Manual of Pediatric Intensive Care

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to

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My Wife
Dr Suprabha Rathee
My Loving Children
Nikita and Shiven

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Foreword

The purpose of a good manual is to provide updated adequate information in a simple and lucid style, for easy understanding to the average students and some challenging advanced topics to the more intelligent class. I am very confident to say that all these requirements have been satisfied by experienced author in this manual. The manual has been largely directed at all the pediatricians and budding pediatric intensivists.

I congratulate Dr Amit Rathee who has tried to compile his all experience and efforts for the betterment of upcoming pediatric remedies in general as well as in intensive care unit.

I also congratulate all contributors for sharing their real time practice experience in this manual.

Hope, the doctors and students will appreciate and make use of this.

I wish all the success to him and his colleagues in this new venture.

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Preface

Pediatrics as a specialty has been going through an exciting phase with all subspecialties taking roots and evolving at a rapid pace. Major strides in pediatrics research have enabled me to develop management protocols, specifically for pediatric population and I am no longer dependent on modifying protocols meant for adult population.

I have made every effort to maintain the quality of the manual.

There is a felt need for a comprehensive manual suitable for Indian settings, as most of the literature available is from Western world. I have tried to make a comprehensive reference material for use of pediatric intensivists. I have tried to cover most of the situations faced in pediatric critical care setting.

I hope, this manual would be useful for practicing intensivists. At the same time, care has been taken to keep it simple so that postgraduate residents will also find it helpful. All the chapters in this manual have been written by practicing intensivists and are based on real-time experience.

I would be grateful for feedback from the readers and colleagues. I hope to keep updating the material so as to keep pace with latest developments. I sincerely hope that this manual would be helpful for practicing pediatricians and would find a place in their clinic, library and critical care units.

Amit Rathee

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Many individuals should be recognized for their significant contribution that helps me in compilation of this manual. First of all, I express my gratitude to my teachers and mentors who showed me the way to translate theoretical knowledge into bed-side care. I am highly thankful to them as they instilled a sense of direction into me that inspired me for writing this manual.

While talking about teachers and mentors, I would like to mention my first teacher of life, i.e. my mother Mrs Darshana Rathee and my first mentor, i.e. my father Mr Sukhvir Singh Rathee. I also would like to acknowledge my motivation power, my wife Dr Suprabha Rathee who always provides the unconditional support and encouragement.

Her patience and understanding during the drafting stage of manuscript were critically important to its timely completion.

I am highly grateful to Dr Ashish Simalti and Dr Sumanth Amperayani. I am highly grateful to my colleagues, nursing staff and students who have created an atmosphere full of camaraderie and curiosity which kept the spark burning during the long journey which this manual was.

I would like to thank all contributors of this manual who have ensured that all chapters are updated with latest information and are also practical for our settings.

I would like to thank CBS Publishers & Distributors Pvt Ltd, for undertaking this project and constantly guiding me while compiling and editing this manual.

Amit Rathee

Contents

CHAPTER 1

Evolution and Organization of Pediatric Intensive Care Unit

Introduction

Modern set up of Intensive care units (ICUs) owe its origin to the polio epidemic of 1952 at Copenhagen.[1] Dr Bjorn Ibsen and his team could reduce patient mortality by greater than half (90–40%) by caring for patients in a earmarked area of the hospital and by giving manual positive pressure ventilation using a rubber bag through a tracheostomy.[2] They admitted the patients with respiratory failure in a special unit providing respiratory care between 28 August and 3 September 1958. Total of 200 patients were admitted in this unit. They underwent tracheostomy, manual positive pressure ventilation using 50% oxygen and regular suctioning.[2] They utilized 400 extra nursing auxiliaries and medical students each working for 8 hr to provide manual ventilation along with 27 technicians everyday to look after these patients.[2] These findings remain relevant to intensive care even today. Now critical care has expanded enormously and almost every hospital has some form of ICU. ICU patients occupy approximately 10% of inpatient acute care beds but the structure and organization of these ICUs tends to differ across hospitals. In view of a need for uniform guidelines regarding the structure and organization of ICUs, ISCCM (Indian Society of Critical Care Medicine) has formulated guidelines regarding ICU planning and designing in India in 2003 which were updated later in 2010.[3]

LEVELS OF PICU CARE

Prior to designing the ICU one should decide which level of ICU is suitable for hospital. Role of each level of ICU is well-defined. In general hospital and district hospital the ICU is more like high dependency unit (HDU) where close observation and monitoring can be carried out. ICUs in large tertiary hospital use complex management to support all body systems. ISCCM has proposed the following levels of ICUs.[3]

Level I

Level I ICU is recommended for small private nursing homes, small district hospitals, and rural area centers. This ICU should be 6–8 bedded with ability to provide resuscitation including short-term cardiorespiratory support and defibrillation. It should have ability to ventilate a patient for minimum 24–48 hr and should have facilities for noninvasive monitoring like: ECG for heart rate and rhythm, NIBP, SpO_2, temperature, etc. Level 1 ICU should be able to arrange safe transport for patients to secondary and/or tertiary centers. It should be managed by a doctor trained in ICU knowledge and technology. It should also have basic imaging backup and clinical laboratory.[3,4]

Level II

Larger general hospitals should setup level II ICUs. This ICU should have bed strength of 6–12 and managed by a qualified intensivist. Duty doctors and nurses should also be trained in the critical care. It should be able to provide invasive and noninvasive ventilation and multisystem life support. They should have ability to manage long-term ventilation and invasive monitoring. 24 hr access to ABG and electrolytes are must as microbiological support besides routine diagnostic support.[3,4]

Level III

ICUs in tertiary level hospitals shoulb be of level III. These are preferably a 10–16 bedded ‘closed’ ICU, headed by an intensivist. This ICU should be capable of providing long-term acute care of highest standard. It should have all recent methods of monitoring, noninvasive as well as invasive like continuous $ScvO_2$ monitoring, cardiac output, etc. investigations like X-ray, 2D ECHO, USG, bronchoscopy and dialysis should be available by the bedside of the patient. It should also have intra and inter-hospital transport facilities. Level III ICU should also have vision for research and should be participating in national as well as international research programs.[3,4]

LOCATION OF PICU IN HOSPITAL

Dedicated PICU to infants and children should be separate entity from the NICU as well as adult ICU.[5] Safe, easy and rapid transport of critically ill children should be considered at the time of planning the location of PICU. The unit should be in close proximity to areas like operating room, emergency department, acute pediatric wards, departments of radiology other diagnostic facilities. Number of lifts should be sufficient to carry these critically ill patients to these places as and when required. Corridors, ramp and lifts should be large enough to enable easy movement of bed. Hospital staff should not pass through the unit and no traffic of goods should be allowed through PICU. PICU should have a single point for entry and exit and it should be manned all the time. But emergency exit points should also be present to be used only in emergencies and disasters. Entry to ICU should not be direct and there should be some barriers from outside entry. Outside PICU there should also be provision for family waiting area for at least one or preferably two persons per admitted patient.[3, 5, 6]

SIZE OF PICU

Defining ideal PICU size is not easy but recommendation in Indian scenario are: 10–16 beds for level III PICUs, 6–12 beds for level II and 6–8 beds for level I.[3] PICUs with beds < 6 are not cost-effective and may not give enough sufficient clinical experience and exposure to P ICU staff similarly PICUs with > 16 beds may be difficult to run, stressful for PICU staff and may adversely affect patient outcome.[3]

