Computer support for genetic advice in primary care

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SUMMARY

General practitioners (GPs) are under increasing pressure to advise patients about genetic risk. Secondary care lacks the resources to deal with the increasing number of referrals for genetic counselling, and thus recommendations have been made to develop primary care genetics. But for most GPs, genetics is unfamiliar territory. Computers could help general practice to provide a genetics service by simplifying the construction and assessment of family trees and by implementing management guidelines. No programs have been written specifically for primary care genetics, but a range of software exists for secondary care. This paper discusses the types of program already available and how they relate to the needs of primary care. Currently available software offers only elements of the outlined 'ideal' program for primary care and may be too complex for a general practice setting. Most importantly, none provide decision support concerning management based on the level of risk, even though this may be the most valuable element. Genetics is an appropriate area for decision support software in general practice, but it would be wrong to assume that this alone is the key to developing primary care genetics. Additional educational strategies for GPs will be required, and the attitudes of patients to receiving expert advice from a computer must be considered. Current practice computer systems will have to develop so they can communicate with Windows-based expert systems, and changes in existing surgery hardware may be necessary. Existing genetics software provides a starting point from which to derive an appropriate system for general practice. A carefully developed decision-support system could empower GPs to meet the challenge of offering a high-quality genetics service in primary care.

Keywords: genetics; practice computer systems; decision support; general practitioners.

Introduction

GENERAL practitioners (GPs) are under increasing pressure to advise patients about genetic risk. Developments arising from the Human Genome Project are beginning to reach the level of primary care, with patients presenting with worries about their family history of cancer and other common diseases. Such concerns are fuelled by media coverage of advances in molecular biology and the growing public awareness about genetic tests for inherited cancer. Secondary care services lack the resources to deal with the increasing number of referrals for genetic counselling.[1] In response, recommendations from the government and from within the profession have been made to develop a primary care genetics service,[2,3] but doubts exist over how prepared GPs are to offer such a service.[1]

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For most GPs, genetics is unfamiliar territory — currently they receive little training in taking an adequate family history or drawing a pedigree. The rapid developments in molecular biology make keeping up-to-date virtually impossible for doctors managing a multitude of medical problems in their daily practice. Concerns have been expressed about the ethical implications of genetic advances in primary care, particularly relating to confidentiality of genetic information and the potential for genetic discrimination.[4] GPs may also be reluctant to accept further work that is traditionally viewed as the remit of secondary care.

Computers could help general practice to provide a genetics service by simplifying the construction and assessment of family trees, and by implementing management guidelines.[5,6] They could educate GPs about the role of genetic testing, creating more realistic expectations about a referral to a geneticist. This article reviews the types of software currently available to clinical geneticists, suggesting those programs that may be most useful for primary care, and proposes software developments to meet the needs of GPs more closely.

Primary care computing

Over 90% of general practice surgeries are computerized, and more than 60% of GPs use computers in the consultation.[7] For several years there has been interest in computerized decision support in general practice, and a variety of systems have been developed for prescribing,[8] immunization,[9] chronic disease management,[10] and cancer prevention.[11] Computers increase the use of guidelines[12] and can improve clinical performance at the possible expense of longer consultations.[13] Despite this, decision support has not been adopted into routine general practice. The reasons for this are numerous. Wyatt and Spiegelhalter argue that more careful evaluation prior to commercial release could improve the uptake of expert systems.[14] Many existing programs do not deliver advice that is sufficiently specific to individual patients. To provide such advice requires a system that aids decision-making, using existing guidelines at the appropriate moment in the consultation.[15] This approach formed the basis of CAPSULE, a computer support system for primary care shown to improve compliance with prescribing guidelines.[16]

Currently there are no computer systems written specifically for primary care genetics, but many applications exist for genetics in the fields of botany, molecular biology, and clinical genetics. It is beyond the scope of this article to review all these, but instead I will discuss examples of the type of program currently aimed at secondary care geneticists and how they relate to the needs of primary care.

Computer systems for secondary care genetics

The full range of computer systems for clinical geneticists has been reviewed previously,[17] but essentially they can be categorized according to function: databases to assist with diagnosis, programs for risk calculation, and programs for pedigree drawing (Table 1).

Several databases exist that contain descriptions of dysmorphic syndromes and other inherited conditions, which provide the geneticist with advice on diagnosis and management. The most extensive is Online Mendelian Inheritance in Man

Table 1. Types of program developed for clinical geneticists.

Function of program	Examples of program
Database	OMIM, POSSUM, SYNDROC
Risk calculation	LINKAGE, RISK
Pedigree drawing	Geninfer, Cyrillic, Progeny,[32] PEDRAW[33]

(OMIM),[18] which is a catalogue of human genes and genetic diseases with links to MEDLINE articles and genetic sequence information. It can be accessed via the Internet and has a searchable database detailing current knowledge on the genetics of both common and rare disorders. Some programs go beyond this, offering specific diagnostic advice for rare conditions based on the pattern of clinical features entered (e.g. POSSUM,[19] SYNDROC[20]).

