INFORMATION RESOURCES IN PHARMACY AND HEALTHCARE

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Received 21 November 2012; accepted 11 December 2012

Abstract
Informatics, a broad academic field encompassing human-computer interaction, information science, information technology, algorithms, areas of mathematics (especially mathematical logic and category theory), and social sciences that are involved. In this article Drug Information systems, controlled vocabularies, bibliographical databases are listed and described in detail along with examples. The Pharmaceutical literature available on the World Wide Web and guidelines to search them are discussed here. The drug information databases available for professionals and patients and Pharmacy Information Systems used in pharmacies nowadays is discussed in a comprehensive manner.

Keywords: Informatics; drug information system; controlled vocabularies; bibliographic database; BIOSIS, CAS, SCI.

Introduction:
Information technology (IT) is a branch of engineering dealing with the use of computers and telecommunications equipment to store, retrieve, transmit and manipulate data. The Information Technology Association of America has defined IT as “the study, design, development, application, implementation, support or management of computer-based information systems.
Informatics, a broad academic field encompassing human-computer interaction, information science, information technology, algorithms, areas of mathematics (especially mathematical logic and category theory), and social sciences that are involved.
Informatics is the study of the best practices in information accrual, handling, dissemination, and comprehension using appropriate technology. No part of Pharmacy and Pharmaceutical Sciences be it basic pharmaceutical sciences (e.g., pharmacogenomics, pharmaceutical chemistry, pharmacokinetics), pharmaceutical technology and management (e.g., pharmaceutics, pharmacoeconomics, study design), or clinical pharmacy practice (e.g., therapeutics, drug information, diagnostics, patient counseling) is unaffected by the informatics or information technology.
Pharmacy informatics
The American Society of Health-System Pharmacists (ASHP) defines Pharmacy Informatics as an important subset of medical informatics in which pharmacists “use their knowledge of information systems and medication-use processes to improve patient care by ensuring that new technologies lead to safer and more effective medication use.”

Medical Informatics
The American Medical Informatics Association (AMIA) defines Medical Informatics as “the use of information science and technology to advance medical knowledge and improve quality of care and health system performance.”
The American Association of Medical Colleges defines Medical Informatics as “the rapidly developing scientific field that deals with resources, devices, and formalized methods for optimizing the storage retrieval and management of biomedical information for problem solving and decision making.”

Bioinformatics
Stedman’s Medical Dictionary defines Bioinformatics as “the scientific discipline encompassing all aspects of biologic information acquisition, processing, storage, distribution, analysis, and interpretation that combines the tools and technology of mathematics, computer science, and biology with the aim of understanding the biologic significance of a variety of data.”

DRUG INFORMATION SYSTEM
The drug information system is comprised of the following to provide a better healthcare to the public.

- Primary Literature
- Drug Information Databases
- Internet Resources
- Hospital Information Systems
- Pharmacy Information Systems
- Drug Discovery
• Pharmacogenomics

Use of Information technology (IT) in Healthcare

Information technology is used very less in healthcare. The radiology department began using image processing, and various departments began developing and using databases for diverse information ranging from patient records to pathology samples to the tumor registry. These systems required expert personnel and in no way communicated or interoperated with each other. The late 1970s and early 1980s saw the emergence of intranets: internal computational networks that started to allow these computers to communicate. In the early 1980s, IT slowly migrated into back office, to inventory control, central supplies, as well as management of pharmaceuticals and other prescribed medical products. In the early 1990s, IT began a slow adoption within prescription management, processing, prescription label generation, pharmacy billing, and work flow. In the mid-1990s, the Internet began to be recognized as an expedient source of some medical and pharmaceutical information.

CONTROLLED VOCABULARIES

A controlled vocabulary is a collection of words with specific meaning; a standard is a collection of rules that determine how the words in the controlled vocabulary can be combined and used for a purpose. Controlled vocabularies are defined to conform to a standard. Standards are static once they are defined but vocabularies conforming to that standard need to be dynamic to embrace new terminology that enters the field in the same way that new words enter the English language.

Examples of standards and the organizations;

• ASC X12, the Accredited Standards Committee (www.x12.org), is an organization that develops electronic data interchange (EDI) standards and related documents for national and global markets, including pharmacy.
• ASTM–ASTM International (www.astm.org) provides technical standards for materials, products, systems, and services.
• HL7, Health Level 7 (www.hl7.org), provides standards for interoperability that improve care delivery, optimize work flow, reduce ambiguity, and enhance knowledge transfer among all stakeholders, including healthcare providers, government agencies, the vendor community, fellow standards-developing organizations (SDOs), and patients.
• NCPDP, National Council for Prescription Drug Programs (www.ncpdp.org), is an organization that develops standards for all areas of the pharmacy services industry.
• NGC, National Guideline Clearinghouse (www.guideline.gov), is a public resource for evidence-based clinical practice guidelines.
• CPT(currentproceduralterminology;www.ama-assn.org/ama/noindex/physicianresources/ 3112.shtml) is the most widely accepted medical nomenclature used to report medical procedures and services under public and private health insurance programs. CPT is maintained by the American Medical Association
• GO (gene ontology) is used to describe gene products (www.geneontology.org).
• ICD (international classification of diseases; www.who.int/classifications/icd/en) classifies diseases and other health problems recorded on many types of health and vital records, including death certificates and health records. It is maintained by the World Health Organization. 40 . Philip E. Bourne and Susan M. McGuinness
• LOINC (logical observation identifiers and codes; www.loinc.org) provides universal codes and names to identify laboratory and other clinical observations.
• NDC (national drug code; www.fda.gov/cder/ndc) is a unique, three-segment number used as a universal product identifier for human drugs and supported by the U.S. Food and Drug Administration (FDA).
• RxNorm (www.nlm.nih.gov/research/umls/rxnorm) provides normalized names for clinically used drugs and links its names to many of the drug vocabularies commonly used in pharmacy management and drug interaction software.
• SNOMED (systematized nomenclature of medicine—clinical terms; http://www.nlm.nih.gov/research/umls/Snomed/ snomed_main.html) is the most comprehensive vocabulary of clinical terms.

