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Personal Digital Assistant Infectious Diseases Applications for Health Care Professionals

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Personal digital assistants (PDAs; also known as "handheld computers," "pocket personal computers," and Palm Pilots) provide immediate access to vital and clinically relevant infectious diseases information at the point of care. Several infectious diseases applications are available that provide information on pathogens, diagnosis, medication, and treatment. In this article, 4 infectious diseases PDA applications are reviewed: ePocrates ID (part of ePocrates Rx Pro), the Johns Hopkins Division of Infectious Diseases Antibiotic Guide, the 2002 Sanford Guide to Antimicrobial Therapy, and Infectious Diseases and Antimicrobials Notes. Drug information, including clinical pharmacology, dosing in patients with renal insufficiency, adverse reactions, and drug interactions, is evaluated for completeness and accuracy by comparison of each application with the package insert. Treatment recommendations for 6 diseases are compared with current practice guidelines. Each PDA infectious diseases application reviewed has unique advantages and disadvantages. This critical review will help health care professionals select the infectious diseases PDA application best tailored to meet their individual information needs.

Personal digital assistants (PDAs) are small handheld computers (e.g., Palm handhelds or Microsoft Windows–powered Pocket PCs) commonly used for data storage, personal organization, office management, and Internet access. Professionals in the medical field are rapidly incorporating PDAs into their practice. A recent survey by the American College of Physicians–American Society for Internal Medicine found that 47% of the respondents use PDAs currently and that 67% of its members intend to use a PDA before the end of 2002 [1]. Other health care professionals, such as nurses and pharmacists, are also incorporating use of PDAs into their daily tasks [2–4].

Health care professionals use PDAs for multiple tasks, such as accessing patient information, writing prescriptions, billing for services, performing medical computations, accessing the Internet and electronic mail, tracking medication errors, and accessing medical textbooks, drug databases, journal articles and tables of contents, and practice guidelines. Some institutions have developed internal references, such as clinical pathways and hospital formularies, that can be downloaded to a PDA.

The advantages of PDAs include portability and ease of searching. The use of PDAs to check drug information at the point of care may reduce medication errors [5, 6]. The Institute of Medicine recommends computer-assisted prescription of medication and the integration of accurate, timely drug information into patient care as key strategies for the improvement of medication safety [7]. Current shortcomings of PDAs include limited storage capacity, privacy and security concerns, possibility of loss or damage, limited software availability, and lack of universal Internet access.

Infectious diseases PDA applications have been available since early 2001 and may reduce variation in therapy selection and minimize errors when used in conjunction with sound medical judgment. This article reviews infectious diseases applications available for PDAs and will help clinicians select one of these valuable resources to meet their individual information needs.

METHODS

PDA applications for review were identified on the basis of (1) personal knowledge, (2) searches of popular health care–related

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PDA Web sites (e.g., PDAMD [http://www.pdamd.com/], Dr. Kent Willyard's Ectopic Brain [http://pbrain.hypermart.net/], PalmGear [http://www.palmgear.com], and Handango [http://www.handango.com/], (3) an extensive Medline search for health care–related PDA articles, and (4) interactions with health care providers specializing in infectious diseases and medical informaticians. Infectious diseases applications were reviewed if they were available for the Palm operating system (OS; Palm) or for Microsoft Windows–powered Pocket PCs (Microsoft), if they featured content focused primarily on infectious diseases, and if they could be downloaded from the Internet. Applications were examined using a Palm m500 with an expansion card, a Handspring Visor Pro (Handspring) with an expansion card, or a Palm IIIc. Each application was evaluated for personal computer (PC) hard drive requirements, PDA system requirements, salient features, and extent and accuracy of content. To evaluate the accuracy and completeness of the content in each application, drug information was compared to the information in the drug package insert, and treatment information for 6 diseases was compared to current practice guidelines published by the Infectious Diseases Society of America (IDSA).

RESULTS

On the basis of the above criteria, 4 PDA applications were identified and reviewed: ePocrates ID (part of ePocrates Rx Pro) [8], the Johns Hopkins POC-IT (Point of Care Information Technology) Antibiotic (ABX) Guide handheld version [9], the 2002 Sanford Guide to Antimicrobial Therapy, 32nd edition [10], and Infectious Diseases and Antimicrobials Notes [11]. Tables 1 and 2 give an overview of the technical requirements, features, and cost of each application.

ePocrates ID

Founded with venture capital in 1998, ePocrates offers several products for PDAs, including ePocrates Rx and ePocrates Rx Pro, which contains ePocrates ID, information about alternative medicines, drug tables, and the MedMath program. The mission of ePocrates is to "provide prescribing physicians with easy access to evidence-based, peer-reviewed drug information, including the latest treatment guidelines and off-label indications" [12]. Edward Fang, editor-in-chief of ePocrates, estimates that 30% of physicians (600,000) in the United States use $\geqslant$1 ePocrates PDA application (Edward Fang, personal communication). Prior to October 2002, ePocrates ID was available as a free, stand-alone application, but now it is only available with purchase of ePocrates Rx Pro. This review focuses mainly on the information contained in ePocrates ID but will mention some features of the ePocrates Rx Pro package. When ePocrates ID was available for free, Dr. Fang estimated the application had >250,000 users (Edward Fang, personal communication). ePocrates ID was created by a team of infectious diseases specialists from several academic institutions. Two infectious diseases specialists and the editor review all new content.

