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# Experience with a Computerized Interactive Protocol System Using HELP

SCOTT R. CANNON* AND REED M. GARDNER

*University of Utah, Salt Lake City, Utah*

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A computerized, interactive audit and decisionmaking system based on the HELP system is proposed for non-physician providers in ambulatory health care. Four protocols were implemented upper respiratory-ear, nose, and throat; urinary tract infection; chronic hypertension; and chronic diabetes. Two physicians' assistants used the system for 175 patient encounters. Data entry error rates (1%) were significantly less than those of paper protocols. For the upper respiratory, ear, nose, and throat protocol, 11 percent of the encounters resulted in physician referrals with one false-negative and four false-positive decisions. False-positive antibiotic therapy decisions by assistants were safely reduced. Patient acceptance of the automated self-history was good. No alienation of the assistants was noted. Less than two minutes per patient terminal time was required by the assistants.

## INTRODUCTION

Paraprofessional health providers or "physicians' assistants" are frequently utilized to reduce the amount of time physicians spend handling the relatively simple cases that make up the bulk of ambulatory health care. Physicians' assistants with supervision have been effectively used to provide well-child care, regular adult physicals, prenatal care (1), chronic diabetes and hypertension maintenance programs ( 2 ) , and therapy for minor acute illnesses and trauma (3, 4). Patient acceptance of these providers has been high (5, 6).

If some health care is delegated to nonphysicians, it is important that the patient is assured that the performance by these providers is of the highest quality. Morally and ethically, physicians need a method of supervision and control with standards and criteria for audit and review. The most effective method of support for these assistants has been the use of protocols-explicit logic defining the data to be collected and the disposition, diagnostic, and treatment decisions to be made based on that data for a given patient complaint or problem. Protocols typically consist of paper checklists or flowcharts which indicate correct data collection and a color-coded logic or branching structure which assures arrival at appropriate decisions. As the patient is seen, the physician's assistant is instructed to check the appropriate boxes or fill in the blanks which follow the logic and instructions. Extensive work has been carried out over the last several years to develop the medical logic involved in protocols for various presenting complaints (5- 8).

Unfortunately, users have reported several significant problems associated with paper protocol/assistant utilization: An audit of the protocol forms from the evaluation of the minor respiratory illness protocol developed by Komaroff revealed that the assistants deviated from the protocol in some manner on 39% of patient encounters (9) . Of these errors, 24% were deviations consisting of incorrectly recorded data, 8% were

* Present address: University of Texas at San Antonio, San Antonio, Texas 78285.

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departures from protocol recommendations, and 7% were omissions of data called for by the protocol which might have effected decisionmaking.

In the evaluation study by Sox (5) where 3024 patient encounters involving 11 protocols and 23 assistants were audited, the clinical logic of the protocols was followed accurately in only 47% of the cases. Of the errors committed, 55% involved performing procedures not required, and 38% involved omission of data important to the protocol decisions. The audit also indicated that in 5% of the patient encounters, there was no indication of referral to the physician, although this action was indicated by the algorithm logic.

Another problem that accompanies the paper protocol method-and a probable contributing cause of misuse-is the alienation of the assistants. Having the logic prominently displayed seems to imply that the practitioner needs to be "told exactly what to do each time" by the logic of the protocol, a situation which is insulting and constraining to some. Second, it is somewhat aggravating to have to answer those questions on a protocol which conveys the medical logic, but which does not directly describe clinical findings: e.g., "are three or more grey boxes checked?" (10). A further problem mentioned is the lack of adaptability. Many clinics have felt the need to adapt or modify the paper protocols to better fit specific patient populations or clinic procedures-a difficult procedure with paper forms (11).

Computer administration of paper protocols has reduced the errors associated with following protocol logic, but does not eliminate the problem of provider alienation and increases the cost of protocol implementation and modification (2, 4, 11-13).

This paper is a report of experience in the development and implementation of a computer-administered interactive protocol system with the intention of (a) reducing protocol error rates by detecting errors in data collection through real-time interaction and reliable logic execution, (b) reducing protocol alienation by allowing unstructured data recording and prompting only to the extent that data had been missed, (c) allowing easy implementation and modification of protocols by noncomputer oriented providers through utilization of the HELP system (14), (d) providing computer-generated reports, statistics, and records, and (e) allowing implementation on minicomputers.