Traditionally, a major component of genetic counselling is the calculation of genetic risk, and several programs have been developed for this purpose. LINKAGE is designed for risk calculation and linkage analysis (a method of studying genetic markers that co-segregate or are 'linked' with specific diseases).[21] It accounts for quantitative and qualitative information (e.g. genetic markers, affection status). For example, before gene testing for Duchenne muscular dystrophy was possible, the program was used to calculate the risk of being a gene carrier on the basis of the pedigree and creatine kinase levels. The advantage of this type of program is that it can calculate risk of specific diseases using statistical methods applied to epidemiological data. LINKAGE has used data from the CASH study[22] — an American case-control study of breast, ovarian, and endometrial cancer — to calculate an individual's risk of breast cancer. It uses the Claus model to assess risk based on the pattern of affected and unaffected relatives,[23] and has been shown to be an effective method of selecting families for *BRCA* gene testing.[24] Similarly, RISK uses the Gail model[25] to calculate individualized risk of breast cancer based on age at menarche and first birth, family history of breast cancer, number of breast biopsies, and presence of atypical hyperplasia.[26] Both these programs can therefore provide personalized risk advice to women concerned about breast cancer and help them make informed choices about screening or preventive strategies.

There are many pedigree drawing programs that vary in their ease of use, capacity to deal with complex families, and ability to interpret the pedigree by communicating with LINKAGE files. PEDRAW is a relatively older program that can handle quite complex pedigrees and is reasonably straightforward to use.[27] Progeny is a more versatile program that can store extensive information about individuals in a pedigree, including results of investigations and histological slides.[28] Cyrillic is the only commercially available product that combines a pedigree drawing program with calculation of genetic risk.[29] It uses LINKAGE to apply the Claus model to calculate risk for women with a family history of breast cancer, and is established in several cancer genetics clinics in Britain. The Massachusetts Institute of Technology is currently writing a program for genetic counsellors entitled GENINFER, designed to draw pedigrees and calculate risks for a range of genetic conditions, including single gene Mendelian disorders and diseases with more complex patterns of inheritance.[30]

The current systems developed for clinical geneticists lack rigorous evaluation or are still under development, and hence one cannot make specific judgements about their effectiveness. With such a range of genetics software already available, it is worth considering which elements would be most useful in general practice and whether any desirable features are lacking.

Requirements of an expert system for primary care genetics

The basic requirements of an expert system in general practice and the elements provided by each of the current programs are outlined in Table 2 along with their availability and costs. Clearly a program on rare conditions such as POSSUM would be inappropriate for primary care. OMIM could play a role as an up-to-date source on genetic diseases, but much of the information provided is irrelevant to general practice.

For any program, probably the most important factor is that it guides the doctor through each stage of its use. It is estimated that currently a GP with a list size of 2000 patients will see one to two patients per month about a family history of breast cancer,[31] and fewer still for other familial conditions. Thus the program must be relatively intuitive for the infrequent user. In general practice, the family history will be the mainstay of genetic risk assessment for common diseases,[32] and thus the system should include a pedigree drawing program with simultaneous display of the pedigree. Ideally the pedigree should have two sets of symbols: a standard geneticist's set and a non-expert set that will be more meaningful to patients and GPs. This would allow data checking by both doctor and patient and provide a focus for discussion of the family history in the consultation, possibly improving the quality of information recorded. The need for a pedigree drawing program should not be underestimated — the family tree is the basic unit of analysis in genetics and will act as a common method of communication between primary and secondary care.

General practitioners require a method of risk assessment based on the family history. This need not necessarily be a precise statistical risk calculation but could be a risk categorization on which the doctor can base management decisions. This would be consistent with national guidelines for familial breast cancer currently being developed, which aim to separate women into low, moderate, and high risk groups.[33] By their very nature, guidelines on genetic risk assessment are complex, allowing for the variety of permutations within a pedigree that defines risk. A computer system should be able to implement these guidelines within the consultation, based on the information from the pedigree.

The difficulties communicating genetic risk are well known and partly reflect the problem of presenting risk in purely numerical terms.[34] The use of patient-centred graphical techniques to discuss risk has been described[35] and could be implemented by the program to improve patient understanding of the issues involved. In general practice this would be particularly useful for counselling and reassuring the majority of patients who will be at low risk of carrying known disease susceptibility genes such as *BRCA* and *HNPCC*.