Salient features. ePocrates ID provides information on >300 infections, >350 pathogens, and >250 drugs. Users may search for information according to anatomic location of infection, "bug" (i.e., pathogen), or drug (figure 1*A*). The location screen lists 13 discrete anatomical locations from which empiric and specific drug therapies for a particular indication can be accessed. The "bug" screen presents pathogens alphabetically or by classification. By accessing a series of screens, the user can move from the specific "bug" to relevant infections and their treatments.

The drug screen lists medications alphabetically by generic name and includes a classification abbreviation (i.e., "topical," "antiviral," "ophthalmic," "anaerobic coverage," or "antiparasitic"). Once the drug is selected, to proceed further, an indication for use must be selected (figure 1*B*). After selecting an infection, the user accesses a screen where basic information concerning drug administration (i.e., drug, dose, and route and frequency of administration) is stated for all drugs that could be used to treat the infection (e.g., esophagitis; figure 1*C*). A complete drug monograph is available only by linking to the drug reference guide in ePocrates Rx Pro [8].

Regardless of the search pathway used (i.e., "bug," drug, or location), the core of ePocrates ID clinical information is a standardized infectious diseases screen (figure 1*D*). For each infection, ePocrates ID provides the following resources: 1) a screen of empiric drug therapy in a numbered list from most to least preferred treatment regimen; (2) a screen of pathogen-specific drug therapy in a numbered list from most to least preferred treatment regimen; 3) a screen of other information that provides a brief clinical "pearl" related to the history or diagnosis of the infection and, in many instances, 1 or 2 references to a review article, a practice guideline, and/or an infectious diseases textbook; and (4) a screen for notes, which can be used to record personal notes, such as references or formulary information.

Advantages. ePocrates ID links seamlessly to the drug monograph in ePocrates Rx Pro, which provides more detailed drug information about adult and pediatric dosing, contraindications, drug interactions, adverse reactions, basic pharmacological information, and drug cost. Additionally, ePocrates Rx Pro includes a drug and alternative medicine interaction module, MultiCheck, that allows clinicians to check for interactions of $\leqslant$30 prescription drugs and/or alternative medicines. Users of ePocrates Rx Pro receive DocAlerts each time they HotSync (i.e., when the PDA is connected to a desktop or laptop computer and the Internet). DocAlerts notify users of

Table 1. Overview of selected features of 4 infectious diseases personal digital assistant applications.

Feature or variable	ePocrates ID (part of ePocrates Rx Pro)	Johns Hopkins Division of Infectious Diseases Antibiotic Guide for Handhelds	Sanford Guide to Antimicrobial Therapy	Infectious Diseases and Antimicrobials Notes
URL	http://www.epocrates.com	http://www.hopkins-abxguide.org	http://www.sanfordguide.com/	http://www.pdamedsolutions.com
Cost of application	Introductory price of $49.99 for a 1-year subscription	Free	$25.00	$39.99
OS or device availability	Palm OS ver. 3.0 or higher	Palm OS ver. 3.0 or higher; MS Windows–powered Pocket PC devices	Palm OS ver. 3.0 or higher; MS Windows-powered Pocket PC devices	Palm OS ver. 3.0 or higher
Memory required, MB				
Palm OS	2.7	1.2	1.5	.732
MS Windows-powered Pocket PC OS	NA	4.9	3.5	NA
Updates and currency	Quarterly updates can be downloaded from company Web site	Automatically updated during HotSync or ActiveSync	Periodic updates can be downloaded from company Web site	E-mail updates sent to subscriber 4 times yearly
Expansion card(s) supported				
SD/MMC[a]	No	Yes	Yes	Yes
Sony CLIÉ Memory Stick	No	Yes	Yes	Yes
Handspring Visor Expansion modules	No	Yes	Yes	Yes
HandEra 330 (if VFS is enabled)	No	Yes	Yes	Yes

NOTE. MS, Microsoft; NA, not applicable; OS, operating system; PC, personal computer; SD/MMC, Secure Digital/MultiMediaCard; URL, uniform resource locator; ver., version; VFS, virtual file system.

[a] Available for the Palm M500, M505, M125, M130, and i705 devices and the Handspring Treo 90.

Table 2. Overview of drug information in and related technical features of 4 infectious diseases personal digital assistant applications.