## Materials and Methods

Before attempting to implement interactive protocols, the question of protocol need in a rural clinic was considered. Charts from the ambulatory care clinic in Castledale, Utah were reviewed to determine the distribution of patient problems and define areas where computerized protocols might have the most favorable impact. The clinic is in a small agricultural and mining community and is staffed by two nurse practitioners. A traveling physician provides support one or two days per week.

The computerized interactive protocol system was then developed at the University of Utah Department of Medical Biophysics and Computing using the LDS Hospital computer facility at Salt Lake City and the HELP decisionmaking language which was developed at the same site (14). It was designed to aid the assistant in the following manner: Patients would initially take a computer administered self-history. After reviewing the self-history, the assistant examines the patient and enters findings into the system in an unstructured manner by typing key words or phrases. Based on this historical and physical exam data, the interactive protocol system would decide what diagnostic, procedural, and therapeutic decisions should be considered for the patient. These decisions would then be audited by the system according to protocol logic. If any data necessary for these decisions were found lacking, the assistant would then be prompted for the collection of that data. As items are entered, the addition of any new data would cause the system to consider additional decisions. As soon as the data set was complete for the decisions that were being considered, the diagnoses, procedures, and treatments which were justified by the protocol would be displayed.

Protocols were defined using the decision block or "HELP Sector" concept of the HELP system which allows easy definition of medical logic in an English language method designed for noncomputer health

providers (Fig. 1) Each Sector-or small group of Sectors-represents (a) a particular decision message, (b) data to be considered for the decision (chosen from the HELP library menu), (c) audit logic specifying data that is necessary and sufficient for the decision, and finally, (d) the evaluation logic for the decision itself. The example in Fig. 1 has the diagnostic message "PHARYNGITIS/TONSILLITIS" which is to be displayed if the statement "((A EQ 3) AND (B EQ 3)) AND ((C OR D) OR I) OR F" is true. (The constant 3 indicates a "yes" answer to a historical question as apposed to a 0 for "not asked" or a 1 for "no"). The body of the Sector contains the data items to be used in making the final evaluation and the data-collection audit criteria. The historical and physical data items A through G are to be considered for the pharyngitis or tonsillitis decision. The logic in item H defines the audit criteria. If H is true, the "STOP' indicates that no further data are necessary to make the final decision. Instead of beginning with findings and trying to define what steps or decisions should be made in a branching logic flowchart, HELP protocols are generated by beginning with

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SECTOR 18
DIAGNOSIS: PHARYNGITIS/TONSILLITIS, POSSIBLE STREP
INHIBIT LOGIC = ALWAYS PRINT
FVAL      ((((A EQ 3) AND (B EQ 3)) AND (C OR D)) OR I) OR F
A. (A)  DO YOU HAVE A SORE THROAT? BOOL A GE 1 LAST FROM 1 MON BEFOR
            NOW
B. (A)  HAVE YOU HAD FEVER OR CHILLS WITH THIS ILLNESS? BOOL A GE 1
            LAST FROM I MON BEFOR NOW
C. (A)  POSTERIOR PHARYNGEAL WALL, (B) INFLAMED LAST FROM 1 MON BEFOR
            NOW
D. (A)  POSTERIOR PHARYNGEAL WALL, (B) EDEMATOUS LAST FROM 1 MON
            BEFOR NOW
E. (A)  POSTERIOR PHARYNGEAL WALL, (B) PURULENT EXUDATE LAST FROM 1
            MON BEFOR NOW
F. (A)  TONSILS, (B) INFLAMED LAST FROM 1 MON BEFORE NOW
G. (A)  LAB CULTURE RESULTS, (B) GRAM POSITIVE COCCI, (C) STREPTOCOCCUS
            LAST FROM 1 MON BEFOR NOW
H. IF (((AGE 2) AND C) AND E) AND F STOP
 I. ((E OR G) AND (C OR (A EQ 3))
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FIG. 1. A HELP sector for the diagnostic decision of pharyngitis/tonsillitis with a possibility of a streptococcus infection.

treatment and diagnostic decisions and then defining what data and criteria justify those decisions.