1. Bibliographic databases are tools available for finding published materials; for example, library catalogs are bibliographic databases used to find items owned by a library. Each record describes a specific work, such as a book or journal; fields include title, abstract, author, author affiliation, publication date, volume, page numbers, subject headings, etc. Controlled vocabularies also help manage ambiguity. Using the controlled vocabulary helps ensure that the searcher uses the same language the database uses to describe the subject.

2. Medical Subject Headings

In the biomedical literature database, MEDLINE, the preferred controlled vocabulary terms of the subject field are called medical subject headings (MeSH). MEDLINE includes a thesaurus, the MeSH database, to help users locate preferred MeSH terms for their subjects. MeSH evolved over 150 years. Long before computers and electronic databases, controlled vocabularies were used to search the biomedical literature. The first computer-searchable database of medical literature, called the Medical Literature Analysis and Retrieval System (MEDLARS), was produced in 1964.

3. Drug nomenclature standards.

Drug nomenclature standards are examples of controlled vocabularies. Investigational drug codes are often used for drugs early in development, when chemical names are trade secrets. These codes sometimes appear in the literature at early stages. Many bibliographic databases include a CAS RN field that helps specify drug searches. Generic names are assigned later in a drug’s development by the United States Adopted Names (USAN) Council. Sometime international (INN), British (BAN), or Japanese (JAN) adopted names differ from the USAN name, so a comprehensive search would have to include all adopted names. For example, the most effective way to search for a drug in a hospital system may be the NDC; some chemical
literature databases can be searched very effectively by chemical structure; and the best nomenclature to use in MEDLINE is the generic (USAN) name.

4. The Unified Medical Language System
The unified medical language system (UMLS) is a semantic network of bibliographic database vocabularies; it is a metathesaurus including over 60 vocabularies used in the biomedical sciences. The NLM established the UMLS to facilitate interoperability between information systems. The UMLS includes MeSH, SNOMED, ICD, GO, and many more. It also includes a controlled vocabulary for drug information, RxNorm, which reconciles all the different terms used for drugs and defines synonymy at a more granular level than merely the generic name.

5. Ontology
In healthcare, ontology describes, in a computer-readable form, the knowledge of a particular domain, including both syntax and semantics. The most well known ontology the gene ontology (GO) used to describe gene products. Earlier in the development of molecular biology, as new genes were discovered, there was a tendency to name them after the person who discovered them or to assign a variety of common names. For example, intracellular homology domain of FAS (Apo-1) and the TNF-receptor became known as the death domain.

6. Sources of Literature
Pharmacists, as partners in the healthcare team environment, rely on accurate, timely drug information in every phase of clinical decision making, including choice of drug, appropriate dosage and administration, safety, cost effectiveness, adverse effects, drug interactions, and more. The ACPE standards also require that information resources be integrated into teaching programs and that schools “should provide organized programs to teach faculty, preceptors, and students the effective and efficient use of the library and educational resources.” Accreditation Council for Pharmacy Education.

Tertiary sources include information that has been compiled and repackaged, such as meta-analyses, practice guidelines, review articles, textbooks, encyclopedias, and Web sites. Some databases that provide summary information from reviews of primary literature also fit in the category of tertiary sources. For example, Clinical Pharmacology and Micromedex are drug information databases to which many hospitals and academic institutions subscribe. Pharmacists should be familiar with commercially available tertiary drug information databases and be able to evaluate and select the best database products to support the services they provide.

Secondary sources are indexes that provide information about and access to primary and tertiary sources. The index of a textbook is an example of a secondary source that points the reader to specific information within the book. Online indexes created and maintained by abstracting and indexing services organize information about articles published in newspapers, magazines, scholarly journals, and more. These online indexes are also known as “bibliographic” databases.

Internet search engine is also a secondary source because it leads users to both primary and tertiary sources on the Web. Without the searchable secondary source, the primary article would be almost impossible to locate; the searcher would have to browse through thousands of journals in the hope of finding articles about the chosen topic. For example, a pharmacy resident who wants background information on the condition of a patient should start with tertiary sources, such as textbooks or Web sites, to find overviews of the subject and would then use a library catalog or Web search engine to locate those tertiary sources. A pharmacist who wants to find the best current evidence on the efficacy of one drug over another could use MEDLINE or another index of medical literature to find primary studies comparing the drugs.