Variable	ePocrates ID (part of ePocrates Rx Pro)	Johns Hopkins Division of Infectious Diseases Antibiotic Guide for Handhelds	Sanford Guide to Antimicrobial Therapy	Infectious Diseases and Antimicrobials Notes
Drug information				
Dosing information				
Adult	+	+	+	+
Pediatric	+[a]	−	+	+
Renal	+[a]	+	+	+
Clinical pharmacology				
Mechanism of action	+[a]	−	−	+
Route of metabolism	+[a]	−	−	−
Route of elimination	+[a]	−	−	+
Half-life	−	−	+	+
Adverse reactions	+[a]	+	+	−
Precautions/contraindications	+[a]	−	−	+
Drug interactions	+[a]	+	+	+
Pregnancy	+[a]	+	+	+
Lactation	+[a]	−	−	−
Forms	+[a]	+	−	−
DEA category	+[a]	−	−	−
Cost	+[a]	+	+	−
Other information				
Author opinion	−	+	−	−
Diagnostic	Minimal	Extensive	None	Intermediate
Literature references	Minimal	Intermediate	Extensive	None
Drug information–related feature				
Notes/customizability	+	−	−	−
Automatic update	−	+	−	−
Expansion/memory card support	−	+	+	+

NOTE. DEA, US Drug Enforcement Agency; +, present; −, absent.

[a] The drug monograph is located in ePocrates Rx Pro, not in ePocrates ID.

clinical updates, medication safety alerts, health news, and advertisements for specific drugs.

Disadvantages. ePocrates is a private company funded by venture capital and advertising revenue that has business relationships with pharmaceutical companies and other health-related companies and organizations. ePocrates has the ability to track how health care providers use the database (especially which drugs are referenced), and it could potentially sell aggregate data for revenue but, to date, has not done so (Edward Fang, personal communication) [13]. The sale of DocAlerts to drug companies and to government agencies and the development of integrated formularies are ePocrates' current sources of revenue. ePocrates emphasizes that sales and clinical activities are kept separate and that an objective perspective in the content of the application is maintained (Edward Fang, personal communication).

Although ePocrates Rx Pro updates automatically during HotSync, ePocrates ID does not automatically update. New versions of ePocrates ID are available for download every quarter. Searching for drugs by trade name is not possible but would be helpful and useful. ePocrates ID is potentially inflexible because users may obtain only treatment information based on predefined infection modules produced by ePocrates ID. ePocrates Rx Pro is the most expensive application reviewed; a 1-year subscription costs $49.99.

Hardware and software requirements. ePocrates offers its products for the Palm OS version 3.1 or higher and has no plans to develop applications for Microsoft Windows–powered

Figure 1. Examples of screens displayed in ePocrates ID

Pocket PC devices. ePocrates Rx Pro with ePocrates ID requires 2.7 MB of storage space. The application is not compatible with expansion memory cards.

Johns Hopkins Division of Infectious Diseases Antibiotic Guide for Handhelds

The Johns Hopkins Division of Infectious Diseases Antibiotic Guide (ABX Guide) is a "decision support tool" intended to provide clinicians with concise, digested, and timely information about the diagnosis and treatment of infectious diseases [14]. The information is arranged such that it is instantly accessible at the point of care. Johns Hopkins POC-IT, the production team for the ABX Guide, wants to help physicians make evidence-based patient care decisions and avoid overprescribing antibiotics (Sharon M. McAvinue, director, and John G. Bartlett, editor-in-chief, Johns Hopkins POC-IT, and Laura Marcial, Johns Hopkins University, personal communication). The POC-IT initiative began with an infectious diseases Web site and, in early 2001, expanded into handheld devices to provide information at the point of care. The Johns Hopkins Web site provides the same information as the ABX Guide for PDAs but has expanded references. The information on the Web site and in the PDA application are free.

Salient features. The information in this application may be located by searching for a diagnosis, a pathogen, or an antibiotic (figure 2*A*). From the diagnosis section, 1 of 18 distinct anatomical sites can be selected, each of which leads to specific infection choices. For example, tapping on "Diagnosis," "Respiratory," and "Pneumonia," in that order, leads to a standardized module that explains treatment regimens, diagnostic criteria, common pathogens, important points, and author opinion on this topic (figures 2*B* and 2*C*). The author opinion section allows the user to select drugs to be explored and compared. The author explains his or her drug recommendation, which often includes a rationale, a short discussion of related literature, and information about possible adverse reactions, toxicity, and cost. Treatment sections list antimicrobial regimens and other treatments, such as surgery or other beneficial therapies. The treatment regimens are often detailed. For example, the module on acute osteomyelitis specifies treatment regimens for hematogenous osteomyelitis (pathogen-directed therapy) and contiguous-focus osteomyelitis (with or without vasculopathy) and an oral regimen designed to follow parenteral therapy.

Searching by pathogen name leads to a module detailing treatment regimens, clinical relevance, sites of infection, important points, and author information. A second drop-down menu displays various treatment regimens. For example, for *Clostridium difficile* infection, the user may choose "antibiotic treatment," "special considerations," and "multiple relapses."

