An interactive computerized protocol for the management of hypertension: effects on the general practitioner's clinical behaviour

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SUMMARY. This paper reports an experimental study of general practitioners' use of an interactive computerized protocol for the management of hypertension, focussing particularly on the protocol's effects on doctors' clinical behaviour. Prior to its computerization a paper-based version of the protocol was used enabling a comparison of the alternative forms. Doctors' delivery of care was assessed from video recordings of 89 consultations and from the records made during these consultations. Comparisons were made of consultations conducted under control and experimental conditions. Use of paper and computer protocols resulted in significant improvements in the doctors' delivery of care, in terms of the range of verbal and physical examinations conducted and recorded. The protocol's effects were most marked when the computerized version was used. However, use of the computer protocol resulted in the recording of information on the non-occurrence of certain events which had not been explicitly elicited during the verbal examination; features of the design which were intended to encourage adherence to the protocol resulted in the recording of unsubstantiated information. It is concluded that the detail of the verbal examination suggested by the protocol may have been inappropriate to the realities of a general practice consultation. The findings provide some useful insights for the design of future computerized protocols for the management of chronic conditions.

Introduction

IN the last few years many general practitioners in the UK have installed computer systems in their practices. Typically these are used for patient registration, recall and the processing of repeat prescriptions. As the initial problems are overcome, these new systems may open up new opportunities, for example in audit and preventive medicine, and thus provide considerable advantages over previous manual procedures.[1] The potential of such systems, however, will be greater still when they are also used in consultations with patients, for example, acute and repeat prescribing could be computerized as could record summaries and encounter notes.

Currently many patients with chronic illnesses are being transferred from hospital to community-based care. General practitioners are able to provide a more personal service for chronically ill patients than hospital doctors and, as they know their patients well, they may also be better able to identify and respond to individual patient needs. As general practitioners become responsible for larger numbers of routine consultations for chronic conditions, the establishment and use of management protocols could enhance their delivery of care. A major component of such protocols is a checklist of examinations and investigations, helping to ensure that all the necessary screening and monitoring procedures are carried out each time a patient attends the surgery.

Computer terminals in the consulting room could provide interactive protocols which may be less cumbersome to use and therefore more practical than paper-based forms. Computerized protocols can also be selective in the prompts they present, tailoring them to specific requirements in individual consultations. They can provide a profile of a patient's relevant history and information for monitoring the condition of individual patients over time and for evaluating treatment regimens on groups of patients.

This paper reports a study of general practitioners using a computerized care protocol for the management of hypertension. It focusses particularly on the protocol's effects on the doctors' clinical behaviour during consultations — the range of verbal and physical examinations conducted by the doctor and the information recorded by the doctor.

Method

Background

The computer system used was a trial system developed by the IBM UK Science Centre as part of a joint research project with the Department of Community Medicine at Sheffield University Medical School. The MRC/ESRC Social and Applied Psychology Unit have evaluated the system's impact on doctors, staff and patients. The system offers facilities for an age–sex register and for recall and repeat prescriptions; through consulting room terminals, it provides facilities for the review and update of patients' record summaries, encounter notes, and repeat prescribing information, in addition to the hypertension protocol described here. The system is fully described elsewhere.[2] Findings from the different areas of the project are also described in previous publications.[1,3–7]

The project involved two Sheffield practices, one with four doctors operating from a single location with about 8000 registered patients, the other with about 20 000 patients and seven doctors, operating from two separate sites.

The protocol

The protocol consisted of a series of prompts for specific investigations to be carried out or for decisions to be made by the doctor during consultations for chronic hypertension. It was designed by a general practitioner involved in the project and a hospital consultant specializing in hypertension, with advice from the other general practitioners in the project. The management of hypertension was discussed and a set of rules which were thought to reflect the optimum care for a typical hyperten-

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sive patient were drawn up; the protocol was then constructed from these rules. The protocol was used in paper form for a period of three months in routine consultations for hypertension, in order to test its design and compare it with the computerized version. The computer protocol was later used for a period of six months, again in routine consultations. Necessary information from the patients' records cards was entered into the computer. With the computer protocol not all the prompts had to be presented every time the protocol was used — only examinations required at the particular consultation were prompted; time-dependent examinations were omitted (for example examination of fundi was required only at six monthly intervals), as were those proscribed by answers already given.

