS TRAINER AND THE MEDICAL DIS: IIMERSME

Recently, the Medical Readiness Trainer group at the University of Michigan[103,104] described the first ever use of the Human Patient Simulator (HPS) in the distributed, interactive simulation mode with the simulator operated remotely by the trainees from as far as 3000 miles (Fig.2). The remote trainees could control the HPS via Internet-based control device allowing real time viewing of the simulator generated vital signs

Fig. 2 *Two physicians at a remote location (Puerto Rico) during a training session on a Human Patient Simulator located in Ann Arbor, MI, nearly 3000 miles away. The laptop computer screen contains two windows: one permitting remote control of all simulator functions, and the other displaying all pertinent physiological data of the "patient". The star-shaped device on the table is a standard conference telephone for hands-free voice communication. Left of the telephone stands a mini video screen (Via TV Phone, 8x8, Inc.) permitting direct observation of the HPS and its physical behavior (such as movement of the chest). Apart from the laptop computer (IBM Thinkpad), all other elements of this set-up can be bought at a very moderate price at almost any electronic supplies store. Plain Old Telephone (POTS) – based connection (two lines) and a 56 Kb modem are used to access the Internet. It is most likely the simplest and cheapest solutions to advanced distributed medical training based on HPS technology that is accessible to virtually anyone.*

Fig. 3 *On the left, Via TV Phone (8x8, Inc.) unit showing the instructor (right side of the unit's screen) and two trainees at the simulator site. The remote trainees (see Fig. 2) observe both the simulator and the instructor on the screen. On the right, a laptop computer with HPS remote control interface and vital sign display. Vital signs can be presented either as numbers or, as on a standard hospital monitor, in form of continuous lines with numerical values in a side bar. Monitor sounds (beeps, alarms) can be also generated. Both the remote trainees and the instructor can control the HPS. In a typical training session, the instructor sets the scenario (shock, cardiac arrhythmia, severe burn, asthmatic attack, etc.), then cedes control of the HPS unit to the remote trainee(s) whose task is to manage the case using remote control of the machine. Remote commands instruct the HPS to perform electronically the required procedures (such as defibrillation, intubation, placing of catheters) electronically. Once appropriate drugs are selected and their dose determined by the trainees, these can be also "administered" via remote control. Although remote access to the simulator eliminates haptic (force) feedback and the ability to train manual procedures, even this form of training is intellectually challenging and its pace, just like in the real life, can be very brisk. The real time presence of an expert instructor (either at the simulator site or, just as that of the trainees, at a remote but different location) allows immediate correction, advice, and debriefing. Scenarios can be re-run as many times as required assuring proper mastery of the involved treatment algorithms.*

(displayed either on a computer screen monitor (Fig.3) or a standard hospital bedside monitor), and execution of simulated procedures (e.g., insertion of catheters) and drug treatments. The POTS-based visual link utilized a commercially available (COTS) and very inexpensive video system (Fig.3).. On purpose, apart from the simulator, the cost of all other devices used for the exercise was kept at the absolute minimum.

The trainees (junior family practitioners, nurses, and paramedics) were expected to recognize and treat chest trauma, shock, and cardiac arrhythmia. While the very important element of tactile (haptic) input was missing, the remote trainees were expected to manage the assisting team (e.g., nurses) at the simulator site, pass appropriate orders, initiate proper treatment, modify the approach depending on the "patient status".

At the end of the exercise, a statistically significant ($p<0.05$, $N=30$, Wilcoxon) improvement was observed in self-assessed confidence and preparedness of the trainees in execution of the appropriate treatment of fairly common medical emergencies[104]. More importantly, however, the results clearly demonstrated that the very expensive and scarce resources (HPS and the expert teacher) could be shared with anyone who had access to the rudimentary forms of telecommunications and the inexpensive computer equipment provided with a link to the Internet.

