Computer Program for Diagnosing and Teaching Geographic Medicine

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One of the unique aspects of infectious disease is its wide variety, both in time and place. The specialist practicing in India may have little or no expertise in Peruvian disease. A colleague in New York may be called upon to diagnose and treat conditions originating in Africa, Asia, South America, Fiji and Papua, New Guinea. At the same time, this colleague must be familiar with the pathogens that originate in Texas, Hawaii, and Canada. Indeed, even the full-time infectious diseases specialist may not be conversant in diseases such as lagochilascariasis, louping ill, and lobomycosis. War, famine, education, immigration, and business travel have contributed to the advent of specialists in Geographic Medicine and Emporiatrics, otherwise known as Travel medicine.

The "art" of diagnosis is largely an ability (albeit subconscious) to rank probabilities based on the incidences of likely diseases and the chance of encountering given clinical features within each disease. In theory, Bayesian analysis could be employed to diagnose disease accurately when given proper input. A multicenter study was undertaken to test a comprehensive computer driven-software program that incorporates worldwide epidemiologic and clinical parameters.

Materials and Methods

Computer Program Design

Interactive data bases that represent rates and clinical probabilities were constructed for 308 diseases; 127 symptoms, signs, and laboratory findings; and 205 countries. Reported statistics published by the World Health Organization and national health ministries were used where available. These were supplemented by data for neighboring countries and previous years when necessary (Table 1). In cases where the accuracy of disease reporting was suspect (e.g., AIDS in Africa), more realistic published estimates were used.

The data base is limited to infectious diseases (Table 2). It does not include slow viral illnesses and a number of self-defined and obvious conditions such as otitis externa and furunculosis. As the program is designed to diagnose clinically apparent disease, data regarding asymptomatic carriage or infestation were adjusted accordingly. Figures regarding the incidence of signs and symptoms within each specific disease were derived from standard textbooks and reviews. Clinical and epidemiologic data are updated on a continous basis.

The program user is first requested to indicate the country of disease origin and is then presented with a list of 22 basic clinical parameters, which are grouped according to body system. A + or - response to each of the latter is indicated by using any of a variety of computer keystrokes. A + response automatically opens a computer window that requests further details. Thus, if the user indicates that a rash is present, he will be asked to further define the nature and distribution of the skin lesions. An additional window is available for the entry of laboratory test results (hematologic, cerebrospin, hepatic, or renal) if available.

User input is processed by a Bayesian matrix, and compatible diagnoses are presented in order of probability in a bar graph and numerical format. Ancillary clues for all listed diseases are accessed by specified key strokes as follows: incubation period, clinical hints, geographic distribution, vector, vehicle, reservoir, etc. Additionally, drugs of choice and dosages for adult or pediatric therapy are listed. The diagnosis list is accompanied by an ancillary screen, which indicates rare (albeit compatible) clinical findings in each disease listed for the patient in question. An additional interactive screen lists all additional clinical findings that could improve diagnostic specificity.

Separate computer modules allow the user to study specific diseases and antiinfective agents without regard to a specific patient. The user may, for example, request a listing for all parasitic diseases acquired in Togo from the bites of mosquitoes; or of all drugs which interact with alcohol. In addition to the epidemiologic and clinical parameters outlined above, screens are available that outline the worldwide distribution of each disease, as well as the current status of AIDS, malaria, tuberculosis, yellow fever,

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Table 1 Sources Used in Maintaining The Epidemiologic Database