The computer protocol presented four consecutive screens to the doctor during the course of the consultation. The first screen displayed details of when the patient was recalled to attend the surgery, how early or late the attendance actually was, and if there was any special reason for the attendance, for example if at the last consultation the blood pressure was outside the target range or the protocol had recommended tests. The doctor was also prompted to ask the patient whether any of six new events had occurred since the last appointment (Figure 1). The second screen displayed all the physical examinations which should be performed, a maximum of nine (Figure 1), and the third screen displayed the last six recorded blood pressures in graphic form so that trends could be seen. The doctor was also asked to indicate whether the present blood pressure was considered to be outside the target. Finally, the fourth screen could provide recommendations for tests, therapy review, referrals and recall. The protocol, its development and structure are more fully described by Evans and colleagues.[8]

New Events

What new events have occurred since the last appointment?

Myocardial infarction	(y or n)
Angina/chest pains	(y or n)
Intermittent claudication	(y or n)
Cerebral ischaemia (specify type)	(p or t or n)
Vertigo	(y or n)
Gout	(y or n)
Other (specify)	

Physical examinations

Weight of patient	** kg
Examine urine:	
Is albumin present?	(y or n)
Is glucose present?	(y or n)
Take blood pressure:	
Systolic	
Diastolic	
Take pulse	(per min)
Is rhythm abnormal?	(y or n)
Are there any basal crepitations present?	(y or n)
Is the heart clinically enlarged?	(y or n)
Specify degree of ankle oedema	(c or m or n)
Examine peripheral pulses (left)	(a or r or nor)
(right)	(a or r or nor)
Are fundi abnormal?	(y or n)
If yes are there any vessel changes?	(y or n)
haemorrhages?	(y or n)
papilloedema?	(y or n)
microaneurysms?	(y or n)

Figure 1. *The principal prompts of the protocol. y = yes, n = no, p = persistant, t = transient, c = considerable, m = moderate, a = absent, r = reduced, nor = normal.*

Research design

Trials of the protocol took place at the larger of the two practices only. Both manual and computer versions of the protocol were used in routine hypertension consultations by three doctors at one site of this practice. As the same doctors worked at both sites the other site provided a control — consulting room terminals were not introduced there. The consultations by each of the doctors at each site were studied during three time periods: T1, before the protocol had been introduced; T2, when the paper protocol was being used at the experimental site; and T3, when the computer protocol was being used at the experimental site. The design thus resulted in six distinct experimental conditions: four control conditions where no protocol was used and two conditions where protocols were used. The sample comprised 89 consultations; the numbers of consultations in each experimental condition are shown in Table 1.

Measures

Selection of the sample was opportunistic; all consultations for chronic hypertension which occurred during each data collection period were recorded on videotape until a suitable sample size with equal representation of each of the three participating doctors was achieved. Recordings were made with the consent of the participating patients and doctors in accordance with principles laid down by the local ethical committee. A related study of patients' reactions to their consultations showed that these were unaffected by the videorecording.[9] From the videorecordings of each of the consultations the occurrence of the following events was noted:

1. If the doctor asked a general question relating to the patient's health, for example 'How are you?' or 'Has anything new happened since I saw you last?'
2. If the doctor conducted any of the physical examinations included in the protocol (Figure 1).
3. If the doctor asked specifically for information on any of the events included in the protocol which require only verbal examination (Figure 1).
4. If the doctor asked any other specific, health related questions, not covered by the protocol.
5. If the patient provided any information on events included in the protocol — this may have been in response to 1 or 3 above, or volunteered.
6. If the patient provided any information on events not included in the protocol — this may have been in response to 1 or 4 above, or volunteered.

In addition it was noted if any information on events or examinations related to the protocol was recorded during each consultation. This was achieved by an examination of the patient's records, the paper protocol, or a log of the computer protocol's use, as appropriate.