ROOM LAYOUT AND BED AREA

Layout

Layout of PICU room can either be open ward type or divided into cubicles. Room layout should be such as to allow staff to see all patients from central station. Bed space of 100 sq ft has been recommended as minimum in Indian circumstances with bed space of 125–150 sq ft area considered desirable.[3] even higher recommendations up to 250 sq ft per bed have also been made.[6] Nursing station, equipment area, doctors and nurses rooms, toilet and apace for patient movement are additional space requirements amounting to about 100–150% of patient room area. One to two rooms should have capability for isolation where immunocompromised patients can be kept. These rooms should have 20% space extra compared to other rooms.[3]

Beds should have enough space around them for performing routine ICU procedures like central line or chest tube placement and also for easy access for electrocardiography, portable ultrasound and bedside electroencephalography machine.[5] Standard curtains or unbreakable removable or fixed partitions made of wood, aluminium or fiber can be used to create partition between two room for privacy of patients.[3]

Utilities Per Bed

Every intensive care unit is expected to have proper lighting, electrical power, compressed air, oxygen, vacuum, water, and environmental control systems which support the needs of the children and staff of critical care team under normal as well as emergency situations. Standard of these facilities must exceed regulatory and accreditation agency codes. According to the ISCCM guidelines (2010) one compressed air outlet, two wall oxygen outlets, two vacuum outlets and at least 12 electrical plug points are required for level I and level II PICUs. For level III PICU, 3 vacuum outlets, 3 oxygen outlets, 2 compressed air outlets and 12–14 electrical outlets are recommended by ISCCM. One monitor per bed should be available which should be placed at a height comfortable for doctors as well as nurses.[3]

Beds

To allow easy access for emergency airway management, the head end of the patient's beds should be approximately two feet away from the head wall.[3] Bed's head end and foot end should be maneuverable to keep head end up or low. To prevent pressure sores, there should be provision of at least two or preferably more air/water mattress. All beds should have a railing to avoid accidental fall of small children. An emergency alarm button should be available at every bed in order to activate code system in case of emergencies. A bedside cart should also be provided to keep patient belongings and also required patient items.[3]

Central Nursing Station

Central nursing station is like the nerve center of the PICU. It should be located in a way that allows monitoring of all patients by healthcare staff which can be either direct or indirect monitoring by video monitoring. In most PICUs, central station looks after 6–12 beds arranged in L or U fashion. This central nursing station should have area of sufficient size to comfortably accommodate all necessary staff functions. Adequate space should also be provided for central monitors, computers and its printers when automated systems are functional. Adequate space along with seating arrangement should be planned for both nurses and physicians for medical record keeping. File cabinets, shelf and other storage required for medical record forms should be located in a way that they are accessible to all personnel requiring their use. For communication at least two telephone lines are recommended.[3, 5, 6]

ENVIRONMENTAL REQUIREMENTS

Heating, Ventilation and Air-conditioning System of ICU

The ICU should ideally be centrally air-conditioned and also should have central heating for control of temperature. Safe and suitable air quality should be maintained all the times. A minimum of six total air changes required for every room per hour. Two air changes per hr should be composed of outside air.[3] If central air-conditioning is not available, cubicles are recommended to have fifteen air changes every hr and other patient areas should have these at least three times in one hour.[3] The sluice and laboratory and dirty utility, need five changes every hour, but two in an hr are sufficient for other staff areas.[3] Re-circulated air must pass through suitable filters in central air-conditioning systems. It has been recommended that air filtration should be 99% efficient with particles down to 5 microns.[3]

Temperature of ICU should be kept at a level which is considered comfortable for the patients as well as ICU personnel. In PICUs having enclosed patient cubicles, the temperature should also be adjustable in each cubicle with option of temperatures between 16 and 26°C.

Backup power sources like invertors and generators to ensure an uninterrupted power are must for PICU. Power supply back up should start automatically in the event of a power failure and should be sufficient to run air conditioner and equipment. Stabilization of voltage is also mandatory and UPS (uninterrupted power supply) system is preferred in the PICU.

Lighting

PICU should be designed to allow natural light as much as possible. Each patient should have an access to natural sunlight. Windows form an important part of sensory orientation. Preferably most beds should have a view of windows to reinforce orientation of day and night. There are proven advantages of access to outside natural light in PICU.[7,8] Natural lighting also decreases power consumption hence the electricity bill. It may also benefit staff morale and outcome of patient. Studies have also shown that use of synthetic artificial daylight in this kind of setting may deliver better results for those working in night time and may also be helpful in maintaining the circadian rhythm.[7, 8]

Overhead illumination and light from the surrounding areas should be enough to carry out routine nursing tasks, including paperwork. At least 20 foot-candles (fc) of total luminance should be ensured and at the same time it should not exceed 30 fc.[3] Night lighting should not be brighter than 6.5 fc for regular use and 19 fc for intermittent periods to minimize sleep disruption during patient monitoring.[3] Separate provision for lighting for emergencies and bedside procedures should be made. It should be located in the ceiling above the patient and should be able to illuminate the patient with minimum of 150 fc shadow-free.[3]

Noise Control in ICU

Technology development has also increased noise levels in PICU environment well above the international recommendations. Some of the noise polluters in ICU include, telephones, mobile phones, alarms from medical equipment air-conditioning besides routine things like staff conversations, opening and closing doors, etc. The adverse effects of noise on admitted patients include sleep deprivation, heart rate and blood pressure variations, impairment of immune function and catabolic metabolism.[8, 9] Similarly noise also impacts staff negatively resulting in increased mental stress, annoyance, diminished intelligibility of speech, adverse job performance and ultimately patient safety.[8] Noise levels in most hospitals are usually between 50 and 70 dB with many episodes above this range. These are much higher than recommendation made by the International Noise Council. As per these recommendations that noise levels in hospital PICU should not be louder than 45 dB (A) during daytime, 40 dB in the evening, and 20 dB at night-time.[3] For these reasons, floor coverings which absorb sound are recommended to be used; walls and ceilings should also be constructed of materials having high sound absorption capabilities. Glass doors, counters and partitions are also effective in decreasing noise levels.

Equipment

Following points should be considered when choosing equipment for PICU the:

- Proven use in pediatric patients
- Accuracy and adaptability established for pediatric population
- Ease of use by PICU staff
- Trouble shooting guidance
- After sale support of the company for maintenance services
- Cost-benefit analysis.

A suggested list of equipment for a tertiary level PICU is shown in Table 1.1. This is not an exhaustive list and more equipment can be added or modifies as per requirement of individual unit.

Equipment Storage

Vital supplies which are used frequently and those required for emergencies should be stored within or close to PICU so that they are available readily and also are easy to find.