- Official Health Ministry Reports
  - Bericht Uber dat Gesundheitswesen in Osterreich [Austria]
  - Boletin Epidemiologico de Chile
  - Boletin Epidemiologico Nacional [Argentina]
  - Boletin Epidemiologico y Microbiologico [Spain]
  - Boletin Informativo [Bolivia]
  - Bulletin Epidemiologique Hebdomadaire [France]
  - Canada Communicable Disease Report [Canada]
  - CDR Weekly [United Kingdom]
  - Choroby Zakazne I Zatrucia W Polsce [Poland]
  - Communicable Diseases Intelligence [Australia]
  - Community Health & Disease Surveillance News Letter [Oman]
  - Comportamiento de Patologias Immunoprevenibles [Argentina]
  - Daten des Gesundheitswesens [Germany]
  - EpidAktuellt [Sweden]
  - Epidemiology Bulletin [Taiwan]
  - EPI-NYT [Denmark]
  - Heilbrigdisskyrslur [Iceland]
  - IASR [Japan]
  - Health Statistics Ireland [Ireland]
  - Monthly Epidemiological Bulletin [Israel]
  - Morbidity and Mortality Weekly Report [USA]
  - MSIS-rapport [Norway]
  - Notiziario dell'Instituto Superiore de Sanita [Italy]
  - Terveys [Finland]
  - Weekly Epidemiological Record [WHO]
- Journals and Periodicals
  - AIDS
  - American Journal of Clinical Pathology
  - American Journal of Diseases of Children
  - American Journal of Epidemiology
  - American Journal of Medicine
  - American Journal of Public Health
  - American Journal of Tropical Medicine and Hygiene
  - Annals of Internal Medicine
  - Antimicrobial Agents and Chemotherapy
  - Applied Microbiology
  - Archives of Internal Medicine
  - British Medical Journal
  - Bulletin of the World Health Organization
  - Clinical Infectious Diseases
  - Clinical Microbiology Reviews
  - European Journal of Microbiology and Infectious Diseases
  - Harefuah
  - Infectious Disease Clinics
  - Infectious Disease Clinics of North America
  - International Journal of Systematic Bacteriology
  - Israel Journal of Medical Sciences
  - JAMA
  - Journal of Antimicrobial Chemotherapy
  - Journal of Clinical Microbiology
  - Journal of Clinical Pathology
  - Journal of Hospital Infection
  - Journal of Internal Medicine
  - Journal of Infectious Diseases
  - Journal of Pediatrics
  - Journal of Travel Medicine
  - Lancet
  - Medical Journal of Australia
  - Medicine
  - Morbidity and Mortality Weekly Report (CDC)
  - New England Journal of Medicine
  - Pediatric Clinics of North America
  - The Pediatric Infectious Disease Journal
  - Pediatrics
  - Reviews of Infectious Diseases
  - Scandinavian Journal of Infectious Diseases
  - South African Medical Journal
  - Southern Medical Journal
  - The Medical Letter
  - Transactions of the Royal Society of Tropical Medicine and Hygiene
  - Tubercle
  - World Health Statistics Quarterly

and cholera. The therapeutic spectrum, toxicity, dosage and other characteristics of anti-infective agents and vaccines are also available.

Multicenter Study

Questionnaires reflecting the computer input screen were distributed to six senior full-time infectious disease specialists. (The authors' own institution was excluded). Participants were requested to record all positive and negative clinical data for consecutive patients with established diagnoses. Since the majority of cases were anticipated to represent disease acquired in the study country (Israel) a similar number of "hypothetical" cases acquired abroad was also elicited. Questionnaires were assigned code numbers and submitted in a blinded fashion, with diagnoses recorded on a separate sheet. All results were collated and entered into a data base (dBase III+) prior to to review of the clinical diagnoses. Statistical analysis employed the chi-square test for unpaired proportions.

Results

Four hundred ninety and five of 513 cases submitted were suitable for analysis (Table 3). Ninety four individual infectious diseases were represented among these cases (Table 2). The computer program accurately identified the clinical diagnosis in 75.3% of actual cases and in 64.0% of hypothetical cases ($p = .009$). The clinical diagnosis was included in the computer differential diagnosis list in 94.7%. The accuracy of diagnosis was highest for parasitic disease ($p = .04$) and diseases acquired