Analysis

The percentage of consultations in which the doctor asked a general question relating to the patient's health was calculated for each of the six experimental conditions. For the other measures the mean number of occurrences per consultation in each of the six conditions was calculated. Analysis of variance was used to test for differences in the mean value of each measure across the different experimental conditions, the independent factors being the experimental conditions and the doctor consulted. The analysis was designed so that any doctor effects and

doctor by condition interaction effects were controlled for when experimental condition effects were being tested. Analysis of variance was also used to perform a set of four *a priori* contrast tests on each of the study measures. These compared:
a) Mean at the control site during T2 with the mean there during T3, to determine whether control sessions were affected by changing from paper to computer protocol at the experimental site.
b) Mean at the control site during T1 with the mean there during T2 and T3 combined, to determine whether introduction of the protocols affected the control sessions.
c) Mean at the experimental site during T2 with mean there during T3, to determine whether the computer protocol produced different results from the paper protocol.
d) Mean at the experimental site during T1 with mean there during T2 and T3 combined, to determine whether the introduction of protocols lead to changes at the experimental site.
Again doctor effects and doctor by condition interaction effects were controlled for when these contrasts were tested.

Results

Table 1 presents unadjusted means for all doctors on each of the study measures in each of the six experimental conditions. The results of the analysis of variance for the condition effect and each of the contrast tests are also included. The analysis revealed significant doctor effects on some of the study measures but these will not be discussed here.

Physical examinations conducted and recorded

The use of the protocol had a considerable impact on the range of physical examinations conducted by the doctors. The mean number of physical examinations included in the protocol which were conducted by the doctors ranged from 1.42 to 3.31 per consultation in the non-protocol conditions; when the paper and computer protocol were used the means were 5.78 and 6.93 respectively. The condition effect was statistically significant and contrast (d) showed that introduction of the protocols lead to significant increases in the number of examinations conducted at the experimental site. Contrast (b) showed a significant carry-over effect to the control site, that is, doctors also increased the number of examinations that they conducted at the control site after protocols had been introduced at the experimental site. However, the effect was not as great at the control site as at the experimental site.

A similar pattern of results may be observed for the measure of information recorded on protocol-related examinations, although in this case there was no significant carry-over effect to the control site.

Table 1. Number of consultations, percentage of consultations in which the doctor asked a general question relating to the patient's health and mean number of occurrences per consultation (for all doctors) for each study measure in each condition. Condition effects and effects shown by four *a priori* contrast tests.

	Control site			Experimental site			Condition effect	*A priori* contrast tests[a]			
	T1 no protocol	T2 no protocol	T3 no protocol	T1 no protocol	T2 paper protocol	T3 computer protocol		(a)	(b)	(c)	(d)
							F	*F*	*F*	*F*	*F*
Number of consultations	12	13	14	17	18	15	—	—	—	—	—
General questions (% of consultations)	*83*	*69*	*100*	*82*	*94*	*80*	NS	NS	NS	NS	NS
Physical examinations included in the protocol	1.42	3.31	2.57	1.94	5.78	6.93	45.33***	NS	13.54***	NS	135.65***
Specific questions on events included in the protocol	0.42	0.38	0.43	0.35	1.10	1.50	4.35**	NS	NS	NS	12.21***
Other specific questions not covered by the protocol	0.33	1.00	0.21	0.70	0.33	0.13	2.40*	4.01*	NS	NS	6.24*
Information given by patient on events included in the protocol	0.42	0.38	0.57	0.41	1.22	1.60	5.48***	NS	NS	NS	14.64***
Information given by patient on events not included in the protocol	1.00	1.31	1.28	1.16	0.72	0.60	NS	NS	NS	NS	NS
Information recorded on protocol-related events	0	0.08	0.07	0	2.70	6.00	555.9***	NS	NS	259.3***	1435***
Information recorded on protocol-related examinations	0.80	1.46	1.43	1.41	5.28	6.80	53.93***	NS	NS	NS	139.3***

* $P<0.05$. ** $P<0.01$. *** $P<0.001$. NS = not significant. T1 = time period before the protocol had been introduced; T2 = when the paper protocol was being used at the experimental site; T3 = when the computer protocol was being used at the experimental site.
[a](a) Mean at the control site during T2 compared with the mean there during T3; (b) mean at the control site during T1 compared with the mean there during T2 and T3 combined; (c) mean at the experimental site during T2 compared with the mean there during T3; (d) mean at the experimental site during T1 compared with the mean there during T2 and T3 combined.