Four protocols were implemented upper respiratory-ear, nose, and throat; urinary tract infections; chronic hypertension; and chronic diabetes. Existing protocol logic in these four areas was first reviewed-primarily protocols developed by Sox (5) and Komaroff (7). Protocol diagnostic, therapeutic, and referral decisions to be made by the assistants were then listed. Criteria for these decisions were then defined, establishing data collection requirements for the protocols. Once the medical logic was defined in HELP Sectors, the administration of the protocols was enabled by establishing a list of pointers for each data item and each protocol decision Sector which referenced other protocol decisions. For example, should the assistant indicate "POSTERIOR PHARYNGEAL WALL, PURULENT EXUDATE" to the HELP system patient record, the list of pointers associated with that data would cause decisions for pharyngitis, possible strep, and antibiotic administration to be audited or considered by the interactive protocol system after the assistant had completed the initial data entry. The patient's record would then be searched for the data necessary for these decisions as defined by the Sectors. Any missing data (with respect to time constraints imposed by the decision Sector) would then be prompted to the assistant for collection. If the antibiotic administration Sector was evaluated as being "true," for example, its pointers would cause the consideration of the Sectors concerned with possible risk

of antibiotic reactions. The protocol is not a tree structure, but a more general graph with data collection and decision nodes which can be entered at any point. Traversal loops are prevented by remembering the traversal path. In this manner, all decisions indicated by data entry or by previous decisions are audited by the system regardless of the order of data entry for the protocol logic. Reports are also generated by HELP and formatted under appropriate headings (Fig. 2). The HELP Sector execution system is used then as a protocol "driver" independent of logic and data.

After the chart review, two physicians' assistants were involved in using the computerized interactive protocol system on actual patient encounters for three months with the four protocols. Both assistants were first instructed in use of the CRT terminal and familiarized with the various protocol text key words. Although the assistants were given the various protocol audit criteria for presenting complaints in written form, no attempt was made to teach them to handle patients according to any algorithm approach or in any way differently than they were accustomed. The purpose of the system was not to require that any certain approach be followed, but only to ensure that once a patient workup had been completed, audit criteria had been met and justifiable decisions had been made.

Both assistants were interviewed prior, during, and after the study to determine user attitudes. During

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                    *** PROTOCOL SYSTEM REPORT ***

                                  ENTP

12/  2/77        3000040

PATIENT, DEMO A.

***   CURRENT HISTORY QUESTIONS WITH YES ANSWERS:
      HAVE YOU FELT PAIN OR ITCHING IN EITHER EAR?
      DO YOU HAVE A FEELING OF FULLNESS OR PRESSURE IN YOUR EAR?
      DO YOU NOW HAVE A RUNNY, STUFFY, OR CONGESTED NOSE?
      HAVE YOU HAD A FEVER OR CHILLS WITH THIS ILLNESS?
      DO YOU HAVE A COUGH?
***   CURRENT PHYSICAL EXAM DATA
      EAR, NOSE, AND THROAT, TYMPANIC MEMBRANE, INFLAMED
      EAR. NOSE, AND THROAT, TYMPANIC MEMBRANE, FLUID IN MIDDLE EAR
      VITAL SIGNS, TEMPERATURE (C X10)      375
      EAR, NOSE, AND THROAT, EXTERNAL CANAL, NORMAL BILATERAL
      EAR, NOSE, AND THROAT, PARANASAL SINUSES, NORMAL BILATERAL
      EAR, NOSE, AND THROAT, POSTERIOR PHARYNGEAL WALL, NORMAL
      EYE EXAMINATION, CONJUNCTIVA AND SCLERAE, NORMAL
      EAR, NOSE, AND THROAT, TONSILS, NORMAL
      EAR, NOSE, AND THROAT, MASTOIDS, NORMAL
      CHEST AND LUNG EXAM, PULMONARY AUSCULTATION. NORMAL
***   OTHER CURRENT DATA USED IN DECISIONS:
***   CURRENT DECISION LIST:
      DIAGNOSIS:   OTITIS MEDIA
      DIAGNOSIS:   SEROUS OTITIS
      DIAGNOSIS:   VIRAL UPPER RESPIRATORY INFECTION
      TREATMENT: PENICILLIN V 500 MG Q.I.D. X 10
      WARNING:     ALLERGIC HISTORY SUGGESTS THAT THE PATIENT SHOULD BE
                   WATCHED AFTER PENICILLIN ADMIN.
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FIG. 2. Hard-copy printout of the patient encounter including data and decisions

COMPUTERIZED HISTORY QUESTIONNAIRE

1. Do you feel you had problems understanding how to use the terminal to answer the questions?
2. Do you feel that the questions asked adequately express your problem to the clinic?
3. Do you feel this was an acceptable method for the clinic to use to collect information about your problem?
4. Do you feel you answered any of the questions incorrectly?