The only way to access 1 of the 160 drug monographs in the ABX Guide is to search for the drug under the "Antibiotic" tab. At this point, a drug classification tree appears (with the

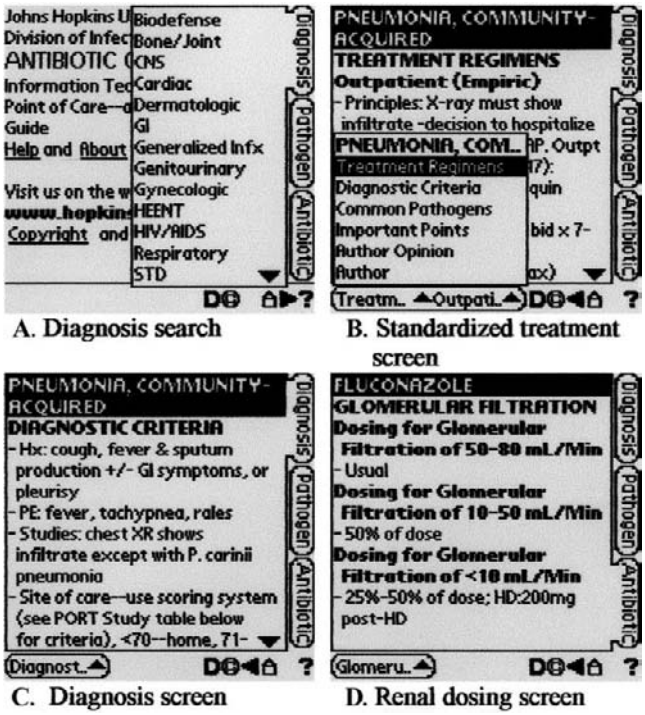

Figure 2. Examples of screens displayed in the Johns Hopkins Division of Infectious Diseases Antibiotic Guide for Handhelds.

headings "antibacterial," "antifungal," "antimycobacterial," "antiparasitic," "antiviral," and "other"). Selecting a drug category leads to a generic drug list, and, upon selecting the desired drug, the user can view information about drug class, indications, adult dosing, adverse reactions, interactions, spectrum of activity, formulations, renal dosing, and pregnancy risk (figure 2*D*).

Advantages. On the basis of our use of the ABX Guide in the clinical setting and the findings of this critical review, we believe that this application offers the most extensive and specific clinical information of the 4 applications reviewed. Users will find information on disease and infection prevention, details on diagnosis, and therapy recommendations, including primary and alternative antimicrobial regimens. Users will find extensive information on bioterrorism, including diagnostic criteria, primary and alternative treatment regimens, and dosing for special populations, such as pregnant women and patients with renal impairment. Although information on pediatric dosing is not currently available in the application, there are plans to incorporate this information in the near future. Many references to the literature are found in the ABX Guide.

The Johns Hopkins University Division of Infectious Diseases produces the ABX Guide. Before information is incorporated into the application, it passes through 6 rigorous levels of review for accuracy and readability by infectious diseases specialists, primary care providers, and the physician editors. Although, currently, most authors are faculty at Johns Hopkins University, several specialists from outside Johns Hopkins also edit and write modules. Identification of the author and inclusion of the date on which each module was last updated provides reassurance that information is current and from a respected source. The inclusion of the "Author Opinion" section provides useful background to the treatment decision-making process. The ABX Guide can be automatically updated through HotSync (Palm OS) or ActiveSync (Microsoft Windows-powered Pocket PC) operations.

Johns Hopkins University and several unrestricted grants from pharmaceutical companies fund the application. The Johns Hopkins University Division of Infectious Diseases does have the ability to collect information about how the application is used. This data, in the form of aggregate data, may only be used for future educational research.

Disadvantages. The ABX Guide continues to add information on additional pathogens to the application, but the selection is currently limited to 64 pathogens. In addition, the ABX Guide could offer a more complete system of reference for antimicrobials. An alphabetic list of all drugs by trade and generic name would be useful. Drugs listed in treatment regimens found through the diagnosis or pathogen paths are not hyperlinked to the drug monographs. When information other than adult dosing information (i.e., drug, dose, and route and frequency of administration) is desired, additional time is required to search for the drug monograph through the Antibiotic tab.

Hardware and software requirements. The ABX Guide is available for devices using Palm OS version 3.0 or higher and Microsoft Windows–powered Pocket PC devices. It requires 1.2 MB of memory for the Palm OS and 4.9 MB for the Microsoft Windows–powered Pocket PC OS. The application will run from expansion memory cards, including Compact Flash, Secure Digital, and Sony Memory Stick (Sony).

The 2002 Sanford Guide to Antimicrobial Therapy, 32nd edition

The paper version of the Sanford Guide to Antimicrobial Therapy has been a well-known reference in the infectious diseases arena for >30 years. In contrast to the first edition, which included a mere 10 generously spaced tables and information on 34 antimicrobials, the 32nd edition contains 23 tables and information on >140 antimicrobials, often presented in extremely small print. This pocket-sized reference is a favorite among medical house staff and physicians and is one of the most commonly carried pocket manuals in print [15]. The Sanford Guide has recently begun offering its well-known information on its Web site and in a PDA version, for a small fee ($25).