Integrating genetic advice software into primary care

Although computer decision-support systems have been proposed as a method of developing a primary care genetics service, Table 2 demonstrates that currently available software offers only elements of the outlined 'ideal' program for primary care and may be too complex for a general practice setting. Most importantly, none provide decision support about management based on the level of risk, however, this is probably the most valuable element.

Genetics is an appropriate area for an expert system in general practice, since it is a rapidly changing field in an unfamiliar area

Table 2. Requirements of a genetic advice program for primary care and a comparison of current software.

Program	Common disease	Ease of use	Pedigree drawing	On-screen pedigree	Risk calculation	Decision support	Commercially available	Cost
OMIM	Yes (and rare)	Good. Searchable database but much information irrelevant	No	No	No	No	Yes, via Internet	Free
POSSUM	No	Moderate	No	No	No	Yes	No	N/A
RISK	Yes	Good	No	No	Yes but based on inappropriate factors for primary care	No	No	N/A
PEDRAW	N/A	Moderate. Confusing data entry boxes	Yes	Yes	No	No	Yes	$45
Cyrillic	Yes	Moderate. Unintuitive method of drawing pedigree	Yes	Yes	Yes	No	Yes	£499
Progeny	N/A	Good once data entry fields entered	Yes	Yes	No	No	Yes	$900
Geninfer	Yes	Under development	Yes	Yes	Yes	No	Not currently	N/A

of medicine. Guidelines exist for managing family histories of cancer that might be best implemented by computer, particularly since consultations in this area are relatively infrequent and the guidelines are complicated. It would be wrong though to assume that computerized advice holds the key to developing primary care genetics. Evidence exists that GPs are prepared to offer genetic counselling if they receive further education in genetics.[36] GPs may only use a computer program for genetic advice if they feel confident about genetics generally and if it does not consume too much of their time. Furthermore, it is uncertain how patients might react to expert advice provided principally by a computer.[37] Perhaps the most significant barrier for British general practice however, is the problem of integrating decision support software into existing practice systems. Although some are moving towards a Windows operating system (e.g. Emis, VAMP), none can communicate directly with Windows-based programs. The inability to share patient information between the general practice system and a decision-support program coupled with the use of 'dumb terminals' on many doctors' desks is a major hurdle to the integration of expert systems in primary care. If general practice is to upgrade both its hardware and software, then it must be convinced of the possible benefits. About half of the referrals from primary care to a breast cancer genetics clinic are for women with only mildly elevated risk.[38] A program providing referral advice at the point of patient contact could have a significant impact on workload in these clinics and reduce referral costs. However, given the number of referrals currently made by an individual GP in this area, this benefit alone may be insufficient to drive such a major change.

If information technology is going to provide an answer for primary care genetics, then lessons must be learnt from previous attempts to provide decision support in general practice. Careful evaluation prior to commercial promotion is essential so that the program meets the needs of the users and that its effects on process of care and patient outcomes are known. Advances in genetics will continue to feed into primary care. Existing genetics software provides a starting point from which to derive an appropriate system for general practice. A carefully developed and evaluated computer decision-support system could empower GPs to meet the challenge of offering a high quality genetics service in primary care.

References

1. Kay C, Harris H, Harris R. Genetic testing, common diseases, and health service provision [Letter.] *Lancet* 1996; **347:** 686.
2. House of Commons Science and Technology Committee. *Human genetics: the science and its consequences.* London: HMSO, 1995.
3. North West England Faculty of the RCGP. *Genetics in primary care.* A report from the Faculty Genetics Group. [Occasional Paper 77.] London: Royal College of General Practitioners, 1998.
4. Sweeney B. Genetic advances: great promise tempered with concern. *Br J Gen Pract* 1997; **47:** 544-555.
5. Emery J. Familial breast cancer. *Fam Pract* 1997; **14(5):** 422.
6. Harris R, Harris H. *Genetics in primary care*. [Report on workshop of EC Concerted Action on Genetic Services in Europe (CAGSE) in association with the RCGP Spring meeting, Blackpool, UK, 28 April 1995.] *J Med Genet* 1996; **33:** 346-348.
7. NHS Management Executive. *Computerisation in GP practices 1993 survey*. London: DoH, 1993.
8. Vadher B, Patterson D, Leaning M. Evaluation of a decision support system for initiation and control of oral anticoagulation in a randomised trial. *BMJ* 1997; **314:** 1252-1256.
9. Rosser W, Hutchison B, McDowell I, Newell C. Use of reminders to increase compliance with tetanus booster vaccination. *CMAJ* 1992; **146:** 911-917.
10. Brownbridge G, Evans A, Fitter M, Platts M. An interactive computerised protocol for the management of hypertension: effects on the general practitioner's clinical behaviour. *J R Coll Gen Pract* 1986; **36:** 198-202.
11. McDowell I, Newell C, Rosser W. Computerized reminders to encourage cervical screening in family practice. *Fam Pract* 1989; **28:** 420-424.
12. Johnston M, Langton K, Haynes B, Mathieu A. Effects of computer-based clinical decision support systems on clinician performance and patient outcome. *Ann Int Med* 1994; **120:** 135-142.
13. Sullivan F, Mitchell E. Has general practitioner computing made a difference to patient care? A systematic review of published reports. *BMJ* 1995; **311:** 848-852.
14. Wyatt J, Spiegelhalter D. Evaluating medical expert systems: what to test and how? *Med Info* 1990; **15:** 205-217.
15. Pritchard P. Decision support for GPs: towards a more certain future? *J Info Prim Care* 1995; September: 3-5.
16. Walton RT, Gierl C, Yudkin P, *et al*. Evaluation of computer support for prescribing (CAPSULE) using simulated cases. *BMJ* 1997; **315:** 791-795.
17. Fischer C, Schweigert S, Spreckelsen C, Vogel F. Programs, databases, and expert systems for human geneticists - a survey. *Hum Genet* 1996; **97:** 129-137.
18. Center for Medical Genetics and National Center for Biotechnology Information, National Library of Medicine (Bethesda, MD). *Online Mendelian Inheritance in Man, OMIM™.* http://www.ncbi.nlm.nih.gov/omim/ 1997.
19. Stromme P. The diagnosis of syndromes by use of a dysmorphology database. *Acta Paediatr Scand* 1991; **80:** 106-109.