Table 1.1: List of equipment for 12-bedded ICU

Sr. no.	*Name of equipment*	*Number*	*Specifications*
1.	Noninvasive ventilators	3	With provision for CPAP and IPAP
2.	Over bed tables	1 for each bed	ALL SS with 1–2 cupboards in each to store drugs medicine, side tray for X-rays, BHT, on wheels
3.	Head end panel	1 per bed	With 2 O_2 outlets, 2 vacuum, 1 compresses air and 12 electric outlets, provision for music, alarm, trays for 2 monitors, 2 drip stands, 1 procedure light
4.	Freeze	1 + 1 for use or use of staff and doctors	With deep freeze facility
5.	Infusion pumps	2 per bed in ICU	Volumetric with all recent uopgrading drug calculation
6.	Bedside monitors	1 per bed	2 invasive BP, SpO_2, NIBP, ECG, RR, temp probes with trays
7.	Ventilators	6	With pediatric and adult provision, graphics, and non-invasive modes
8.	Syringe pumps	2 per bed in ICU	Pediatric infusion pump
9.	Defibrillator	2 with TCP facility	Adult and pediatric pads with transcutaneous packing facility
10.	ICU beds	1 for each bed	Electronically maneuvered with all positions possible with mattress, now beds are available which give lateral positions also
11.	Resuscitation	2 for ICU	To hold all resuscitation equipment and medicines
12.	Pulse oxymeter (small units)	2	As standby units
13.	ABG machine	1 + 1	Facility for ABG and electrolytes second 1 as standby
14.	Computers	2	With laming, internet facility and printer to be connected with all departments
15.	HD machines	1	User friendly
16.	CRRT	1	High flow/speed model
17.	Glucometer	2	
18.	CO, SVR, $ScvO_2$ monitor	1	As described
19.	Airbeds	6	To prevent bedsores
20.	Intubating video scope	1	To make difficult intubations easy
21.	ICU dedicated ultarsound and Echo machine	1	With recent advances to look, instantly even at odd hours vascular filling, central lines, etc.
22.	Bedside X-ray	1	
23.	ETO sterilization	1	To sterilize ICU disposables regularly
24.	Spinal board	2	For spine trauma patients
25.	Rigid cervical spine collars	4	For stabilizing cervical spine
26.	Ambu mask different sizes	10 sets including 2 for pediatric use	Silicon, ETO sterilization
27.	Pollution control buckets	1 set for each bed	
28.	Trays for procedures	For putting central lines, ICD, catheters, etc.	
29.	IA balloon pump	1	
30.	Fiberoptic bronchoscope	1	

An area should be provided for the storing and securing of large equipment when not in use. Storing space should be adequate to provide ease of searching the location as well as retrieval of desired item. A refrigerator is essential for some of the pharmaceutical products.

Clean and Dirty Utility Room

Utility rooms should be divided into two separate rooms: Clean and dirty which should not be interconnected. These utilities must be temperature controlled. Air supply from dirty utility should be exhausted outside. Clean linen and sterile supplies should be stored in clean utility room. Dirty utility room should have a separate sink with hot and cold mixing faucets. Covered bins for waste materials and soiled linen must be provided. A sink or other designated area for emptying and cleaning urine bottles and bedpans is also necessary.

Waste Disposal

Biomedical waste is well-recognized to be a major health hazard to environment including patient, healthcare workers and general public. Biomedical waste must be properly segregated at the source itself. Color coded containers (yellow, blue, red and black) should be kept by the bedside of each patient to dispose of different types of wastes. All government regulations related to biomedical waste disposal should be strictly complied with. As this is a dynamic issue, hospital authorities need to keep abreast with latest government advisories regarding biomedical waste management.

Hand Hygiene and Prevention of Infection

Hand hygiene is recommended as most effective method of infection. WHO steps of hand hygiene should be displayed prominently and PICU staff should ensure that these steps are hand hygiene are followed. Every bed should have attached alcohol based hand rub, to be used before caregiver touches the patient. A sink like one in operating room with foot or elbow operated water supply system and antiseptic soap solution should be available at an easily accessible point, where two persons can wash their hands at same time.

Stat Laboratory

All ICUs should have 24-hr active clinical laboratory services. If this service cannot be provided by the central laboratory of hospital, a satellite laboratory should be set up adjacent to the ICU(s) to serve this function. This satellite facility should be able to provide basic chemistry and hematology evaluation, along with arterial blood gas analysis.

Conference Room

A conference room should be set up for intensivist and staff for continuing education, discussion of difficult cases, staff education and other necessary meetings related to quality improvement. This room should also have a small library facility which should provide ready access to important intensive care, journals, books and policy manuals.

Human Resources for PICU

Development of human resource is one of the vital components of PICU. Human resources include intensivist/s, nurses, resident doctors, respiratory therapists, physiotherapist, nutritionist, technicians, computer programmer, biomedical engineer, clinical pharmacist and other support staff like cleaning staff, guards and class IV. All of them should be qualified, highly motivated dedicated, and ready to work in stressful conditions for longest periods of time. One of the limiting factor in PICU is scarcity of such individuals and very high turnover.

Team Leader

Intensivist is the PICU team leader. He or she should be a pediatrician trained qualified, and experienced in pediatric critical care. He or she should spend >50% of his or her time in PICU. PICU intensivist should be a full time practitioner particularly for PICU in tertiary centers. He/she should have the following responsibilities:

- Establishing protocols and policies with the help of an expert group
- Implementation of these policies and protocols involving admission and discharge criteria for smooth functioning of PICU with
- Assurance and improvement of quality
- Advising administrative authority about equipment needs
- Continuing medical education of medical, nursing and ancillary staff
- Maintaining PICU statistics related to mortality and morbidity
- Being part of infection control committee.[3]

Medical Staff/Resident Doctors

Pediatrician with good airway and pediatric advanced life support skills and active PALS certification should be part of medical team. He should have MCI endorsed postgraduate level qualification. Other residents can be graduates or postgraduate depending upon level of PICU. This team should be present round the clock in PICU. The ideal doctor to patient ratio has not been decided in literature but it is recommended that one doctor should not look after > 5 critical patients. These include children who are on ventilator or suffering from multiorgan dysfunction syndrome needing invasive monitoring.[3]

Nursing Staff

One nurse should be available for every child who is being ventilated or who has multiorgan failure. This nurse should have structured training for working in ICU. In no circumstance there should be < 2 nurses for 3 patients of this severity as this will adversely impact outcome. One nurse for 2 or 3 beds is acceptable for patients who are not very sick and who do not require intensive monitoring.[3]

Ancillary Staff

The PICU should be adequately staffed including physiotherapists, respiratory therapists and nutritionist for imroving patient care. In addition, radiographers, technicians and biomedical engineers should also be available in hospital all the time for emergencies like need for urgent chest X-ray in a child with suspected pneumothorax or troubleshooting problems requiring immediate attention like central gas supply problems, power failure, malfunctioning equipment, etc. Clerical staff is required for communication and paper work important for smooth functioning of the unit. It is also very important to have cleaning people who are efficient and sensitive to patient care needs. Social workers play an important role to help support families emotionally and even financially in the stressful circumstances of PICU stay.

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CHAPTER 2

Information Technology

Introduction

Sound and reliable information is the foundation of decision-making across all health system building blocks, and is essential for healthcare delivery system. The health information system provides the underpinnings for decision-making and has four key functions:

1. Data generation
2. Compilation
3. Analysis and synthesis
4. Communication and use.

The health information system collects data from the health sector and other relevant sectors, analyzes the data and ensures their overall quality, relevance and timeliness, and converts data into information for health-related decision-making.[1]

There is a broad consensus that healthcare in the 21st century will require the intensive use of information technology and clinical informatics to acquire and manage data, transform the data to actionable information, and then disseminate this information so that it can be effectively used to improve patient care. Nowhere is this more evident and more important to patient outcomes than in the intensive care unit (ICU).[2]

The use of information technology has become integral part of the healthcare environment. Computers are embedded into everything from mechanical ventilators to bedside intravenous infusion pumps and bedside monitors. Yet, physicians as a group and the healthcare field in general have been slow to embrace technology when compared with other large industries, such as aviation, banking and travel. Paradoxically, medicine is perhaps one of the most information-rich fields, and its practice is entwined with the management of information. Medical care is so complex and extensive that it exceeds the capacity of the human mind to implement it without the help of information technology. The focus of this chapter is on those information technologies and applications that have demonstrated a significant impact on healthcare delivery or those that have the potential to do so. Information technologies have the potential of reducing errors, improving efficiency and quality of care, and reducing healthcare costs.