Table 2 Diseases and Pathogens Included in the Data Base

Abscess, intraabdominal*
Actinomycosis
Adenovirus infection
Aeromonas & marine Vibrio infx.
AIDS*
Amebiasis*
Amoeba - free living*
Angiostrongyliasis
Angiostrongyliasis abdominal
Anisakiasis
Anthrax*
Argentine hemorrhagic fever
Ascariasis
Aseptic meningitis, viral*
Aspergillosis
Babesiosis*
Bacillary angiomatosis
Bacillus cereus food poisoning
Balantidiasis
Bartonellosis
Bertielliasis
Blastocystis hominis infection
Blastomycosis*
Bolivian hemorrhagic fever
Botulism
Brain abscess*
Brazilian purpuric fever
Brucellosis*
California encephalitis group
Campylobacteriosis*
Candidiasis
Capillariasis, hepatic
Capillariasis, intestinal
Cat scratch disease*
Cercarial dermatitis
Chancroid*
Chikungunya
Chlamydia infections, misc.
Chlamydia pneumoniae infection
Cholecystitis & cholangitis*
Cholera*
Chromomycosis
Chronic fatigue syndrome
Chronic meningococcemia
Clonorchiasis*
Clostridial food poisoning
Clostridial myonecrosis
Clostridium difficile colitis*
Coccidioidomycosis
Coenurosis
Colorado tick fever
Common cold*
Conjunctivitis inclusion
Conjunctivitis viral
Cowpox
Crimean Congo hemorrhagic fever
Cryptococcosis*
Cryptosporidiosis*
Cyclospora infection
Cutaneous larva migrans*
Cutaneous leishmaniasis*
Cyclospora infection
Cysticercosis*
Cytomegalovirus infection*
Dengue*
Dermatophytosis
Dicrocoeliasis
Dientamoebal diarrhea
Dioctophyme renale infection
Diphtheria
Diphyllobothriasis
Dipylidiasis
Dirofilariasis
Dracunculiasis*
Eastern equine encephalitis
Ebola Disease
Echinococcosis*
Echinococcus – multilocular
Echinococcus vogeli infection
Echinostomiasis
Ehrlichiosis – E. chaffeenensis*
Ehrlichiosis – E. sennetsu
Endemic syphilis (bejel)
Endocarditis – infectious*
Entamoeba polecki infection
Enteritis necroticans
Enterobiasis
Enterovirus infection*
Entomophthoromycosis
Epidural abscess
Erysipelas or cellulitis
Erysipeloid
Erythrasma
Escherichia coli diarrhea
European tick encephalitis
Far eastern tick–borne enceph.
Fascioliasis
Fasciolopsiasis
Filariasis – Brugia malayi
Filariasis – Brugia timori
Filariasis – Bancroftian
Gardnerella vaginalis infection
Gastrodiscoidiasis
Giardiasis*
Glanders
Gnathostomiasis*
Gonorrhea
Granuloma inguinale
Group C viral fevers
Hantavirus resp. distress*
Hemorrhagic fever & renal synd.
Hepatitis A*
Hepatitis B*
Hepatitis C
Hepatitis delta infection
Hepatitis E
Herpes simplex infection*
Herpes simplex encephalitis*
Herpesvirus simiae infection
Herpes zoster*
Heterophyiasis
Histoplasmosis*
Histoplasmosis – African
HIV infection – initial illness*
Hookworm
Hymenolepis diminuta infection
Hymenolepis nana infection
Ilheus
Influenza*
Intracranial venous thrombosis
Isosporiasis
Japanese encephalitis*
Karelian fever
Kawasaki disease
Kingella infection
Kyasanur Forest disease
Lagochilascariasis
Laryngotracheobronchitis
Lassa fever*
Legionellosis*
Leprosy
Leptospirosis*
Linguatulosis
Listeriosis*
Liver abscess, bacterial*
Lobomycosis
Loiasis*
Louping ill
Lyme disease*
Lymphocytic choriomeningitis
Lymphogranuloma venereum
Malaria*
Malignant otitis externa
Mansonelliasis – M. ozzardi
Mansonelliasis – M. perstans
Mansonelliasis – M. streptocerca
Marburg virus disease
Mayaro
Measles*
Mediterranean spotted fever*
Melioidosis*
Meningitis, bacterial*
Metagonimiasis
Microsporidosis
Monkeypox
Mononucleosis, infectious*
Mucocutaneous leishmaniasis
Mumps
Murray Valley encephalitis
Mycetoma
Mycobacteriosis – M. marinum*
Mycobacteriosis – M. scrofulaceum
Mycobacteriosis – M. ulcerans
Mycobacteriosis – systemic*
Mycoplasma pneumoniae infec.* Myiasis*
Nanophyetiasis
Necrotizing skin/soft tissue infx.
Nocardiosis*
North Asian tick typhus
Norwalk agent gastroenteritis
O'nyong nyong
Ockelbo disease
Oesophagostomiasis
Omsk hemorrhagic fever
Onchocerciasis*
Opisthorchiasis
Orbital infection
Orf
Ornithosis*
Oropouche
Osteomyelitis
Otitis media
Paracoccidioidomycosis
Paragonimiasis
Parainfluenza virus infection
Parvovirus B19 infection
Pasteurellosis*
Pediculosis
Penicilliosis
Pentastomiasis
Pericarditis, bacterial
Perinephric abscess*
Perirectal abscess*
Peritonitis, bacterial
Pertussis
Pharyngeal & cervical space infx.
Pharyngitis, acute bacterial
Pinta
Plague*
Plesiomonas enteritis
Pleurodynia
Pneumocystis pneumonia*
Pneumonia, bacterial*
Pogosta disease
Poliomyelitis (wild or vaccine)
Powassan
Pseudocowpox
Pyodermas (impetigo, abscess, etc)
Pyomyositis*
Q fever*
Queensland tick typhus
Rabies
Rat bite fever – spirillary
Rat bite fever – streptobacillary
Relapsing fever*
Respiratory syncytial infection
Reye's syndrome