In the subsample of consultations in which protocols were used, nine examinations were always prompted. The examinations which still tended to be omitted were urine, peripheral pulses and fundi. Peripheral pulses and fundi were not examined during consultations where the paper protocol was used; with the computer protocol peripheral pulses were examined in 33% of consultations and fundi in 53%.

Verbal examinations conducted and recorded

Using the protocol also had an effect on the doctor's verbal examinations. The protocol always prompted the doctor to examine the patient verbally about the occurrence of six possible events (Figure 1). The mean number of specific questions on events included in the protocol clearly increased with protocol use. The overall condition effect was statistically significant, and contrast (d) showed that protocol use increased the number of questions asked by doctors at the experimental site. However, the mean values for the conditions where the protocol was used remained low. As expected, a similar pattern of results was observed for the measure of information given by the patient on events included in the protocol: this information was directly elicited by the doctor's specific questions. However, these two sets of figures contrasted interestingly with the mean numbers of protocol-related events on which information was recorded during the consultation — the effect of the protocol was much more pronounced on this measure. It would appear that when using the paper protocol and, to an even greater extent, the computer protocol, doctors entered information which they had not explicitly elicited from the patient. Such entries almost always indicated that an event had not occurred.

Other questions

The percentage of consultations in which the doctors asked a general health question was apparently not affected by use of the protocol. Most consultations in all the experimental conditions included such an inquiry.

Analyses did reveal a significant condition effect on the number of specific questions not covered by the protocol which were asked by the doctor, that is, questions about other problems related to the patient's hypertension or about unrelated problems. Contrast (d) showed that significantly fewer questions not covered by the protocol were asked at the experimental site when the protocol was used. Contrast (a) also showed a significant change between periods T2 and T3 at the control site, a finding which is difficult to interpret, however, in view of the similarity there during periods T1 and T3. A similar trend is apparent for the measure of information provided by the patient on events not included in the protocol, although here the condition effect did not reach statistical significance. These measures do provide some evidence of a focussing effect of using a protocol.

Comparison of paper and computer protocols

For all the measures which were affected by protocol use the effect of the computer protocol appeared to be greater than that of the paper protocol. For the measure of information recorded on protocol-related events contrast (c) showed that the difference in means between the two protocol conditions reached statistical significance.

Discussion

A well-designed protocol for the management of patients with a chronic illness should represent a high standard of care for such patients. If the hypertension protocol used in this study was indeed well-conceived then the study showed a significant improvement in the standard of care for hypertensive patients resulting from doctors' use of the protocol. This is due particularly to the range of physical examinations conducted by the doctors during consultations for hypertension, which was considerably enlarged with protocol use. The number of possible new events specifically covered by the doctors' verbal examinations was also significantly increased by protocol use, although not to the same extent.

For both physical and verbal examinations there was also considerable improvement in the recording of findings, although in the case of the verbal examinations it appeared that the non-occurrence of events was being recorded even though substantiating information had not been explicitly elicited. Brownbridge and colleagues reported a similar finding in a study of the use of a computer diagnostic aid by doctors in hospital outpatient consultations.[10] When the protocol was used the doctors usually also asked one or two more specific protocol-related questions, but did not conduct the full verbal examination as suggested by the protocol.

It seems likely that the verbal examination with the protocol was too detailed and therefore inappropriate to the realities of a general practice consultation. A consultation in which the doctor asked such questions as, 'Have you had a heart attack since I saw you last?' or 'Have you had a stroke?' would undoubtedly have seemed unnatural to both participants and may well have worried the patient. Drury draws attention to the tendency of some doctors to set unrealistic and inappropriate standards for general practice.[11] Designers of protocols for use in general practice consultations should be wary of this tendency. Protocols which are unrealistic in certain respects, even though generally well-conceived, will not easily find acceptance among potential users. The protocol used in this study appears to have been over-ambitious in parts and may have been improved if doctors could have responded 'not applicable' to some of its prompts. It was possible for doctors to make such entries but in the case of the prompts on specific new events it was much easier for them to enter yes or no. This aspect of the protocol's design was intended to encourage adherence. However, it appears that doctors preferred to use their own judgement and usually they deemed it unnecessary to ask specifically about all the events prompted while still feeling able to enter 'no' in response to the prompts. With a simple 'not applicable' response option the protocol would still present all the prompts, and thus offer the same potential for improving clinical performance, but at the same time its design would recognize the protocol's status as an *aide-mémoire*. Such protocols are not intended to override the doctor's own judgement.