Even at its "simple" or "low end" level, the work of the MRT opened worldwide access to the HPS-based training to all who need it at a level where the discontinuous elements of previously acquired theoretical knowledge must be assembled and focused on a specific medical task under very stressful conditions, and where the level of performance determines the life or death of the patient. At a much higher level of technology, the Medical Readiness Trainer uses a fully immersive shell of the CAVE-generated synthetic environment (Virtual Reality) surrounding the HPS unit[102]. The

setting permits generation of multiple environments (hospitals, field conditions, moving platforms such as ships in seaway, MEDEVAC helicopters or ambulances). In addition, the introduction of the synthetic environment allows essentially instantaneous access to the entire wealth of Web/Internet-based medical information[102], e.g., the patient data, video clips, showing details of medical procedures, literature databases, and even a full range of simulated monitoring devices. All these tools are represented as synthetic floating billboards which can be moved in and out of the field of view as needed. The "Hyper Rich MRT" (Fig..4) represents the ultimate in the ultra-sophisticated training where both individuals and teams have access to all resources but are trained under conditions of the maximum "real life" stress.

The Hyper Rich MRT is also devised as a "command post" allowing control of widely distributed HPS units. Hence, the trainee operating in the CAVE environment may be trained in management of multiple casualties, with the emphasis shifted from a single patient to the "actionable command and control" within a large-scale medical operation (e.g., casualty department, field hospital, large clinic, etc.). Due to this capacity, a network (IIMERSEME) of national and international "Hyper Rich Medical Readiness Trainers" can provide the medical equivalent of Distributed Interactive Simulation used with such success by the armed forces of the USA and her allies[93].

The IIMERSEME (Immersive and Interactive Medical Education/Research Simulation and Modeling Environment) concept is rooted in the DIS standards[105] modified for medical use. In similarity to DIS, it utilizes high speed telecommunication networks (Internet2) for linking individual IIMERSEME centers in order to provide coordinated, simultaneous simulation at distributed worldwide

Fig. 4 *Hyper Rich MRT. The simulator (METI, Version "B") resides within a fully immersive virtual reality (VR) environment generated by the CAVE^{TM}. The picture shows VR recreation of a patient bay at the Department of Emergency Medicine at the University of Michigan. Note that the environment provides a wealth of resources typically seen at a well-equipped hospital. X-ray light box is on the rear wall. Vital signs monitor (upper slanted box. Ultra sound monitor can be seen immediately below. Barely visible to the right is a "floating billboard" that can contain relevant information such as patient data (either real or generated for the particular scenario), literature references, instructional video clips, etc. In the scenario shown, the physician listens to the chest sounds (generated in a scenario-relevant manner by the HPS) of a patient injured in a serious road accident. In the background can be seen a VR rendition of a severely burned person. This "texture map" of represents the pioneering use of fully immersive VR to depict major forms of injury constitutes as a part of MRT's ongoing effort to use advanced computer modeling and simulation to create realistic, interactive rendition of disease. Such models can be placed on the Web as publicly available training resources that will facilitate education, and reduce the use of animals in medical and biomedical education.*

sites separated by very long distances. The price of access to such networks is both very high and continues to be a major concern even within the "medically affluent" environments such as USA[106]. Moreover, the cost of a single "Hyper Rich MRT" unit (between 1.5 and 2 million dollars) is significant even for some of the most well endowed medical training centers of the "First World". For an institution located in an underdeveloped country, the cost of an IIMERSEME center is and may remain prohibitive for years to come. On the other hand, cheaper alternatives begin to emerge, and the Medical Readiness Trainer group is now experimenting with "portable synthetic environment" devices such as the flexible membrane visualization technology (VIZ4D system by Ethereal Technologies, Ann Arbor, MI)[106]. Once developed and tested, local training centers based on "portable" synthetic environment (virtual reality) systems and remote access to HPS units will provide highly efficient operational (as opposed to experimental) training platforms that can be easily linked to the best teaching/training expertise in the world. Rapid development of telecommunications, visualization, and simulation technologies will make such training units both available and affordable to the nations of limited wealth but with a desperate need for training their medical personnel. The Strasbourg paté of medical training and education will become available to all.