Table 2 Diseases and Pathogens Included in the Data Base ***(Continued)***

Rheumatic fever	Schistosomiasis – japonicum	Tetanus	Typhus – epidemic
Rhinoscleroma	Schistosomiasis – mansoni*	Thelaziasis	Typhus – scrub
Rhinosporidiosis	Schistosomiasis – mattheei	Thogoto Toxic shock syndrome*	Urinary tract infection*
Rhodococcus equi infection	Schistosomiasis – mekongi	Toxocariasis*	Varicella*
Rickettsialpox	Septicemia, bacterial*	Toxoplasmosis*	Venezuelan equine encephalitis
Rift Valley fever	Septicemia, fungal*	Trachoma	Venezuelan hemorrhagic fever
Rocio	Shigellosis*	Trench fever	Vesicular stomatitis disease
Rocky Mountain spotted fever*	Sindbis	Trichinosis*	Vibrio parahaemolyticus infection
Roseola or human herpesvirus 6	Sinusitis	Trichomoniasis	Visceral leishmaniasis*
Ross River disease	Smallpox	Trichostrongyliasis	Wesselbron
Rotavirus infection*	Sparganosis	Trichuriasis	West Nile Fever
Rubella*	Spondweni	Tropical phagedenic ulcer	Western equine encephalitis
Sabia	Sporotrichosis	Tropical pulmonary eosinophilia	Whipple's disease
Salmonellosis	St. Louis encephalitis	Trypanosomiasis – African	Wound infection
Sandfly fever*	Staphylococcal food poisoning	Trypanosomiasis – American*	Yaws
Sarcocystosis	Strongyloidiasis*	Tuberculosis*	Yellow fever
Scabies	Subdural empyema	Tularemia*	Yersiniosis*
Scarlet fever	Suppurative parotitis	Tungiasis	Zygomycosis*
Schistosomiasis – haematobium*	Syngamiasis	Typhoid and enteric fever*	
Schistosomiasis – intercalatum	Syphilis*	Typhus – endemic	
	Taeniasis		
	Tanapox virus disease		

*denotes cases submitted for diagnosis in the present study

in Africa ($p = .04$) and South East Asia ($p = .03$); no such differences were noted with respect to body system and patient age group.

Discussion

The major problem in developing an infectious disease diagnosis program is difficulty in obtaining reliable and accurate incidence data. The reporting rate for diseases varies widely between countries and among differing diseases within any given country. Furthermore, the computer program assumes that the patient is a citizen or local resident of the country in question. Incidence data for tourists and expatriates may vary from those of the indigenous population. In some cases, the country of acquisition may not match the country of residence.

Selection of discriminative clinical and laboratory parameters for the data base is complicated by the fact that individual infections are quite similar, often producing fever, cough, rash, elevated white blood cell count, etc.

Table 3 Evaluation of a Computer-Driven Infectious Disease Diagnosis Program (percent)

	Nature of Infection					
	Bacterial	*Parasitic*	*Viral*	*Fungal*	*Total*	*Correct* *
Actual cases	150	30	100	15	295	222 (75.3)
Hypothetical cases	97	60	33	10	200	128 (64.0)
Total	247	90	133	25	495	
Correct diagnosis*	186 (75.3)	60 (66.7)	88 (66.2)	16 (64.0)	350 (70.7)	
Correct diagnosis included in differential†	236 (95.5)	87 (96.7)	124 (93.2)	22 (88.0)	469 (94.7)	