BIBLIOGRAPHIC DATABASES
A bibliographic database is an electronic A bibliographic database is an electronic index of literature that can include books, journals, magazines, etc. When primary sources are needed, scholars start with an Internet search engine (e.g., Google or Yahoo!), which scans Web sites and other information on the Web for their search terms. These searches yield a large number of results that must be filtered to select the best results. When the desired sources are journal articles, the Internet search engine can be a useful place to start; for example, Google Scholar indexes the journal articles in PubMed, the NLM’s free Web interface to MEDLINE. At the time of this writing, however, bibliographic databases are more powerful and comprehensive search tools for accessing scholarly literature than Internet search engines. Bibliographic databases are specific to subject areas, the selection of the appropriate database provides an initial focus on the subject before the search process even begins. Bibliographic databases also provide better tools for focusing searches to find the most relevant studies while filtering out irrelevant results. For example, in searching for biomedical literature, a PubMed search provides more control over recall and precision than a Google Scholar search. Search strategies The challenge of good literature searching is to focus the search precisely on the topic without losing relevant information—that is, to cast a wide enough net to retrieve as many relevant documents as possible, while minimizing the number of irrelevant documents. Information retrieval experts refer to this as a balance between recall and precision, where precision is the ratio of the number of relevant documents to the total number of documents retrieved in a search and recall is the ratio of relevant documents retrieved to the total number of relevant documents that exist.

Guidelines for Searching Bibliographic Databases
Each bibliographic database has unique search tools.

Guidelines
1. Identify the Main Concepts Consider specific aspects of the topic and include terms to help focus the topic. For example, if the topic is diabetes mellitus, consider whether specific age groups, interventions, or other aspects are of interest.

2. Define Search Terms Write down as many terms as possible that describe the main concepts, including synonyms. Some databases have fields for nomenclatures such as Chemical Abstracts Service (CAS) registry...
numbers, which can be very useful in searches for a specific chemical substance.

3. Use Boolean Logic

Boolean logic has many applications; in this context, it is used to combine search terms in a logical query to inform the bibliographic database how to interpret the query and run the search. The Boolean “AND” operator will produce results that include all the terms in the search. If we search for “acetaminophen” AND “adverse effects,” we would retrieve only the references that discuss both topics.

Acetaminophen AND Adverse Effects

Fig :5.2 The Boolean “AND” operator.
Acetaminophen OR Adverse Effects

Fig ure 5.3 The Boolean “OR” operator.

5. Use Multiple Sources

Use multiple databases to broaden the scope of the search. This is especially important when writing literature reviews, which require extensive background information. No one database is comprehensive; it is essential to be aware of the variety in scope and content among sources. Literature on drugs, pharmaceutical sciences, and pharmacy practice may be found in a variety of bibliographic databases. The most appropriate source will depend on the topic, but it is always a good idea to use multiple sources. Drug information resources over the life span of a drug.

6. Use Appropriate Drug Nomenclature

Choose appropriate drug nomenclature for the search. Drugs may be designated only by their CAS registry number, chemical name, a manufacturer’s investigational drug code, or possibly a generic name. After marketing, a drug will have many more designations, including its National Drug Codes and proprietary or brand name.

7. Launch New Searches from Results

Authors listed in references may be hyperlinked, so a click will invoke a new search on that author’s name. Look for links to “related articles,” which will locate articles with common index terms or common references. Sometimes index terms are listed in database records and can be used to find other records indexed with those same terms.

THE CHEMICAL ABSTRACTS SERVICE

The CAS provides a useful bibliographic database of chemical information, including drug information dating from 1907 to the present. Using the CAS is usually more efficient and effective than searching the biomedical literature when chemical or physical properties of drugs or information on chemical synthesis and product formulations are sought. The CA database includes several unique fields not typically found in bibliographic databases, such as chemical structures, chemical property data, and manufacturers. The CAS also includes many document types such as patents, dissertations, and technical reports in addition to journal articles. Because of its great breadth, CAS is often used to locate documents not indexed elsewhere. Patents describing the manufacture of a specific drug fall into this category. CAS is available as an online database. SciFinder Scholar (SFS) provides an easily searched interface for CAS and is licensed by many large institutions. SFS provides a wealth of chemical data in addition to citations to published articles and other documents. It has property data, such as pKa and solubility for millions of compounds.

BIOLOGICAL ABSTRACTS (BIOSIS)

BIOSIS is available as the BIOSIS Previews database. It indexes journals, books, book chapters, dissertations,
conference proceedings, and patents from 1926 to the present in the major fields of biology, including biochemistry, biotechnology, genetics, nutrition, and many other areas of interest to pharmacists. BIOSIS Previews is useful in finding information about drugs in very early trials in animals. It is also a good source of information from books and book chapters because many bibliographic databases, including MEDLINE, do not include books.