Salient features. Now in its second year, the PDA version of the Sanford Guide mirrors the paper version, with the same familiar sections and tables. To accommodate a wide range of users, the opening screen is split into a "Rapid Reference" section and an "Index" (figure 3*A*). Rapid Reference, similar to the table of contents in the paper version of the Sanford Guide, provides quick access to 17 commonly used tables, such as "Initial Choice of Antimicrobial Therapy" or "Antimicrobial Spectra" (figure 3*B*). Users familiar with the organizational structure of the paper version may find that the Rapid Reference section provides the quickest path to the desired information. For those not intimately familiar with the Sanford Guide tables, the Index (A to Z) function allows users to search for a term in an alphabetical list (figure 3*C*). An Index-based search retrieves a list of tables in which the infection, pathogen, or drug is mentioned. If >1 table appears, which occurs commonly when searching for a drug, the user must determine which table will most appropriately supply the desired information. Each term searched retrieves a variety of tables, but there is no consistent format for the information presented. Therefore, it can be difficult for the user to learn how to locate information quickly.

The PDA version of the Sanford Guide uses scroll bars extensively to fit the voluminous information onto 1 "digital page," such as the data for community-acquired pneumonia (figure 3*D*). Information that appears overcrowded in the paper

Figure 3. Examples of screens displayed in the Sanford Guide to Antimicrobial Therapy.

version has been reformatted for optimal display on the handheld screen.

Advantages. Extensive references to the primary literature and practice guidelines are sprinkled throughout the application, and there is even a table entitled "Selected Directory of Resources" that provides Web site addresses and telephone numbers that can be used to obtain more information on some topics of interest (e.g., bioterrorism, vaccinations, and occupational exposures). The PDA version allows for internal hyperlinking among tables within the application, an improvement over the paper version, which would require the user to continually flip among different tables to answer a question. A real-time creatinine clearance calculator, found under table 9C, assists with the accurate determination of antibiotic doses.

Disadvantages. Some tables that are viewed easily in the paper version do not transfer well to the small PDA screen. For example, table 4, "Comparison of Antimicrobial Spectrum," one of the Sanford Guide's most commonly used tables, does not translate well to the PDA format and does not allow for easy visual comparisons of antibiotic coverage. For this purpose, many Sanford Guide devotees use the PDA version of the Sanford Guide as a supplement to, rather than a replacement for, the print edition (Jeb Sanford, editor-in-chief, Sanford Guide, personal communication). The Sanford Guide is not designed to serve as a drug information resource. Unlike the other applications reviewed, no standard drug monograph provides comprehensive drug information. Drug information can be found by referring to several of the tables in the Sanford Guide. Like the paper version, the PDA version is an annual publication; the user must purchase and download it yearly. Current owners are notified via electronic mail of periodic updates to the PDA version, and updated versions can be downloaded from the publisher's Web site. The PDA version of the Sanford Guide costs $25.

Hardware and software requirements. The Sanford Guide requires 1.5 MB of storage space for devices using Palm OS version 3.0 or higher and 3.5 MB of space for devices using Microsoft Windows–powered Pocket PC OS version 3.0 or higher. The Sanford Guide supports Virtual File System–compliant devices, including the expandable memory cards for the Palm m500 and m505 devices, the Sony CLIÉ series, and Compact Flash expansion cards.

Infectious Diseases and Antimicrobials Notes

Infectious Diseases and Antimicrobials Notes (ID Notes) from PDA Medical Solutions was created in May 1999 by "two young entrepreneurial MD/PhD graduates from the University of Montreal Medical School with the purpose of facilitating the access to the vast amount of rapidly evolving medical literature required for day-to-day practice" [16]. These physicians, along with others in the microbiology, infectious diseases, and pharmacy departments at the Maisonneuve-Rosemont Medical Center, a teaching hospital affiliated with the University of Montreal, maintain the application. Current users total 8000,

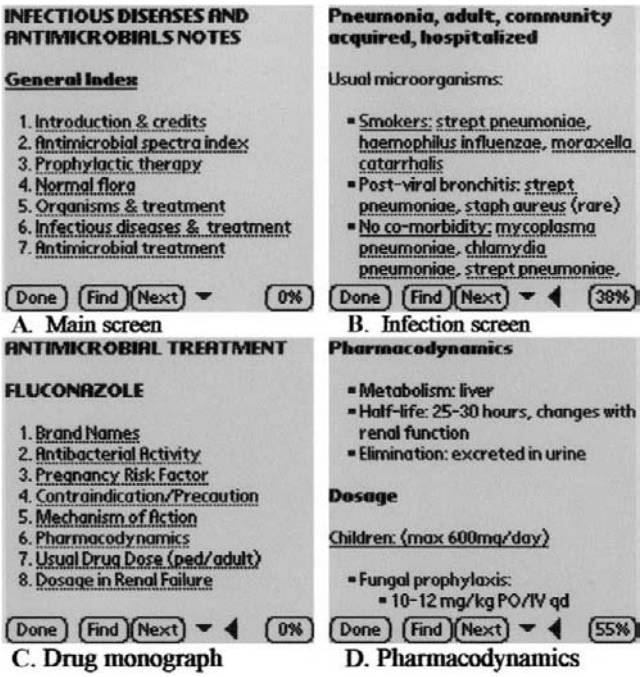

Figure 4. Examples of screens displayed in Infectious Diseases and Antimicrobials Notes.