THE ELECTRONIC MEDICAL RECORD

Over the past 20 years, a number of different forms of electronic health records (EHR) have been discussed, developed and implemented. Further, a number of terms have been used to describe the move from a manual or paper record to one generated electronically in one form or another. Some of the better known terms include: Automated health records (AHR), electronic medical record (EMR), computer-based patient record (CPR), and electronic health record (EHR).

The term electronic health record is widely used in many countries with variation in definitions and the extent of coverage. In today's environment, it is generally accepted as *a longitudinal health record with entries by healthcare practitioners in multiple sites where care is provided.*

In the USA, the current definition of an EHR is: "*The electronic health record includes all information contained in a traditional health record including a patient's health profile, behavioral and environmental information. As well as content the EHR also includes the dimension of time, which allows for the inclusion of information across multiple episodes and providers, which will ultimately evolve into a lifetime record.*"

More simply stated, this type of longitudinal electronic health record could be defined as:

- A comprehensive database of personal, health-related information that is accessed and updated across a healthcare network.[4] Its benefits include:
  - Improved quality of care
  - Cost savings
  - Higher productivity

- Facilitate research by easier aggregation and analysis of health data.

The three principal functions of this or any database are—data acquisition, data access, and data storage (Fig. 2.1).

Data Acquisition

The EMR acquires data from a variety of sources, including hospital registration, nurse and physician input, laboratory services, radiology and other test interpretations, therapist and nutrition services, monitoring devices, and physicians' orders. The most important system that feeds the database is the enterprise-wide master patient index that ensures that each patient is identified properly and uniquely. Every other system must have the correct identifier to deliver its data to the correct patient record. A multimedia database can include images from such platforms as radiographs, electrocardiograms, fetal monitors, sonography, MRIs, CTs, and even paper-based documents, such as consent forms, questionnaires, and sometimes, handwritten notes and hand-drawn diagrams. Data acquisition is organized in a manner that minimizes duplicative effort and maximizes data consistency.[5] Data originating from bedside devices, such as cardiopulmonary monitors, pulse oximeters, ventilators, and intravenous infusion pumps represent critical elements of the patient care record. Technology is currently available to connect devices to the EHR through bedside medical device interfaces (BMDI). BMDI allows properly formatted data from a medical device to flow into and update the patient's EHR.

The capture of textual information such as progress notes, nursing assessments, or even radiology reports can present particular challenges. For the most part, text is entered via a keyboard, but alternatives include voice recognition, handwriting recognition, or handheld or wireless devices.

Data Access

The EMR serves as the focal point for most healthcare professionals. It might be accessed at inpatient sites, in emergency departments, nursing facilities, physician offices, clinics, laboratory facilities, and, possibly, the home of a patient receiving home health services. The ideal computerized patient record is available when and where it is needed. However, databases with sensitive information must be controlled to prevent unauthorized use or alteration. These systems must satisfy five requirements:

1. **Access control:** Only authorized persons are allowed access for authorized uses.
2. **Authentication:** Some confirmation that a person granted access is, in fact, who he or she purports to be.
3. **Confidentiality:** No unauthorized disclosure of information is allowed.
4. **Integrity:** Information content is unalterable except under authorized circumstances.
5. **Attribution/nonrepudiation:** Actions taken (access, data entry, and data modification) are reliably traceable.

The EMR interface should be user-friendly, configurable and capable of providing a full, seamless view of the patient

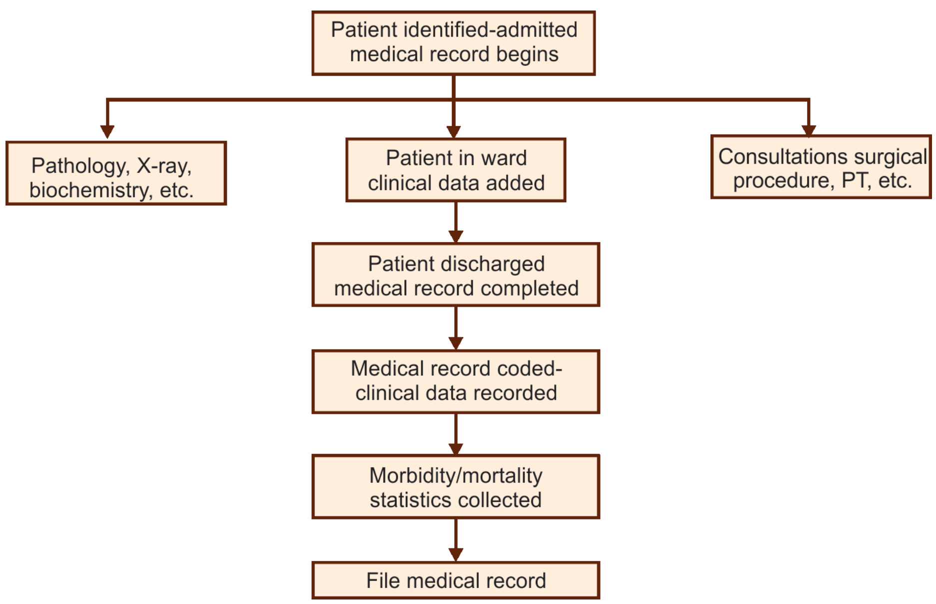

Fig. 2.1: Medical record filing

over time and across points of care. Both detailed and summary views that juxtapose relevant data allow the clinician to acquire the information required to optimize expedient decision-making. Displays should be configured to highlight key information while suppressing clutter but, at the same time, making all pertinent data readily accessible. Dynamic linkages should exist between the EMR and supporting functions, such as expert systems, clinical pathways, protocols, and reference material. Response times must be sufficiently speedy, and workstations should be conveniently accessible to the point of care. Mobile connections would be a bonus, but access of patient data via wireless connections and portable devices must overcome usability and security hurdles before it can be fully implemented. The patient database also supports many areas of research, education, decision support, and external reporting. Thus, data in aggregate must be accessible by personnel in administration, finance, quality assurance, and research areas. The security of the database includes physical security, prevention of unauthorized access, and protection from malicious software.

Data Storage

The multimedia data of the comprehensive EMR are stored on media that allow for long-term storage and for searches and rapid retrieval of enormous volumes of data. The database must be updated in a way that ensures that it is current, complete, and consistent. Data, once entered, should be modifiable only in accordance with strict rules that ensure data integrity. All databases must be backed-up periodically to protect against data loss. Stored data should be marked with time stamps. Although the data can be modified, both the original and the revised versions should be maintained using appropriate time stamping. Appropriate safeguards must ensure database integrity.

Whereas a clinical data repository is a database optimized to retrieve data on individual patients, a data warehouse is a database designed to support data analysis across individuals. Hospitals can use data warehouses to perform financial analyzes or quality assessments. Subsets of a data warehouse that are structured to support a single department or function are called data marts and are designed to perform periodic analyzes or to produce standard reports run repeatedly, such as monthly financial statements or quality measurements. In finance and administration, they can assist in strategic planning and, with appropriate modelling, can predict the impact of decisions before they are made.[6] In medicine, data marts can take the form of a clinical database to support evidence-based decisions. Data mining applications can shift through mountains of data in the warehouse and run complex algorithms to find obscure patterns.