MEDLINE

Created and maintained by the U.S. National Library of Medicine (NLM), MEDLINE is one of the largest literature databases in the health sciences. It indexes close to 5,000 scholarly journals in basic and biomedical sciences, with articles dating from 1950 to the present. MEDLINE does not index conference proceedings or book chapters. The service is available through many vendors who have created various search interfaces.

PubMed

The PubMed interface described in this chapter is freely available on the Web from the NLM and also includes several smaller databases containing some articles that are not part of MEDLINE. PubMed has advanced search features that allow users easily to combine terms with the Boolean AND or OR, as well as to restrict searches to specific fields. There are two ways to search specific fields. The first is to use the “limits” feature and select the desired fields, such as author, journal title, date, or MeSH; the second is to use field qualifiers, which can be entered directly in the query as suffixes to the search terms. For example, if the need was for search terms to be found only in the article title, “your term [ti]” would be entered in the query box. It has a very useful field for pharmacologic action MeSH terms. The PubMed document-type field is especially useful because it indexes over 50 article types to which a search can be limited or that could be excluded from a search (phase I–IV clinical trials, randomized controlled trials, case reports, metaanalyses, practice guidelines, and more). A query could be constructed, for example, to retrieve only randomized, controlled trials or to exclude case reports.

INTERNATIONAL PHARMACEUTICAL ABSTRACTS

IPA is produced by the American Society of Health-System Pharmacists (ASHP) and covers pharmacy and drug information from 1971 to the present. IPA indexes approximately 800 journals plus conference abstracts from the ASHP, American Pharmacists’ Association (APhA), International Pharmaceutical Federation (FIP), and American Association of Colleges of Pharmacy (AACP). Many of the journals indexed in IPA are also indexed in MEDLINE, but a number of journals are unique to IPA, including state and international

Citation Searching

Citation searching is the process by which one locates articles that cite a specific source article. Subject indexes such as MEDLINE allow the searcher to find articles that cite the source article, as long as the articles have subject classifications or text in common. But articles associated by subject would not encompass the entire body of documents that refer to the source. The first such index for science, the Science Citation Index (SCI) was conceived in 1955 by Eugene Garfield, who argued that subject searching was only a starting point for a comprehensive review of the literature because subject classifications were not precise enough to capture all of the ideas in a paper. The first SCI, launched in 1965 as print volumes, indexed 600 journals; it now indexes over 3,000.

THE SCIENCE CITATION INDEX (SCI)

Before Web-based bibliographic databases emerged, citation searching was painstaking work. To determine the total number of times a paper was cited from the year it was published to the present, one had to consult each annual volume of SCI and add up the number of citing references in each year. The online SCI is currently available through several vendors now SCI has a broader subject scope than SFS, BIOSIS, MEDLINE, or IPA. It is a good source of literature on computer science, science business, biotechnology, and other subjects beyond biomedical fields. It has no controlled vocabulary, but users can search by keyword in the same way as with other bibliographic databases.

WEB SEARCH ENGINES AND STRATEGIES.

When the Web was first created in 1991, finding information entailed looking for primary and tertiary sources without the aid of a secondary source. One could browse the Web starting with a known Web site, uniform resource locator—URL, and following embedded links to other Web sites. Bibliographic databases generated their indexes from defined fields related to the articles (author, title, date, abstract, etc.) rather than the full text of the articles. Now web search engines index almost all words collected from scanning the public Web. This includes the full text of any journal that provides its content to a search engine.

Google Scholar provides a search engine for “scholarly” publications, which include peer-reviewed journals and other works (books, theses, etc.) produced by universities, academic publishers, and professional organizations. It searches the full text of these works, but usually only retrieves a short section of the document highlighting the search term. Members of academic institutions can often access the full text of any work their institution owns by setting preferences in Google Scholar to link to library holdings. Google Scholar has citation linking similar to SCI, in which documents are linked to citing articles. Documents are also linked to related articles, as in PubMed, where the articles are related by similarity.

PubMed provides an excellent alerting service, currently called NCBI. Users can run a search in PubMed, save the strategy, and log into their account at any time to run the search again without having to rebuild their query; they can also set up automatic e-mail alerts.

Tertiary Information Sources for Professionals and Patients

Drug Information Databases for Professionals Clinical Pharmacology

Clinical Pharmacology was founded in 1993 by Gold Standard. It is one of the newer comprehensive drug information databases. Records are divided into 11–12 subsections so that the user can reach information quickly. Drug records contain standard package insert
recommendations supplemented by literature sources that can be found by clicking on the reference numbers; many of the references have links to PubMed. Search can be done by several different factors, such as indication, adverse reactions, contraindications, etc. The Natural Medicines Comprehensive Database is also linked to Clinical Pharmacology, providing the user with an extensive database on natural products and nutraceuticals.

**Facts and Comparisons**
Facts and Comparisons ([http://factsandcomparisons.com/](http://factsandcomparisons.com/)) is one of the oldest print drug information sources. It was originally developed as an alternative to the manufacturer focused *Physician’s Desk Reference*. It has two search sections one for drug information and one for disease and symptom searching.

**Lexi-Comp**
LexiComp ([http://www.lexi.com/](http://www.lexi.com/)) is one of the newer drug information databases and is available as online, desktop, and PDA (personal digital assistant) versions. Numerous databases—some produced by outside sources and some aimed at other professions such as dentists and nurses—are available in various combination packages.