20. Schorderet D. Diagnosing human malformation patterns with a microcomputer: evaluation of two different algorithms. *Am J Med Genet* 1987; **28:** 337-344.
21. Lathrop G, Lalouel J. Simple calculations of lod scores on small computers. *Am J Hum Genet* 1984; **36:** 460-465.
22. Long-term oral contraceptive use and the risk of breast cancer. The Centers for Disease Control Cancer and Steroid Hormone Study. *JAMA* 1983; **249(12):** 1591-1595.
23. Claus E, Risch N, Thompson D. Genetic analysis of breast cancer in the Cancer and Steroid Hormone Study. *Am J Hum Genet* 1991; **48:** 232-242.
24. Chang-Claude J, Dong J, Schmidt S, *et al*. Using gene carrier probability to select high risk families for identifying germline mutations in breast cancer susceptibility genes. *J Med Genet* 1998; **35:** 116-121.
25. Gail M, Brinton L, Byar P, *et al*. Projecting invidualised probabilities of developing breast cancer for white females who are being examined annually. *J Natl Cancer Inst* 1989; **81:** 1879.
26. Benichou J. A computer program for estimating individualized probabilities of breast cancer. *Comp Bio Res* 1993; **26:** 373-382.
27. Curtis D. A program to draw pedigrees using LINKAGE or LINKSYS data files. *Ann Hum Genet* 1990; **54:** 365-367 (available from: P Mamelka. Dept of Genetics, SW Foundation of Biomedical Research, PO Box 28148, San Antonio, Texas, USA).
28. Genetic Data Systems. *Progeny*. http://www.progeny2000.com/ 1998.
29. Cyrillic 2.1 version. Cherwell Scientific Publishing Ltd. http://www.cherwell.com 1997.
30. Clinical Decision Making Group, Massachusetts Institute of Technology. *Geninfer*. http://www.medg.lcs.mit.edu/projects/geninfer.html 1997.
31. Bock Gd, Perk D, Ooserwijk J, *et al*. Women worried about their familial breast cancer risk - a study on genetic advice in general practice. *Fam Pract* 1997; **14:** 40-43.
32. Rose PW, Suchard MA. Screening people with a family history of cancer. Taking a family history in primary care is important. [Letter; comment.] *BMJ* 1997; **315:** 1306.
33. Consensus Meeting on the Management of Women with a Family History of Breast Cancer. London: Wellcome Trust, 1998.
34. Hallowell N, Green J, Statham H, *et al*. Recall of numerical risk estimates and the counsellees' perceptions of the importance of risk information following genetic counselling for breast and ovarian cancer. *Psychol Health Medicine* 1997; **2:** 149-159.
35. Calman K, Royston G. Risk language and dialects. *BMJ* 1997; **315:** 939-942.
36. Mennie M, Campbell H, Liston WA, Brock DJ. Attitudes of general practitioners to screening for cystic fibrosis. *J Med Screen* 1998; **5(1):** 11-15.
37. Als AB. The desk-top computer as a magic box: patterns of behaviour connected with the desk-top computer; GPs' and patients' perceptions. *Fam Pract* 1997; **14(1):** 17-23.
38. Harris R, Harris H. Primary care for patients at genetic risk. *BMJ* 1995; **311:** 275-276.

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