Table 3. Comparison of drug information for fluconazole in the drug package insert and in 4 personal digital assistant infectious diseases applications.

Data included or other variable	Drug information, by source				
	Fluconazole package insert [17]	ePocrates ID (part of ePocrates Rx Pro)	Johns Hopkins Division of Infectious Diseases Antibiotic Guide for Handhelds	Sanford Guide to Antimicrobial Therapy	Infectious Diseases and Antimicrobials Notes
Number of taps to access drug information	Not applicable	3	3	Not applicable[a]	4
Total no. of indications	10 (FDA-approved only)	20 (1 for men, 1 for women, and 18 for adults)	14 (10 FDA-approved, 4 referenced in this guide)	40	10
Adult dosing	10 dosing regimens listed based on indication	Indication-specific dosing; must scroll to find target drug with basic adult dosing information (ePocrates Rx Pro: 6 dosing regimens based on indication)	Usual adult dosing (100–200 mg po or 200 mg iv daily, up to 800 mg per day)	Indication-specific dosing; must scroll to find target drug	6 dosing regimens based on indication
Pediatric dosing	5 dosing regimens based on indication	None (ePocrates Rx Pro: 5 dosing regimens based on indication)	None	None	5 dosing regimens based on indication
Renal-failure dosing (based on creatinine clearance)	Loading dose of 50–400 mg, then daily dose based on indication (>50 mL/min, 100%; ⩽50 mL/min, 50%; after regular dialysis, 100%)	None (ePocrates Rx Pro: ⩽50 mL/min, give usual loading dose, then decrease by 50%; after hemodialysis, 100%)	50–80 mL/min, 100%; 10–50 mL/min, 50%; <10 mL/min, 25%–50%; after hemodialysis, supplement with extra 200 mg	50–80 mL/min, 100%; 10–50 mL/min, 50%; <10 mL/min, 50%; after hemodialysis, supplement with extra 200 mg; after peritoneal dialysis, 50%	>50 mL/min, 100%; 11–50 mL/min, 50%; after hemodialysis, give 1 dose; after peritoneal dialysis, no adjustment
Clinical pharmacology	Mechanism of action, route of metabolism, route of elimination, half-life	None (ePocrates Rx Pro: route of metabolism, route of elimination, mechanism of action)	None	Half-life	Mechanism of action; route of elimination; half-life
Adverse reactions	Extensive information: 6 general adverse events are listed, along with organ-specific events reported in clinical trials and postmarketing exposure	None [ePocrates Rx Pro: information divided into serious [6] and common [9])	Divided into frequent (8) and occasional (2)	13 listed with percent incidence	None
Precautions/contraindications	Discusses drug interactions, carcinogenesis, mutagenesis, and impact on fertility	None (ePocrates Rx Pro lists 6 items, including 3 drug combinations to avoid and a statement to use caution in treating patients with renal/hepatic failure)	None	None	5 items listed, including 3 drug interactions
Drug interactions	17 drugs listed, with extensive information on possible interaction, effect, and monitoring	None (ePocrates Rx Pro lists 52 drugs; further information regarding interaction can be obtained by tapping on drug name)	9 drugs listed	23 drugs listed; further information on interaction (and the effect) can be obtained by tapping on drug name	3 drugs listed
FDA pregnancy category	C; with results of studies conducted and case reports	None (ePocrates Rx Pro states C; tap on category or code for definitions)	C; with definition of pregnancy classes; documentation of teratogenic effects	C; with definition of pregnancy classes	C; no further information given
Lactation	Yes	None (lactation information included in ePocrates Rx Pro)	None	None	None
No. of product formulations listed	8	None (ePocrates Rx Pro: 8)	8	4	None
Cost	None	None (ePocrates Rx Pro: $51.96 for four 200-mg tablets; approximate retail cost for 8 formulations are also listed)	$11.85–$47.41 for one 200-mg tablet	$13.00 for one 200-mg tablet	None
Authors listed	No	No	Yes	No	No

NOTE. FDA, US Food and Drug Administration.

[a] Search for "fluconazole" retrieved 7 tables.

and, although PDA Medical Solutions is a Canadian company, most sales of ID Notes are to users in the United States (Éric J-A Beauséjour, owner and founder, PDA Medical Solutions, personal communication).

Salient features. ID Notes is an iSilo document with the following well-defined bookmarks: "Antimicrobial Spectra Index," "Prophylactic Therapy," "Normal Flora," "Organisms & Treatment," "Infectious Diseases and Treatment," and "Antimicrobial Treatment" (figure 4*A*). The Antimicrobial Spectra Index lists antimicrobial drugs and details which pathogens are >60% susceptible to treatment, which are 30%–60% susceptible, and which are <30% susceptible. The Organisms & Treatment section contains information on >400 pathogens; it can be retrieved using an alphabetical index or according to the morphological, taxonomic, or biological characteristics of the organism. Each organism and infection entry briefly explains the microbiological and epidemiologic characteristics, associated clinical syndromes, and diagnosis and describes recommended, alternative, and other effective treatments. The Disease Index lists >300 infections in alphabetical order and by anatomic site. The entry for each infection includes a section that lists possible differential diagnoses, usual microorganisms, and suggested therapy (figure 4*B*).