**Micromedex**
Micromedex ([http://www.micromedex.com](http://www.micromedex.com)) is one of the first electronic drug database providers. Micromedex provides a number of separate databases produced by different providers that can be purchased in many combinations. DRUGDEX is the comprehensive general drug information database produced by Micromedex. The user can reach DRUGDEX monographs and then can either scroll through the record or jump to one of the subsections. The information includes package insert and primary literature abstracts.

**Drug Identification**
Now databases can identify solid oral dosage forms by their markings. Identiindex (from Micromedex) and Ident-A-Drug (from Therapeutic Research [publishers of *The Pharmacist’s Letter*]), RXList; Clinical Pharmacology On-Hand; and Lexi- are some very good examples.

**Drug Interactions Facts** is said to be the least and has the highest specificity and lowest sensitivity. Drug-Reax is also an example. Although no single drug–drug interaction database can currently be relied upon for drug interaction checking, use of more than one source of drug interaction information.  

**Drug Information Databases for Patients**
With the advancements of computers and awareness due to the internet most people are now informed of their disease conditions, symptoms and few cures. The information provide through the internet should also be standardized. Many professional organizations provide guidelines for evaluating health information on the Web. The Health on the Net Foundation (HON) is a nonprofit organization that developed a code of ethics for health Web sites and offers certification for Web sites that adhere to their “HONcode.” The U.S. National Cancer Institute also provides guidelines.

**Health Literacy**
Pharmacists assisting patients with health information must also know patients have varied levels of health literacy. The Institute of Medicine (IOM) defines health literacy as “the degree to which individuals have the capacity to obtain, process, and understand basic information and services needed to make appropriate decisions regarding their health.”

Health literacy should not be confused with literacy in reading and writing. Many intelligent, educated people have low health literacy. Pharmacists know that most patients need some help to understand information about their medications.  

**Resources for Patients**
In order to help patients evaluate health information, understand their health literacy, and tailoring information to their needs, pharmacists should be aware of high-quality tertiary sources on the Web that are made for patients. Although search engines often retrieve high-quality Web sites in the first page of results, they often miss information contained in large megasites or portals. It is therefore important to know about these Web resources for consumers.

1. **MedlinePlus**: Many subscription-based resources, such as Clinical Pharmacology and Micromedex, include drug information for patients, but the best starting point for free consumer health information on the Web is medlineplus.gov, which provides authoritative, noncommercial information that is well organized and available in English and Spanish. MedlinePlus is easy to use. MedlinePlus is compiled by the National Library of Medicine (NLM), National Institutes of Health, and other government agencies and health organizations. The site is updated daily and individual health topics are reviewed at least every 6 months. It includes an illustrated medical encyclopedia, directories for finding doctors or hospitals, health news, tutorials and videos, and links to many other excellent information sources. The NLM provides a drug information portal ([http://druginfo.nlm.nih.gov/drugportal/drugportal.jsp](http://druginfo.nlm.nih.gov/drugportal/drugportal.jsp)) that links searchers to drug information from NLM-sponsored Web sites, including MedlinePlus, LactMed (a database on drug use during breastfeeding), DailyMed (a listing of FDA-approved package inserts), clinical trials, and more.

2. **NCCAM**
Another government-sponsored Web site that is especially useful in pharmacy is the National Center for Complementary and Alternative Medicine (NCCAM; [http://nccam.nih.gov/](http://nccam.nih.gov/)). NCCAM provides general information about safe and effective uses of CAM and links to monographs about herbal therapies and other alternative treatments. The monographs usually include a section on “what the science says,” which describes in lay language the effectiveness of the therapy. NCCAM monographs usually include links to MedlinePlus, where users can find more detailed discussions of the quality of the evidence.

3. **FDA Consumer Drug Information**
The FDA site ([http://www.fda.gov/cder/DrugSafety/DrugIndex.htm](http://www.fda.gov/cder/DrugSafety/DrugIndex.htm)) lists drugs by name. Each drug monograph includes a patient information sheet that explains what the drug is for, how it works, precautions, and how the drug should be taken. Information for patients on FDA-issued warnings about the drug is also included.

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4 CDC
The Centers for Disease Control and Prevention (http://www.cdc.gov/) is an invaluable source of information about many health topics. It is especially useful to both consumers and health professionals as a source of information on immunizations.

4. PDA’s AND HANDHELD DEVICES

Personal Digital Assistants
In their most basic form, all PDAs share some characteristics:
- Storage of personal data (calendar, contacts, “to do” lists),
- Touch screens, solid-state memory,
- Ability to be powered on instantly.

For nearly a decade, there were only two types of PDAs: Palm and Pocket PC, which were differentiated by their operating systems (OS). Now there are two additional major types: the BlackBerry and the Apple iPhone. A few other platforms do exist, such as the Google Android operating system, but the current small number of available applications makes them of limited use, especially in healthcare.