Comparison of computer and paper protocols

Providing the protocol's effects are of benefit then these findings suggest that a computer protocol would be advantageous over a paper one. In this study examinations of peripheral pulses and fundi, which are required only at relatively long intervals, were more likely to be conducted when requested by the computer protocol than by the paper protocol. However, when using the computer protocol doctors were less likely to ask questions which were not required by the protocol than when using the paper protocol, and they recorded information on the absence of events which had not been explicitly elicited.

Doctors found the paper and computer protocols time consuming to use; both increased the length of consultations by about 35%.[12] The extra time was used in completing the protocols, as well as in conducting more thorough examinations. Doctors commented that the computer's guidelines for progressing through the protocol's screens could be confusing. With an improved user interface and an extended period of use, doctors

may have been able to use the computer protocol more quickly. Computer protocols do offer some obvious advantages over paper protocols; a computer can monitor a patient's condition over a series of visits and be selective in its prompts, and the information recorded in it can be more easily retrieved for review.

Comparison of control and experimental sites

For most of the study measures there was no evidence of changes at the control site concurrent with the introduction of protocols at the experimental site. For two measures, the number of physical examinations included in the protocol that were conducted, and the number of specific questions not covered by the protocol that were asked, there was evidence of a carry over effect of protocol use from the experimental site to the control site. However, the size of the effects at the control site was not as great as at the experimental site. These findings suggest that changes at the experimental site were due to the introduction of the protocol and that actual use of the protocols was necessary to bring about the maximum change in the doctors' clinical behaviour.

Focussing effect of protocol use

This study also provided some evidence of a focussing effect of protocol use. When protocols were used doctors tended to ask fewer questions about problems which were not covered by the protocol, or which were not related to the patient's hypertension. This finding reflects the perennial problem faced by general practitioners dealing with people with chronic problems — the patient may be attending for a problem which is not strictly related to the chronic illness being studied.[13] One solution is to conduct special clinics for particular chronic problems only. Doctors might also find the use of special management protocols more amenable in such clinics than in a general surgery. When doctors are presented with this situation in a general surgery they can only use their own judgement to decide whether the other problem should take precedence over the chronic one already being managed. If a management protocol is being used then (assuming the doctor's own judgement is good) this should not make the chronic problem more likely to take precedence. From the results presented here it is not possible to judge whether the protocol's focussing effect detracted from or improved the overall delivery of care. Peer review of the videorecordings would be necessary for such an assessment. However, in order to guard against this possible adverse effect the protocol's design might be improved by making the other category, under new events (Figure 1), more prominent.

A comprehensive evaluation of the computerized hypertension protocol would take account of a broader range of issues than those discussed in this paper. The most important of these would probably be the effect of protocol use on the health of the practice's chronic hypertensive patients and this should be the subject of future research. Other important issues, which have not been fully addressed here, include the effect of protocol use on consultation duration, and the views of the participating patients and doctors. A previous report has included a preliminary discussion of these issues.[12]

Conclusion

The findings presented here emphasize the need for a broad research and development framework if computerized management protocols are to lead to improved clinical care in general practice. The clinical algorithm used in such protocols is of prime importance and consensus among practitioners on the algorithm must be achieved. However, the user interface is of equal importance and the evaluation of any protocol should therefore also include investigations of the type used in this study. Use of the protocol in practice must be acceptable to a wide variety of individual doctors and patients in a variety of locations. It must not seem onerous and must not place undue pressure on doctors to conform. The computer protocol used in this study was based on a simple algorithm and was only intended to jog the memory. It is unlikely that expert systems capable of bettering the doctor's own decision making abilities in all situations will be available in the foreseeable future. Until such time doctors must always be ready to override computerized prompts with their own judgement.

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