Information on >300 drugs can be accessed through the Antimicrobial Treatment bookmark (figure 4*C*). A drug can be selected from an alphabetical list (generic drug names only), by class, or by an index of antimicrobial spectra. Information includes brand names (United States brand names only), antibacterial activity, pregnancy risk factors, contraindications, mechanism of action, pharmacodynamics, pediatric and adult dose recommendations, and the recommended dosage for patients with renal failure.

ID Notes is updated 4 times yearly and costs $39.99, which includes 1 year of updates. Upon purchase of ID Notes, the user receives a 30-day trial subscription of iSilo document reader software. After the expiration of the trial period, users are encouraged to purchase iSilo; the current price for a single user license is $17.50. One feature of the iSilo document reader allows users to create personal bookmarks that provide quick access to frequently used information.

Advantages. ID Notes offers the most extensive information on microbiology and epidemiology. For all drugs listed in ID Notes, information on the mechanism of action and pharmacodynamics is included (figure 4*D*). Unique to this application is a section on the normal flora of the human body. ID Notes also offers a separate section on prophylactic therapy, which describes infection prevention during chemotherapy and the perioperative period.

Disadvantages. The iSilo software that supports this application can be difficult to manipulate. There are several lengthy sections of text that require the user to scroll to find the desired information. If the user does not already own the iSilo document reader, the user should purchase the iSilo software after the trial subscription expires (at an additional cost). The company is currently working on creating its own viewer, which should be available in 2003. Neither author nor references to the literature are contained in the application. References may be obtained by contacting the editors. Multiple misspellings and grammatical errors litter this application. Because it lacks an adverse reactions section for medications, this application lags behind the others reviewed. ID Notes costs $39.99.

Hardware and software requirements. ID Notes requires 96 KB of memory for the iSilo document reader and 636 KB for the document itself. It is available for devices using Palm OS version 3.0 or higher. Users may save the document to expansion memory cards.

Comparison of Applications

To be effective in preventing errors and improving efficiency, the information obtained from a PDA must be reliable. Infectious diseases applications should conform to "gold standards" or established guidelines for standards of care and should contain reliable information about antimicrobial agents.

Comparison of drug information. The quantity and quality of medication information varies among the 4 infectious diseases PDA applications reviewed. For evaluation purposes, we selected 1 drug and compared the information in each application to that in the package insert, which, for this review, was considered the "gold standard" of accurate drug information. On the basis of its pharmacological properties, its need for renal dose adjustment in cases of renal failure, and its well-documented drug interactions, fluconazole was selected as the drug for comparison [17]. The results are summarized in table 3.

None of the PDA infectious diseases applications reviewed supplies all the information available in the package insert for fluconazole. ePocrates ID, with ePocrates Rx Pro, provides the most clinically useful drug information.

All the applications present adult dosing regimens. The Sanford Guide allows the user to select from 40 indications (those that have or those that have not been approved by the US Food and Drug Administration) and, therefore, has the most indication-specific information about dosing regimens. The dosing information in the drug monograph for the ABX Guide is limited, because it only provides a range of usual adult dosing. More detailed indication-specific dosing can be obtained by completing searches through the diagnosis or pathogen tabs.

Pediatric dosing is presented in ID Notes, the Sanford Guide, and ePocrates Rx Pro. In ID Notes, the dosing screen displays pediatric dosing first, which users must scroll past to access adult dosing. Table 16 of the Sanford Guide presents infor-

Table 4. Comparison of antimicrobial therapy recommended by the Infectious Diseases Society of America (IDSA) and by 4 personal digital assistant infectious diseases applications.

	Recommended antimicrobial therapy, by source				
Disease or condition	IDSA [reference]	ePocrates ID (part of ePocrates Rx Pro)	Johns Hopkins Division of Infectious Diseases Antibiotic Guide for Handhelds	Sanford Guide to Antimicrobial Therapy	Infectious Diseases and Antimicrobial Notes
Febrile neutropenia[a]	Amg-AnPen; Amg-Cfep; Amg-Carb [18]	Not found	Not found by search	Not found in index	Amg-Anpen; Amg-Czid
Candidemia[b]	Flu [19]	Not found	Flu; AmB	Flu	AmB; Flu
Community-acquired pneumonia[c]	Mac; Dox; Fluor [20]	Mac; Dox; Fluor	Dox; Mac; Fluor	Mac; Fluor; 2nd generation Csp	Mac; Fluor; 2nd or 3rd generation Csp
Early-stage Lyme disease[d]	Dox; Amox [21]	Dox; Amox	Dox; Amox; Cfur	Dox; Amox; Cfur	Dox; Amox; Cfur; Clm
Acute uncomplicated cystitis	TMP-SMZ for 3 days [22]	TMP-SMZ for 3 days	TMP-SMZ	Fluor for 3 days	Fluor; TMP-SMZ for 3 days
Spontaneous bacterial peritonitis	Ctax for 5 days [23]	Ctri for 7–14 days	Ctax for 10–14 days (5 days is likely adequate for uncomplicated patients)	Ctax (duration not given)	Ctax; AnPen; Ctri (duration not given)