The drug databases comprise individual drug references containing dosage, drug interactions, adverse effects and contraindications, pregnancy and breastfeeding information, and some pharmacokinetic data. The publishers can continuously update the information (typically several times per week); these updates are propagated to the PDA when the user synchronizes it with the personal computer or wirelessly if the feature is available on the PDA.

Epocrates Rx also includes two more useful features at no charge: a multiple drug interaction checker) and health insurance formularies. The drug interaction checker allows the entry of multiple drugs to check for drug interactions or IV compatibility.[17]

Lexi-Drugs
Lexi-Comp also offers this feature but at an additional cost. Interactions are again grouped by severity, but rather than listing single drugs, the interacting drugs are listed side by side under the severity. Tapping on the interaction pops up a window with further information. An evaluation of eight PDA drug–drug interaction analyzing programs found the Epocrates analyzer to be the most reliable in detecting interactions.[18]

Lexi-Drugs is the more detailed reference. For common information (dosages, drug interactions, adverse reactions), both databases provide adequate information, and it is likely that the user will find it more quickly using Epocrates Rx because of its list-like organization. As it is available at no cost and has a drug interaction analyzer makes it a very useful package.

On the other hand, if the user requires more detailed facts—as might be needed in a hospital or educational setting—Lexi-Drugs is a better choice due to its depth of information. Also, both Epocrates Rx and Lexi-Drug could be installed on the same PDA device to take advantage of both. At least eight other pharmacy PDA drug information programs are available with varying strengths and weaknesses. Individuals and students associated with institutions that subscribe to Thomson Healthcare Series (Micromedex) or Clinical Pharmacology can download the respective PDA versions of these programs free of charge.[19,20]

Disease state references.
In this, medical conditions are listed alphabetically and are searchable in the same way as for the drug references. There may be an ability to sort conditions by body system (e.g., only displaying conditions that affect the gastrointestinal system). Click a condition and get a monograph with information on incidence, Causes, differential diagnosis, and treatments including medications. If the disease reference database is associated with a drug reference, click an underlined drug name will hyperlink to the drug’s monograph for dosage information.

Laboratory value references. These databases allow the user to look up reference ranges for a given laboratory test, such as a blood marker or drug concentration, and may even provide suggestions for causes when the value is out of range.

Medical calculators. Medical calculators are another useful category of applications or the PDA. They provide quick determinations of values such as creatinine clearance, glomerular filtration rate, ideal body weight, and many others. The user chooses the formula from a predefined list, enters the patient-specific values into the variable fields, and the result is calculated. MedCalc is a well-built and free calculator suite.[21]

Dosage form identifiers. Lexi-Comp’s Lexi-Drug ID, Epocrates Rx (iPhone and BlackBerry only) and Ident-A Drug (from the publisher of the Pharmacist’s Letter) are examples of PDA dosage form identifiers. Both are text-based identifiers that allow the user to input markings and imprints, shape, color, or scoring to identify the unknown drug. Ident-A-Drug and Epocrates even show a picture to help confirm the identity of the drug.

Alternative or natural products: Alternative medicines and health supplements used by today’s consumers, natural medicine references are great to have on a PDA. Lexi-Comp and Epocrates offer alternative medicine databases. Epocrates integrates the alternative medicines directly into the list of drugs and also allows the user to include these in drug interaction checks.

Infectious diseases. Similar to a disease state reference, these databases allow the user to search for information by infectious agent, syndrome, or body system affected. Lexi-Comp and Epocrates has versions, but the most complete and useful is the PDA version of the Sanford Guide to Antimicrobial Therapy.

Medical dictionaries. Several publishers for both Palm and Pocket PC devices, medical dictionaries are identical to their printed counterparts but have the advantage of being searchable.

Immunizations: It is a full vaccination schedule for children and adults. Based on U.S. recommended childhood and adult immunization schedules, it even gives the recommended catchup schedule for those missing
vaccinations in a series. Clicking on the vaccine name gives further information on the vaccine, such as indications, adverse reactions, contraindications, and administration.

**PDA Softwares for Pharmacists**

**Epocrates**
Available: www.epocrates.com
Devices: Palm, Pocket PC, Windows Smart Phone, iPhone, BlackBerry
Number of drugs: >3,300
Updates: daily
Products/cost:
- Epocrates Rx: free; drug monographs, formularies, drug interaction checker,
- Epocrates Rx Pro: $60/year; Epocrates Rx, infectious diseases, alternative meds,
- IV compatibility
- Epocrates Essentials: $149/year; Epocrates Rx Pro, disease lists, symptom assessor,
- lab values
- Epocrates Essentials Deluxe: $199/year; Epocrates Essentials, ICD-9 codes, medical dictionary.