CLINICAL DECISION-SUPPORT SYSTEMS

Decision-support systems (DSS) are an integrated set of programs and databases that provide users with the ability to interrogate those databases and analyze information, retrieving data from external sources, if necessary, to assist in decision-making.

Retrospective decision-support tools can be applied to aggregate patient data to find historic patterns. Real-time DSSs can be passive or active. Passive systems are activated when clinicians request help. Such assistance can come as reference material, automated calculations, or data review. Active systems include alerts and reminders that are triggered by pre-programmed rules. A warning displayed when penicillin is ordered for a patient known to be allergic is an example of an active DSS.

An effective DSS must have accurate and complete data, a user-friendly interface, a reliable knowledge base, and a good inference mechanism. The knowledge base can include information regarding risks, costs, disease states, clinical and laboratory findings, and clinical guidelines. The inference engine determines how and when to apply the appropriate knowledge, while carefully minimizing disruptions of workflow.

IMPLEMENTATION

The implementation of an EMR system requires an investment of additional staff, hardware, software, and an expanded communications infrastructure or network. The first phase generally provides a patient-centric repository of clinical test results, including laboratory, radiology, pathology, and other textual data. A subsequent phase includes capture of paper document images, radiology images, and other non-textual data. A key phase is the capture of clinical data at the point of care, including vital signs, intake and output, nursing documentation, and physician notes. Physician acceptance and participation can be enhanced by acknowledging the importance of physicians in the process, training them early and often, frequently and routinely eliciting their feedback, and demonstrating responsiveness to their needs and concerns.

PROMISES AND LIMITATIONS

Information technology in the form of an EHR promises improved patient care. Potential benefits of information technology include:

- Providing rapid access to integrated clinical data and extant medical knowledge
- Eliminating illegibility
- Improving communication

- Issuing applicable reminders and checks for appropriate medical actions
- Increasing adherence to guidelines (particularly in the outpatient arena)
- Decreasing medication errors.

In fact, any benefit may be outweighed by new problems introduced by the systems themselves. In effect, one set of problems may be traded for another.[7] Despite considerable progress, the sentiment expressed by G. Octo Barnett in 1966 is often echoed it is frustrating to meet with repeated disappointments when the objectives are superficially so simple.[8] EMR software programs are enormously complex, are built by large teams of programmers with input by numerous clinicians, demand high-speed processors and high-bandwidth networks, and rely on often fragile interfaces with other hospital systems. Errors can and do occur in programming or configuration. Many programming deficiencies can be detected and corrected with thorough testing, in a development environment; however, some of these problems will only become apparent under unique circumstances that are presented by patient care.

Numerous other unintended consequences result from implementing an EMR, including creation of new kinds of errors, increase in work for clinicians, untoward alteration of workflow and change in communication patterns, increase in system demands, continuation of the persistence of paper use, and fostering of potential overdependence on the technology.

NEW ERRORS

Many new errors are a result of poorly designed interfaces.

1. **Juxtaposition errors:** Clinician intending to select one item but selecting another close to it. Long, dense pick lists in a small font exacerbate this problem.
2. A similar error is mistaking an open chart of one patient to be that belonging to another, or picking the wrong patient from a long list of patients.
3. **Interfaces errors:** Patients who have been physically transferred but remain, disembodied, in their previous electronic location may have their care suspended pending completion of the electronic transfer. Worse, should electronic transfers be delayed, medications may be delivered to a patient's former room and administered to a different patient admitted to that room. Allergies may be entered in the bedside system, but interface problems can prevent that information from reaching the pharmacy or nutrition systems.
4. **Rigid implementation of policies and procedures** into the EMR may lead to difficulties in clinical practice when dealing with ambiguous circumstances and exceptions. Sometimes the process of care is incompletely understood, and codification can be disastrous. Policies at most institutions include automatic stop orders that require rewriting medication orders within a specified time frame. Implementing this rule without safeguards could lead to automatic discontinuation of medications and missed doses.
5. **The benefit of legibility** in electronically written notes can be outweighed by novel problems. Overuse of copy-paste functions can result in repetitive, monotonous, and loquacious notes punctuated by the sin of repeating erroneous text verbatim.

Increased Work for Clinicians

1. Although transcription errors can be eliminated by computerized order entry, clinicians have to shoulder the added burden.
2. Documentation in a structured format rather than as free text can enhance completeness and facilitate later data retrieval; however, it can also increase work.
3. Rigidly structured order input can force clinicians to waste time trying different ways to order nonstandard tests or therapies with little guarantee that these orders will actually be executed.
4. Clinical alerts can help clinicians make decisions but persistent interruptions of work by alerts can increase the workload of the clinician who must decipher their meaning and assess the risk in each specific circumstance. The frequency of these alerts can become intolerable when they are not delivered to the right clinician with the right information. When these alerts become too frequent and too predictable, clinicians might adapt response chaining dismissing the alerts with rote keystrokes.
5. Another time-consuming feature of the electronic medical record (EMR), perhaps the most exasperating, is the loss of data. Workstation or interface crashes, network collisions, or other system failures can be the culprit. System delays from a wide variety of causes also waste valuable time, as does having to hunt for an available workstation because those installed are insufficient in number or inconveniently placed.

Unfavorable Alteration of Workflow

The implementation of an EMR requires work processes modelling, but can sometimes result in ossifying those processes to something too inflexible for efficient and effective patient care.

1. Patients expected to be emergently admitted to the PICU but still in transit often have medications and urgent therapies ordered and prepared before arrival. A computerized physician order entry (CPOE system

may prohibit the ordering or dispensing of medications for patients who have not yet been admitted.

2. In a paper environment, nurses arrange dosing schedules based on the ordered frequency and other ordered medications. However, in many CPOE systems, medication orders go direct to the pharmacy and bypass the bedside nurse.
3. Transferring patients from one unit to another or to the operating room typically requires the discontinuation and reinitiation of all orders, including medications. With implementation of CPOE, clinicians without proper direction could suspend rather than discontinue the old orders. Reactivation of suspended orders could result in duplication and double dosing of medications ordered on transfer.

Untoward Changes in Communication Patterns

1. Some users complain that the EMR creates an illusion of communication,[7] in which users believe that information entered into the system will be somehow communicated to the relevant personnel. This assumption can result in the missed or delayed execution of orders or failure to appreciate the recommendations of a consultant.
2. Users may erroneously assume that allergies entered into the system will adequately protect patients from receiving offending food or drugs.
3. Because of the time-consuming nature of CPOE and because workstations are not always available at the bedside, orders are often written after work rounds. By that time, the other members of the care team have disbanded, and clarification of the order requires tracking down and reconsulting the relevant personnel.

High System Demands and Frequent Changes

No installed EMR can remain static for long. Maintenance, revisions, and upgrades of both software and hardware contribute to constant flux.

1. Consequences should be expected with every change, and many changes require testing that can become onerous. Although minor changes can occur without supplemental training of personnel, failure to provide training for some changes can cause significant user frustration and errors.
2. Some configuration changes requested by one group may also adversely affect other users in unexpected ways. Mechanisms must be developed to resolve conflicts of this nature. As clinicians become increasingly dependent on the system, pressure to keep the system operational mounts, requiring around-the-clock technical support.