Do all NEED such paté? Is it, if nothing else, moral to suggest such advanced devices to countries whose populations die of malnutrition, endemic disease, and who have no money to provide the essentials so desperately needed by their citizens. Who wants a cellular telephone when a glass of water separates survival from death? Preventive medicine, emergency and trauma medicine, women's health, nutrition, i.e., all specialties of critical importance for the underdeveloped world (and the training in which, when provided at the local, level is often rudimentary) can be taught at all levels (physicians, nurses, technicians, even lay healthcare workers) using the IIMERSEME platforms and their associated lower cost training networks. The distributed interactive training (Fig.4) in which the trainee is forced to act and react is faster, more efficient, is retained longer, and is more relevant to real life operations[93]. For non-English speakers, training can be performed using native language speaking experts bypassing the language barriers. IIMERSEME-based training provides the latest in theoretical knowledge, methodology, and recommended practice together with the realistic training using hands-on applications of these recommendations. Thus, apart from the very expensive, face-to-face training at the best facilities of the world, no other training methodology exists that can do what IIMERSEME is capable of. Finally, both refresher- and "just-in-time" training (the latter often of critical importance prior to the foreseeable natural disasters such as hurricanes) are vastly facilitated by the IIMERSEME. The training affects large areas (and may be conducted even on the global scale), can be provided by the world-class experts whenever required, and is essentially free of charge. Videotaping of training sessions permits their further usage as low-grade training tools elsewhere and thus broadens the access to quality medical education even further.

It has been said in the context of medicine in the underdeveloped countries that "one must first learn to walk before running"[12]. But if we walk for too long or run too slowly, the already staggering gap of the current disparities will become unbridgeable, the need too intense to be adequately addressed, and the lag too severe to be eliminated. In medicine, the advent of technological revolution could not come more timely. The rich face their aging societies whose members need increasingly higher levels of medical services. The poor face increasing populations whose members have no access to medical services. The world has adequate medical resources to deal with both problems, and the technology provided probably the most important tool in addressing these problems – the Internet and the Web.

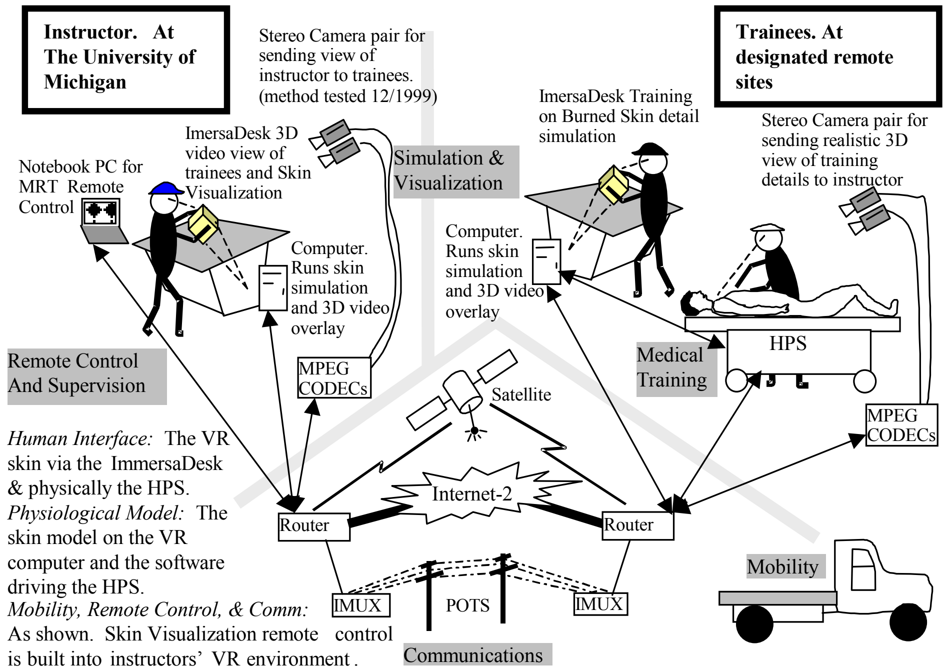

Fig. 4 *Diagram showing the flexibility of advanced telecommunications-based medical training at locations separated be very long distances. Increasing access to the Internet combined with continuously increasing availability of bandwidth at progressively reduced prices allows optimal use of global resources. Highly sophisticated training facilities can be located at only a few locations and accessed electronically by their user. Introduction of mobile training platforms containing portable VR visualization systems allows direct access to advanced training technology at locations where such technology will not be available for a foreseeable future. Finally, probably the scarcest resource of them all – the expert trainer -can be employed in the most optimal manner possible. An expert, today available only to the selected few, may soon train a global audience of students using methods that have not been available even a few years ago.*

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