	Country of Acquisition						
	Israel	*Africa*	*Southeast Asia*	*Europe*	*Latin America*	*North America*	*Other*
Number of cases	308	66	65	24	7	19	6
Correct diagnosis*	205 (66.6)	54 (81.8)	54 (83.1)	16 (66.7)	5 (71.4)	12 (63.2)	4 (66.7)
Correct diagnosis included in differential†	295 (95.8)	62 (93.9)	61 (93.8)	23 (95.8)	6 (85.7)	18 (94.7)	4 (66.7)

*Concordance between the correct clinical diagnosis and the disease listed first in the computer-generated differential diagnosis list; †the correct clinical diagnosis is included in the computer-generated diagnosis list

Similar abnormalities are also found in a variety of noninfectious diseases. An additional difficulty in any diagnostic program is the reliability of user input. The accuracy of clinical input is only as good as the accuracy of history taking, physical examination, and laboratory testing. In some instances, more than one disease may be present, or clinical observations may be factitious or unrelated to the present illness. In the current study, actual cases were correctly diagnosed more often than hypothetical cases (e.g., acquired overseas), thereby suggesting relative unfamiliarity of infectious diseases experts with the clinical features of "exotic" diseases.

During the period January 1989–February 1992, *Index Medicus* listed 2063 papers under the subject heading, "Diagnosis, Computer Assisted," and 7139 under the heading, "Software"; however, no program specifically designed for diagnosis in infectious and geographic medicine has been reported in the English language literature to date. Existing computer-driven diagnostic programs have failed to adequately simulate human intelligence or find widespread practical use in the field.[1–3] As such, software systems (including the program under study) are marketed for "decision support," and display appropriate disclaimers that remind the user that clinical judgment still takes precedence over computer "expert systems."

In a recent study, the "sensitivity" (i.e., ability to include the correct diagnosis in a differential list) of foursuch systems was found to be adequate, but often at the expense of low "specificity" (ability to exclude irrelevant diagnoses).[4] Nevertheless, an accompanying editorial suggested that the alternative diagnoses listed were often valuable to the clinician and would not otherwise have been considered.[5] Indeed, when dealing with infection acquired in an exotic country, the clinician might find an exhaustive differential diagnosis to be quite helpful. Although only 94 diseases (30.5% of the program data base) were represented, our preliminary study suggests that the program under study is comprehensive and accurate, and could prove useful in the diagnosis of infectious and tropical disease. An expanded study among infectious diseases physicians in the United States will be undertaken in the near future.

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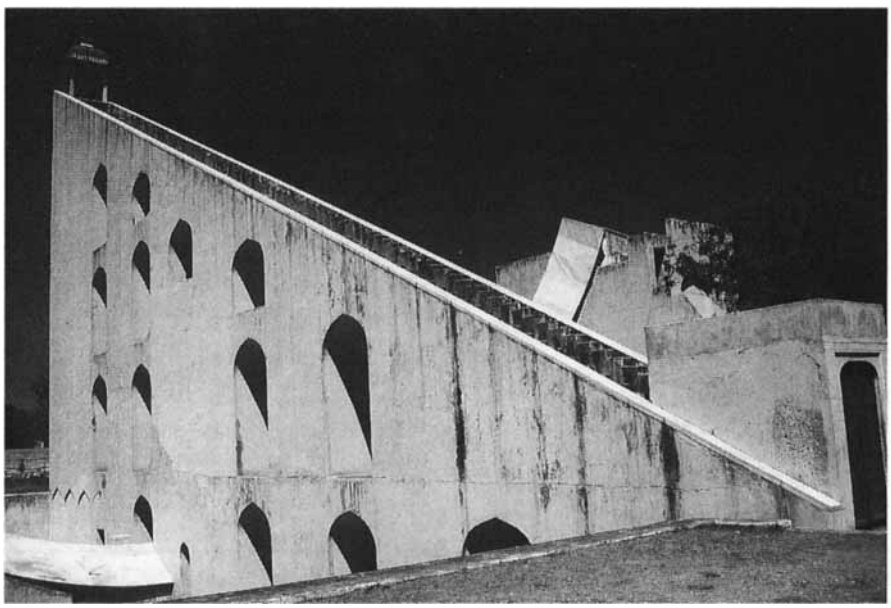

Sundial, 30 meters high, at the observatory of Jantra Mantra built in 1728 by Jai Singh in Jaipur/Rajastan/India. Submitted by Danielle Gyurech, MD and Julian Schilling, MD.