Persistence of Paper

Whereas going paperless is an often stated goal, the elimination of this most versatile recording device is unlikely. An EMR changes the pattern of paper consumption: A higher proportion of pulp is sent to the shredder rather than to medical records.

1. Reports are printed in the process of caring for patients and are often discarded at the end of a shift.
2. Some institutions also regularly print worksheets as backup in the event that the system experiences unscheduled downtime.
3. A more insidious problem of persisting paper can arise when the patient chart is divided between paper and an electronic version, particularly when one medical service writes notes in one medium and another service uses the other. Splitting physician documentation can result in breakdowns in communication, with serious consequences.

Overdependence on Technology

As the EMR becomes more integrated into clinical practice, downtime becomes more onerous to the users. Prolonged failures can even cripple an organization by causing delays, diminishing capacity, and limiting capabilities. Although backup systems can never quite replace the fully functioning system, contingencies for downtime must be developed, and users must be adequately trained to execute these plans efficiently.

Human-Factors Engineering

Human-factors engineering investigates human capabilities and limitations and applies that knowledge in the design of systems, software, environments, training, and personnel management. The application of human-factors considerations in developing an EMR, particularly regarding CPOE, can maximize the successful design and implementation of these systems. Three principles of this study that may improve clinical-information systems are accounting for incentive structures, understanding workflow, and promoting awareness of the activities of other group members.

1. Improving collaboration may decrease the incidence of medical errors.[9]
2. Another important area of human-factors engineering relates to interface design. Interfaces should be simple and consistent, with important data highlighted, such as the patient name or weight. Progressive disclosure means that commonly used and important functions should be presented first and in a logical order.
3. Minimizing human memory load can be accomplished by displaying all relevant information together.

4. Potential user errors should be anticipated and easy error recovery should be designed into the system. Error messages should be informative and could include advice about error recovery.
5. Given the chaotic healthcare environment, the interface should also be designed to forgive interruptions, allowing work to be saved and resumed later.
6. User satisfaction is an important predictor of system success. Ease of use, rapid response time, flexibility and customizability, mobile workstations, implementation of effective decision-support tools, access to reference information, and adequate training and support are all important factors in enhancing both user satisfaction and system success.

PATIENT PRIVACY

The privacy rules protect confidentiality and privacy of protected health information. The intent of these regulations is not to prevent legitimate access to information but to put limits on uses of patient information beyond patient care or business activities directly related to patient care.[10] The privacy rule:

1. Limits the non-consensual use and release of private health information.
2. Gives patients new rights to access their medical records and to know who has accessed them.
3. Restricts most disclosures of health information to the minimum needed for the intended purpose.
4. Establishes new criminal and civil sanctions for improper use or disclosure.
5. Establishes new requirements for access to records by researchers and others.

The privacy rule applies to protected health information whether it is stored in electronic form or not.

Protected Health Information

Ensuring the privacy of personal health information has always been a concern, but the availability of this information in electronic form raises new concerns because securing it is not a simple matter of putting it under lock and key. These rules apply specifically to protected health information (PHI), which is any health information that can be linked to an individual (Table 2.1).

Table 2.1: Elements considered protected health information

- Names
- All elements of dates (except year) for dates directly related to an individual, including:
  - Birth date
  - Discharge date
  - Admission date
  - Date of death
  - Date of procedure
- Telephone numbers, fax numbers
- Electronic mail addresses
- Social security numbers
- Medical record numbers
- Health plan beneficiary numbers
- Account numbers
- Certificate/license numbers
- Vehicle identifiers and serial numbers
- Biometric identifiers, including finger and voice prints
- Full face photographic images and any comparable images
- Address details
- Any other unique identifying number, characteristic

Data Exchange in Single and Multiple Health Organization

Health information exchange (HIE) is the process of sharing patient-level electronic health information between different organizations.[3] HIE provides the capability to electronically move clinical information among different healthcare information systems that is safer and more timely, efficient, effective, and equitable patient-centered care. Further, HIE systems facilitate the efforts of physicians and clinicians to meet high standards of patient care through electronic participation in a patient's continuity of care with multiple providers.

Secondary healthcare provider benefits include reduced expenses associated with:

- The manual printing, scanning and faxing of documents, including paper and ink costs, as well as the maintenance of associated office machinery.
- The physical mailing of patient charts and records, and phone communication to verify delivery of traditional communications, referrals, and test results.
- The time and effort involved in recovering missing patient information, including any duplicate tests required to recover such information.

The primary responsibility of the HIM professional has been to provide accurate data to support the delivery of quality healthcare. The HIM professional has to balance the patient's right to privacy with the need to allow access to health data for legitimate uses.

HIE models: HIEs typically have one of three architectures; centralized, federated (or decentralized), and hybrid. The choice of architecture is driven by the organization's privacy and security practices.

Patient Information Exchanged within an HIE

The overall goal of HIE is to provide a patient's requested clinical information in real time and in a format that allows it to be used effectively by the provider currently seeing the patient. To achieve this purpose, the HIE may provide the requested information in a variety of ways. For example, accepted formats for exchange documents are varied and include the continuity of care document (CCD) or continuity of care record (CCR), scanned documents in PDF, TIFF or other format, HL7 records, plain text records, and the like. In most cases, the document formats are dependent on the original source formatting. The "gold standard" is a document that can be "parsed" to provide discrete data elements that can be incorporated into the current provider's electronic health record (EHR) using standard mapping and conversion techniques.

How a patient's information is maintained, corrected, or updated when new information is sent to the HIE?

A combination of automated and manual processes are in use in various HIEs to maintain the integrity of any EMPI. Typically, the HIE uses the same processes as a self-contained EMPI. It is continuously updated by data sources regarding patients who have opted in and out of the exchange. To a greater or lesser extent, historical information is maintained with all updates as patient matching algorithms match new patient demographic information against existing information. Systems that rely on the algorithm usually set a confidence level, so that if a match does not meet a confidence threshold, then a new patient is created. A report is periodically run to identify likely matches subsequently reviewed by the HIE staff. Depending on staffing availability, HIE staff follow up with the submitting facilities as necessary to verify the validity of the demographic data. Corrections are made as necessary and when indicated. Duplicate patients are merged or linked.

Clinical tools, e.g. barcode, telemedicine, smart infusion pump, etc.

Bar code

Dating back to the 1970s, there has been a continual effort among healthcare settings to adopt bar code technology. In the early 2000s, published reports began to illustrate high rates of medical error and the increasing costs of healthcare. As a result, the desire for bar coding technology in healthcare has grown as a realistic and applicable solution. Ranked first in 2007 and second in 2008 in the Annual Healthcare Information and Management Systems Society (HIMSS) Leadership Survey, HIMSS placed high priority on the use of barcoding technology to reduce medical errors and promote patient safety (Fig. 2.2).

Fig. 2.2: Basic information in a bar code

TELEMEDICINE

Telemedicine is the use of telecommunication and information technologies in order to provide clinical healthcare at a distance.

It helps eliminate distance barriers and can improve access to **medical** services that would often not be consistently available in distant rural communities (Fig. 2.3).