**Lexi-Comp**
Available: www.lexi.com
Devices: Palm, Pocket PC, iPhone, BlackBerry
Number of drugs: >7,000
Updates: multiple times per week
Free trial: 20 uses of any database
Products/cost: $75/year to $300/year depending on package and device.
- Lexi-Drugs
- Pediatric Lexi-Drugs
- Lexi-Natural Products
- Lexi-Infectious Diseases
- Lexi-Lab & Diagnostic Procedures
- Lexi-Interact
- Lexi-Pharmacogenomics
- Lexi-CALC (medical calculators)
- Lexi-I.V. Compatibility
- Lexi-Drug ID
- Harrison’s Practice (disease management tool)
- Lexi-Complete: all 21 Lexi databases
- Lexi-Select: all 17 drug related databases
- Lexi-Clinical: Lexi-Drugs, Interact, Lab & Diagnostic, CALC,

**Harrison’s pharmacology OnHand**
Available: www.clinicalpharmacologyonhand.com
Devices: Palm, Pocket PC
Number of drugs: >6,000
Updates: daily
Free trial: no (free of charge to individuals associated with Clinical Pharmacology subscribing facility)
Products/cost:
- Clinical Pharmacology OnHand: $99/year; drug monographs, interaction checker
- Clinical Pharmacology OnHand Drug Identifier: $39/year; text-based dosage
- form identifier

**Clinical Pharmacology OnHand IV Alert**
Available: $49/year; IV drug compatibility

**Tarascon PDA Pharmacopoeia**
Devices: Palm, Pocket PC, BlackBerry
Number of drugs: ~4,500
Updates: daily
Free trial: 30 days free
Products/cost: $29.95/year; PDA version of the popular pocketbook; 47 reference tables, nine medical calculators

**A to Z Drugs**
Available: www.skyscape.com
Devices: Palm, Pocket PC, SmartPhone, iPhone, BlackBerry
Number of drugs: 700 generic and 2,800 trade names (source is Facts and Comparisons)
Updates: quarterly
Free trial: Web based
Product/cost: A to Z Drugs: $49/year

**Natural Medicines Comprehensive Database**
Available: www.naturaldatabase.com
Devices: Palm, Pocket PC
Updates: daily
Number of drugs: >1,000 natural and alternative medicines
Free trial: no
Product/cost: $59/year; information on drug interactions, uses, and adverse effects; brands, ingredients, and manufacturers listed; ratings on efficacy by indication (possibly effective, possibly ineffective, insufficient evidence to rate); ratings on safety (possibly safe, possibly unsafe, likely unsafe) with references; mechanism of action with references.

**MedCalc—medical calculator**
Available: http://www.med-ia.ch/medcalc/desc.html
Devices: Palm, Pocket PC, iPhone
Updates: new versions released periodically
Product/cost: free; >80 formulas sorted by categories; most with bibliographic references and clinical tips.

**Sanford Guide to Antimicrobial Therapy**
Available: www.sanfordguide.com
Devices: Palm, Pocket PC, BlackBerry
Updates: annually
Free trial: no
Product/cost: $29/year; searchable version of the complete Sanford Guide to Antimicrobial Therapy

**Shots 2008**
Available: www.immunizationed.org
Devices: Palm, Pocket PC
Updates: yearly
Product/cost: free; interactive vaccination schedule for adults and children and catch-up; lists side effects, contraindications, and further information about each vaccine

**Clinical Pharmacokinetics Computer Programs**
Clinical pharmacokinetics is used to improve drug therapy outcomes by optimizing the drug dosage regimen. 22-28

**Avoiding Medication Errors**
The Institute of Medicine estimates that medication errors...
contribute to thousands of deaths each year. It stated that between 44,000 and 98,000 people in the United States die every year due to medical errors. [29]

**Medication Errors in Hospitals**

Medication errors in hospitals are common and have the potential for causing serious harm. Most hospitalized patients are on intravenous (i.v) medications where errors result in risk of serious injury and death. 30-34

Studies in community clinics and medical office practice indicate that outpatient medication prescribing errors occur in between 7.8 and 21% of patients and adverse drug events occur in 18 and 25% of patients.2,18,19 Examples of the reported prescribing errors include inappropriate medication selection, omitting necessary information on the prescription, selecting incorrect dose or directions, unclear quantity to be dispensed, and potential adverse drug–drug interactions. Examples of adverse drug events include adverse reactions caused by a medication error or a previously documented causative drug. Medication discrepancies are prevalent among ambulatory care clinics, ranging from 26 to 76%. 35-37

Examples of the medication discrepancies include medications that patients are taking that are not recorded in the chart or medications that are recorded in the chart that patients are not taking. Furthermore, medication errors from inadequate therapeutic monitoring commonly occur.

**Medication errors are common in long-term-care facilities, especially in nursing homes.**

Medication allergies and changes in medications are often missing in paper-based systems that require transfers of information by humans. The patient and family is mostly not there to consult about medications the patient takes, including the exact name, dose, or frequency of medications used by the patient. Medication reconciliation among facilities and providers is critical and is one of the most important strategies for new health information systems.

**At home, medication errors** occur when patients take the wrong drug or wrong dose or take the right drug and dose at the wrong time. 38

**Technologies That Enhance Medication Safety**

1. **Computerized provider order entry (CPOE)**

   This technology requires the person placing an order for a medication to do so using an information system platform rather than hand-writing or verbally requesting an order. These should not be put in place without healthcare professional oversight because the application must make sense in the clinical context and clinicians are vital in identifying misuses of the technology. Pharmacists are in an ideal position to help implement the recommendations and monitor the outcomes of CPOE and are able to identify and avoid potential points of errors. 39-48

2. **Electronic Prescribing**

   Electronic prescribing, eRx. In this the prescriber uses a computer system which is incorporated with standardized eRx features that interface with pharmacy computerized systems. Using computer systems in the prescribing of medications offers great possibilities for implementing safe medication practices.