NOTE. For treatment recommendations with >1 drug, the primary regimen is listed first; the alternative regimen, second; the tertiary regimen, third; and the quarternary regimen, fourth. AmB, amphotericin B; Amg, aminoglycoside; Amox, amoxicillin; AnPen, antipseudomonal penicillin; Carb, carbapenem; Cfep, cefepime; Cfur, cefuroxime axetil; Clm, clarithromycin; Csp, cephalosporin; Ctax, cefotaxime; Ctri, ceftriaxone; Czid, ceftazidime; Dox, doxycycline; Flu, fluconazole; Fluor, fluoroquinolone; Mac, macrolide; TMP-SMZ, trimethoprim-sulfamethoxazole.

[a] High risk patients (vancomycin not indicated).
[b] Clinically stable patients with no recent azole use.
[c] Outpatient treatment.
[d] No neurological involvement and no cardiac involvement.

mation about pediatric dosing only for applicable indications and certain antibacterials.

Although presented slightly differently, information on dosing in patients with renal insufficiency and dosing for patients undergoing dialysis is provided by each application. Only ePocrates Rx Pro mimics the package insert with regard to the administration of a loading dose for patients with renal impairment.

Limited pharmacological and pharmacokinetic information is available in the applications. The Sanford Guide indicates the half-life of fluconazole (under table 8a). ePocrates Rx Pro and ID Notes provide information on the mechanism of action and metabolism; ID Notes also contains half-life information.

Information on adverse reactions is available in 3 of the 4 applications; it is noticeably missing from ID Notes. The Sanford Guide has the most complete list and even provides the incidence percentage for each reaction. Only ePocrates Rx Pro and ID Notes provide information on contraindications and precautions.

All applications give some information on drug interactions. ePocrates Rx Pro provides the most extensive list with 52 drugs listed that interact with fluconazole, although, at the other end of the spectrum, ID Notes mentions only 3 fluconazole-drug interactions, and these 3 drugs (cisapride, astemizole, and terfenadine) are no longer available in the United States. More detailed information, such as the effect of interaction and suggested dosing modifications, can be obtained from the Sanford Guide and ePocrates Rx Pro by selecting the potentially interacting drug. ID Notes and the ABX Guide do not have this capability.

When the drug information in each application was compared to that in the package insert, no inaccuracies were noted.

Comparison by disease/syndrome. The 4 PDA infectious diseases applications were compared for specific recommendations for the treatment of the following 6 clinical syndromes/infections: febrile neutropenia, candidemia, community-acquired pneumonia, early Lyme disease, acute uncomplicated cystitis, and spontaneous bacterial peritonitis [18–23]. A comparison was made between current IDSA guidelines for treatment of these conditions and the treatment information and/or recommendations in each of the 4 PDA applications. These 6 conditions were chosen because the IDSA has published guidelines for their treatment and because these conditions are commonly encountered in general practice. The results are summarized in table 4.

Although the applications generally supply recommendations similar to those provided by IDSA, only ID Notes provides information about the treatment of patients with febrile neutropenia. Minor differences among the applications include order of the drugs recommended for treatment of community-acquired pneumonia (a macrolide, in the Sanford Guide and ePocrates ID and ID Notes, and doxycycline, in the ABX Guide) and for acute uncomplicated cystitis (trimethoprim-sulfamethoxazole, in the ABX Guide and ePocrates ID, and fluoroquinolone, in the Sanford Guide and ID Notes). ePocrates ID had no recommendations for the treatment of candidemia.

Professional judgment and knowledge of local patterns of susceptibility and antimicrobial resistance should be part of the clinical decision-making process for antimicrobial agent selection. None of the applications reviewed addresses these patterns of local susceptibility or how these patterns would influence the health care professional's decision.

CONCLUSION

Infectious diseases PDA applications for health care professionals are limited, but the 4 applications reviewed contain the information physicians need most at the point of care. Such data include information on antimicrobials (dosing, adverse events, and drug interactions) and antimicrobial dosing in special circumstances (e.g., for patients with renal failure). Use of PDA applications may decrease the errors in medication prescriptions and lead to significant improvements in patient outcomes and reduction in costs.

Each PDA infectious diseases application reviewed offers unique advantages and disadvantages. Physicians familiar with the paper version of the Sanford Guide may find its PDA version similarly useful and familiar. Those looking mostly for drug information may find ePocrates ID, in combination with ePocrates Rx Pro, the best choice, because it contains the most expansive drug monographs. Those looking for in-depth microorganism information may find ID Notes a good companion at the hospital bedside. Those who want to search for syndromes and/or clinical scenarios may find the ABX Guide most beneficial. If forced to choose 1 of the 4 PDA infectious diseases applications reviewed, we prefer the ABX Guide because it updates automatically, it undergoes the most rigorous review process, and it provides the most details about treatment and diagnosis.

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