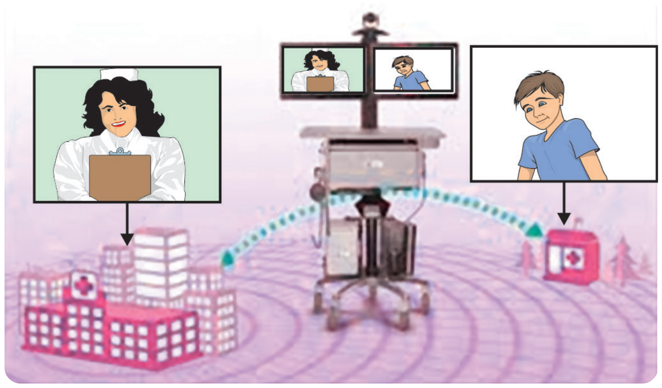

Fig. 2.3: Telemedicine

THE INTERNET

The Internet is a loosely defined aggregate of global computers connected in a network that is constantly evolving. The Internet has undergone phenomenal growth in the last decade and has transformed the very nature of information transactions. In contrast to such traditional information as libraries, the Internet provides instant access to vast amounts of information on any subject, anywhere, at anytime, to anyone with a computer and internet access. For the healthcare worker, it has become both a vast repository of clinical and research knowledge and a tool used in day-to-day practice.

Often, the terms Internet and World Wide Web (WWW) are mistakenly interchanged, but the two are not synonymous. The Internet is a collection of interconnected computer networks, whereas the WWW is a collection of interconnected documents, linked by hyperlinks. The intranet is an internal network that uses Internet technologies and is often used by organizations to provide a secure network to support internal exchange of information.

Internet Communication Services

The Internet supports various forms of communication services and protocols that allow information to flow from point to point, including e-mail, newsgroups, LISTSERVs, file transfer protocols, streaming media, voice-over-Internet protocols, and others.

E-mail

It is extensively used by almost all healthcare workers to communicate among themselves, recent trends include e-mails between physicians and patients, which increases opportunities for patient access to care, education, and the potential for increased compliance to therapy. E-mail is vulnerable to being intercepted, read, or even modified by unauthorized parties. Measures such as encryption, electronic signature, and virus scanning can improve the safety of e-mail communications but may not totally eliminate all of the hazards.

Newsgroups and LISTSERVs

It is an extension of e-mail communications, groups with common interests form a common e-mail group known as a LISTSERV or a mailing list. The e-mails that originate from any member of the group are directed to all members and serve to generate ongoing discussion on any given topic of interest. For example, healthcare workers exchange ideas on pediatric intensive care related topics via the PICU LISTSERV.

Unlike the mailing list, where e-mails are sent to all members, newsgroup messages are posted on a news server from which members can access and respond to the postings. Newsgroup software allows users to search for a topic of interest or to follow all messages in a single discussion thread. Many patients who share a common diagnosis (e.g. Down syndrome) often join newsgroups to communicate with other patients and families with similar medical conditions.

File Transfer Protocol (FTP)

It allows files to be transferred and retrieved between computers connected over the Internet. Documents, images, sound, and video files can all be transferred via this protocol. Digitized radiology files are often transmitted using these protocols.

Streaming Media

Such as webcasts, permit the broadcast of audio and visual data to any remote computer that is connected to the Internet. It may be used to broadcast medical conference proceedings, either live or from archived files, to a large number of participants who may otherwise not have been able to attend in person. Webcasts of talks from nationally and internationally renowned scientists can thus be made available to remote users at anytime. Although, webcasts are primarily one-way presentations to an audience that does not communicate with the presenter, web conferences are smaller, more interactive meetings that enable two or more participants to simultaneously view and hear the same content in real time on remote computers connected via the Internet. Thus, web conferences reduce travel time and expenses involved in face-to-face meetings.

Podcasting

It is a variation of a webcast that contains only audio material. Podcasts can be easily downloaded to portable digital audio players and listened to on the move. The Society for Critical Care Medicine offers iCritical Care podcasts that allow listeners to keep (http://www.sccm.org/SCCM/Publications/iCritical+Care/) up-to-date with the latest topics in critical care.

Voice-over-Internet Protocol (VoIP)

It allows voice to travel over the Internet, has made real-time audio and videoconferencing relatively easy and affordable.

INTERNET SEARCHING TIPS AND RESOURCES FOR PROVIDERS

Although searching the web has become second nature to most healthcare workers, the use of certain advanced search techniques can help to improve the sensitivity and specificity of any given search.

- Frequently visited websites can be bookmarked for easy future access.
- Placing quotation marks around search words in Google ensures that all of the words within the quotation are searched together as a single phrase.
- A minus sign placed before a word ensures that the particular word is excluded from the search.
- A specific term can be searched within a specific website.
- Other advanced search strategies can be accessed from the Google search page by clicking on the link "Advanced Search".
- The Google search engine includes a simple calculator and a conversion calculator that healthcare providers may find useful.

- A recent addition is the Google Scholar Beta search engine at www.scholar.google.com, which is Google's effort to index scholarly literature. Google Scholar allows users to conduct a comprehensive search of scholarly literature that includes peer-reviewed papers, abstracts, and articles, as well as theses and books from academic publishers, professional societies, preprint repositories, universities, and other scholarly organizations. The results are thus more extensive than those obtained by searching the Medline database through PubMed.
- In addition to the PubMed and Google Scholar search engines for journal articles and scholarly work, a number of websites are particularly useful to pediatric critical care practitioners.
  - The Pediatric Critical Care Medicine website at http://www.PedsCCM.org is a comprehensive website dedicated to the specialty.
  - The Virtual PICU website at http://www.vpicu.org provides a common space for the sharing of information by the international community that provides care for critically ill children.
  - Some other useful medical reference websites include www.emedicine.com, a web-based electronic textbook; Up to date online at www.utdol.com, a subscription-based comprehensive electronic textbook to which many academic institutions subscribe; www.mdconsult.com and www.merck-medicus.com, both of which offer similar services that include journal articles, electronic textbooks, drug references, and patient education material.
  - For those who prefer to attend live, in-person CME courses, www.findthatce.com allows users to locate CMEs, searchable by geographic location and topic of interest.

Healthcare on the Internet for Consumers

Using the Internet to obtain health information regarding diagnosis, treatment, and drug medications is one of the most popular consumer uses of the Internet. Patients who share common health problems have formed numerous online communities that provide peer support, information on the latest research, and an exchange of personal experiences. Consumers must be aware of the quality and authenticity of this information before they use it to make critical decisions affecting their healthcare. Many publications on the Internet lack the peer-review process associated with printed publications. An Australian study in 2003 found that many consumers do not properly interpret the healthcare information they find on the Internet and that this, in turn, could lead to anxiety and poor compliance with therapy.[11] A 2004 study found that information on the Internet regarding medical emergencies was often incomplete and, in some cases, potentially dangerous.[12]

A wide range of high-quality websites is available for consumer health information.

- The Medline Plus website (http://medlineplus.gov) is the consumer version of the National Library of Medicine's Medline database.
- The website of the Centres for Disease Control and Prevention (http://www.cdc.gov) contains information that supports the goal of promoting health and quality of life by preventing and controlling disease, injury, and disability.
- Other commercial and pharmaceutical websites include www.WebMD.com, www.Intelihealth.com, and www.DrKoop.com. Many medical societies (e.g. the American Diabetic Association) also provide consumer health information on their websites, as do healthcare insurance organizations.

Internet and Security

Although the Internet is geared toward providing open access to publicly stored information, it is equally important to safeguard transactions related to healthcare and e-commerce from unauthorized access. This protection is achieved either by the encryption of data as it is transmitted over the Internet to prevent its interception or by limiting access to data by placing it on secure internal networks and providing access through authenticated user accounts and passwords. Safe computing practices should be used at all times and by all users within a system (Table 2.2).