   A pharmacist has to ensure that these systems perform properly and are maintained and improved based on feedback and measured clinical experience. 49-54

3. **Clinical Decision Support with Safety Features**

   Computerized decision support tools embedded within CPOE are effective in reducing hospital-based and outpatient medication errors. 55-58.

4. **Bar Coding**

   Bar coding prevents human errors of recording and calculation and to ensure proper identification. Patients can be assigned a bar coded wrist band when they are admitted to a hospital or other healthcare facility. All medication and other orders such as requisitions for laboratory tests and x-rays can also be bar coded to ensure that the right patient receives the correct intervention. Bar coding reduces 60–80% of administration errors. 59,60

**PHARMACY INFORMATION SYSTEMS**

Pharmacy information system support for automation has become vital to optimize the safety and efficiency of the medication use process. Today’s practice of pharmacy incorporates many technologies to assist the pharmacist in delivering care. The adoption of these technologies also allows deployment of advanced safety measures.

An integrated pharmacy information system includes drug distribution automation to ensure the timely and accurate availability of medications. It may also include medication administration programs, such as BCMA, or an electronic medication administration record (eMAR).

Providing accurate and timely information from the pharmacy information system to administration programs better equips nursing to meet the “five rights” of medication administration effectively: right drug, right dose, right route, right patient, and right time.

**Rich Media and Mash ups**

Visualization is a better form of comprehension therefore nowadays visual journals is also in trend. Eg.

- The Journal of Visual Experiments (www.jove.com) is proof that this can work. Jove is a video journal by PubMed.
- SciVee (www.scivee.tv) is yet another experiment. SciVee has the notion of a “pubcast,” which is typically a 5- to 10-minute video clip by one or more of the authors describing the abstract of the paper.

Generally, these computer systems consist of the following components:

- patient file;
- prescriber file;
- drug file;
- insurance information file and billing interface;
- e-prescribing interface; and
- dispensing automation interface.

Softwares may allow an exception or override list of medications that are always available for dispensing to any patient.

**Specialized ADC’s** replaces a medication tray or cart in the operating room. The surgeon is afforded quick access to medications and simple methods for documenting administration during the procedure.

**Smart pumps**

Initially i.v infusion pumps used to provide infusion of piggyback, syringe, or large-volume medication at a
specified rate. Now, software and interfaces are added to these devices to create today’s intelligent or smart pumps. These newer devices are able to store a database of standard i.v preparations, allowing the nurse to select from a list of predefined items when ready to administer an i.v solution to a patient.

**Automated Drug-Dispensing Machines**

Automated drug-dispensing machines (ADDMs) include the pharmacy information system and have the ability to fill, label, and deliver prescriptions. Once the prescription has been processed by the pharmacist, the complete prescription information can be sent electronically to an ADDM. Most ADDMs hold only tablets and capsules. Eg. ScriptPro’s SP 200 contains 200 dispensing cells for tablets and capsules of all sizes. And Baker cells is another example.

**Automated Kiosks**

Automated kiosks are ATM-style machines that sell drugs to patients, not according to the prescription but according to what has been filled by the pharmacist. Kiosks are advantageous as they allow picking up of medicines even paying for their prescriptions with a credit card at any time, even when the pharmacy is closed. Eg. Asteres’ ScriptCenter.

**BCMA** comprises both hardware and software designed to enhance the accuracy of medication delivery to a patient. Hardware components can include mobile computers at each bedside and printing system for placing bar codes on patient identification bands, as well as on medications. BCMA operates using bar-coded patient identification bands and bar-coded medications to be documented in the patient’s medication administration record (MAR) or electronic MAR (eMAR). An eMAR is an important component of BCMA because it holds all of the documented medication administrations completed using BCMA. BCMA technology helps nurses quickly identify the “five rights” of medication administration: patient, drug, dose, route, and time of administration.

The U.S. Food and Drug Administration (FDA) published a final ruling that requires certain human drug and biological products to have a linear bar code on their labels. The bar code, at a minimum, is to contain the National Drug Code (NDC) number. Manufacturers with drugs approved before the final ruling were given 2 years to comply with the request. The intent of the FDA ruling is to help prevent medication errors through the use of BCMA technology by healthcare organizations. The FDA estimated that the ruling could reduce the number of medication errors that occur by 500,000 over the next 20 years.

**REFERENCES**


Information technology and teamwork among the professionals can then interplay to create safe systems of medication administration.


Source of support: Nil; Conflict of interest: None declared
Pharmacists are experts in medicines and their use. They also offer health advice to patients on issues such as sexual health and giving up smoking. See how they use their knowledge of medicines to help people with every type of medical condition and find out how you could use your science skills to become a pharmacist. Working life. Medicines are the most common treatments offered to NHS patients. A pharmacist is an expert in medicines and their use. Their knowledge of medicines and the effect they have on the human body is critical for the successful management of every type of medical condi