Handheld Computers

Point-of-care computing, also known as mobile computing, is a fast-emerging technology that allows users to access information resources at the point of care and at the time of care. Small, portable, handheld computers, also known as personal digital assistants (PDAs) are powerful enough to meet most of the information needs of today's healthcare workers. The newer smart phones combine a cellular phone with a PDA, thus increasing utility while eliminating the need to carry two separate devices. PDAs can provide today's healthcare workers with a wide array of information when and where it is needed. An ever-increasing variety of medical software programs, both free and commercial, is available for downloading from the WWW. A categorized list of software that PICU practitioners may find useful is shown in Table 2.3.

Useful Services for Handheld Computers

A number of websites provide useful medical services specifically geared for use on PDAs.

- MD on Tap (http://mdot.nlm.nih.gov/proj/mdot/mdot.php) is an application that allows mobile healthcare

Table 2.2: Safe computing practices

Back up your data: Safe computing practices can decrease the risk to your data but cannot eliminate it altogether
Use antivirus software: Use real-time virus protection at all times. Scan all files obtained across network or Internet connections, including from e-mail, websites, instant messaging, or other sources. Scan all flash drives, CDs, or other removable media that are given to you. Scan all software before you install it
Beware of e-mail attachments: Be suspicious of all e-mails, but especially those that are unexpected or out of character. Do not set the e-mail program to automatically open attachments. If the e-mail program can render HTML messages, set it to disallow all executables (ActiveX, Java, and JavaScript)
Do not share: File sharing and printer sharing should be disabled, if these functions are not needed. If they are needed, limit access to your network.
Use a firewall: Files attempting access to the Internet or Internet servers attempting to access your computer should be investigated before they are granted access in the firewall configuration
Protect passwords: Follow accepted guidelines for creating strong passwords. Do not record passwords in any unsecure documents. Disable password management in the web browser
Keep security updated: Obtain and install all software security updates, particularly for operating systems, e-mail clients, and web browsers
Keep browser security updated: Consider setting the browser security setting on "high" to prevent ActiveX or Java programs from running
Use macro virus protection: Offered by some programs, notably Microsoft Office, macro virus protection identifies files that contain any macro before they are opened

professionals to search and retrieve MEDLINE citations directly from their handheld devices, through a wireless connection to the Internet.

- An alternate way to access the MEDLINE database via PDA is the PubMed website, http://pubmedhh.nlm.nih.gov/nlm/, which has been specifically optimized for searching the MEDLINE database via mobile handheld devices.
- The MerckMedicus PDA tools include useful downloads, such as the Pocket Guide to Diagnostic Tests; Asthma Guidelines from the National Heart, Lung, and Blood Institute; and other DSS tools.
- MD Consult Mobile is a PDA companion to the web-based MD Consult service that allows users to read medical news, drug updates, and tables of contents from journals on their PDAs.

Table 2.3: Medical software for handheld

Drug references
Pediatric Lexi-Drugs is the handheld version of the standard pediatric drug reference book that is by far the most comprehensive and widely used pediatric drug reference. *ePocrates Rx* is another drug reference available for free downloading to PDAs
Medical References
Some of the commonly used pediatric reference textbooks available in the handheld format include *The Harriet Lane Handbook, the 5-Minute Pediatric Clinical Consult,* and the *Washington Manual Pediatrics Survival Guide,UptoDate*
Medical calculators and utilities
ER and ICU Toolbox is a useful modules include PALS protocols, codemedications and drip calculators, a drug calculator, an antibiotic guide, a toxicology guide, and many more
PICU Tools (free) is similar software application that consists of many useful calculators, such as a blood gas calculator, Swan-Ganz calculator, and other reference materials
Documents to *Go is* a suite of programs equivalent to desktop Microsoft Office Suite software
Patient databases
PatientKeeper is a popular patient database program that integrates with clinical-information systems to provide ready access to test results, medication histories, allergies, vital signs, and other clinical information through handheld computers at the point of care

Limitations and the Future of Handheld Computers

- The small screen size limits the amount of information that can be viewed in one screen, and the display can sometimes be visually challenging.
- Although the compact form factor makes PDAs portable and convenient to carry, the chance of damage from inadvertently dropping these small mobile devices is increased.
- Unlike desktop computers, PDAs can be easily misplaced or stolen, and because PDAs can store relatively large amounts of patient data, loss or theft of the device may potentially jeopardize the confidentiality of protected health information. A 2006 meta-analysis of surveys revealed clear evidence of an increasing trend in PDA usage by healthcare professionals. The overall adoption rate by individuals ranged between 45 and 85%, indicating a high but somewhat variable adoption.[13]

TELEMEDICINE

The Office for the Advancement of Telehealth describes telemedicine as the use of electronic information and telecommunication technologies to support long-distance clinical healthcare, patient and professional health-related education, public health, and health administration.[14] Telemedicine has been used universally for decades in the form of simple telephone communications between healthcare providers and patients, as well as healthcare education provided to medical practitioners.

Telemedicine is more commonly used to ensure equitable access to expert medical care in remote and underserved areas, provide remote patient and provider education, reduce travel requirements, improve patient care, and reduce costs. Technologies that are commonly used to provide live, interactive communications between linked sites, making telemedicine feasible, include video-conferencing, Internet communications, store-and-forward imaging, streaming media, and land-line and wireless communications.

Several studies have demonstrated that full-time intensivist coverage in ICUs results in a significant reduction in ICU mortality, lengths of stay, and resource utilization.[15] Yet, the national shortage of intensivists and the high cost associated with 24-hr intensivist coverage are barriers that preclude hospitals from providing such services. The application of telemedicine in ICUs is ideally suited to address this shortfall by allowing off-site intensivists to monitor and care for many more ICU patients than is possible with direct hands-on care. Initial studies of remote ICU monitoring conducted at the Johns Hopkins University demonstrated a reduction in severity-adjusted ICU mortality by 68% and a 44% reduction in the incidence of ICU complications. ICU lengths of stay and ICU costs were also decreased.[16] A commercial remote ICU telemedicine company, VISICU, evolved from this research and offers continuous management of ICU patients by providing off-site remote monitoring to augment the on-site care provided by local healthcare providers. Although remote ICU care via telemedicine will not replace onsite care, it can supplement the level of care by improving the level of expert physician coverage. A systematic review of > 600 telemedicine cost-benefit studies found that > 10% of the studies met the criteria for good economic analysis. Of the 24 studies included in the review, many were small-scale or short-term projects, leading the authors to conclude that the current evidence did not conclusively demonstrate a cost-benefit advantage from telemedicine projects.[17] Similarly, a Cochrane review in 2000 that evaluated clinical outcomes identified seven telemedicine trials and concluded that evidence from these trials failed to show unequivocal clinical benefits.[18]

CONCLUSION

Although the use of information technology in healthcare has been gathering rapid momentum, its widespread implementation and uniform utilization are still a dream that has not been fully realized. Technology will undoubtedly continue to play a greater role in all aspects of health delivery, including clinical practice, research, and education. However, it will never replace compassionate patient care and human contact. Experience has clearly shown that the improper selection and implementation of technology in the healthcare arena will produce negative results instead of bringing about improvement in safety, efficiency, and costs. To successfully make this transition, organizations must be committed to innovation, progress, and change. Individuals and organizations that is most adaptive to this changing healthcare climate brought on by increasing use of information technology will emerge successful.

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