FIG. 3. Questionnaire administered to patients who completed the computerized self-history.

implementation, system time requirements and prompting were logged by software for each encounter. Prior to using the system for an encounter, each assistant's decisions were recorded to provide some measure of probable system impact. After each encounter, a physician would review the chart and protocol report with the assistant in an attempt to detect usage errors. A brief questionnaire (Fig. 3) was administered to patients to measure attitudes toward the self-history.

## RESULTS

A total of 662 patient encounters with 207 patients were audited from the Castledale clinic records to assess protocol need. Patient problems were classified as major medical (6%). minor medical (50%), major trauma (1%), minor trauma (7%), and administrative (35%). Major problems were those patients referred to the physician by the practitioners. Cases where the practitioners treated patients and then recommended that a physician be seen at a later date were classified as minor. Administrative visits involved all well-patient care (checkups, innoculations, etc.). Follow-up visits for the same problems were not included. The distribution of complaints was similar to those found in other ambulatory care facilities (Fig. 4).

An attempt was made to measure the uniformity of care provided by comparing the nurses with themselves and with the physicians by (a) counting the number of prescriptions and (b) noting the variety of drugs given for random and upper respiratory-ear, nose, and throat complaints (Table I). Significant differences (P c 0.05) were detected between the practitioners and the physicians for simple upper respiratory-ear, nose, and throat problems for the average number of drugs prescribed per visit, the number of different drugs prescribed, and the number of drugs prescribed more than once over all visits. Significant differences were found ($P < 0.05$)

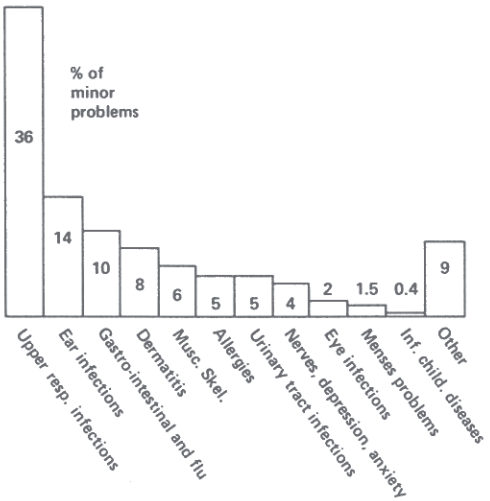


FIG. 4. Classification of minor medical problems from the chart audit of the Castledale Utah rural clinic to assess the applicability of protocols.

between the two nurses for the same upper respiratory-ear, nose, and throat complaints in the three drug prescriptions areas.

During system implementation, a total of 175 patient encounters were handled by the system for upper respiratory-ear, nose, and throat and urinary tract infection problems. (An insufficient number of encounters involving the diabetes and hypertension protocols were recorded for adequate evaluation of the system in these areas.) A considerable amount of prompting was done by the computer for both providers. For the URI-ENT protocol, the computer prompted an average of 5.9 times per patient visit (std dev = 5.5). The average was 4.2 times (std dev = 4.0) for UTI encounters. It was discovered during the study, however, that once the assistants became familiar with system operation, they would frequently use the slower but easier method of waiting to

TABLE I

COMPARISON OF PRESCRIPTIONS FROM THE TWO NURSE PRACTITIONERS AND PHYSICIAN AT THE CASTLEDALE CLINIC FOR RANDOM AND UPPER RESPIRATORY OR EAR, NOSE, AND THROAT COMPLAINTS

| | Random complaints (nurses) | E.N.T. complaints (nurses) | E.N.T. complaints (physician) |
|---|---|---|---|
| 1. Number of visits | 99 | 80 | 46 |
| 2. Number of prescriptions given | 232 | 198 | 83 |
| 3. Average number of prescriptions per visit | 2.3 | 2.5 | 1.8[a] |
| 4. Number of different drugs prescribed | 71 | 43 | 18[a] |
| 5. Number of drugs prescribed two or more times | 35 | 21 | 9[a] |

[a] Statistically significant difference ($X^2$ test, $P < 0.05$) between the nurse practitioners and the physician.

be prompted to enter data. Both assistants also indicated that with unusual or unfamiliar problems, they would frequently be curious about the machine's criteria. By entering only the presenting complaint, they could follow the audit through the prompting process. As a result, little measure of the need for interactive prompting is available from these encounters. Those instances where a particular item was overlooked could not be identified.

Of the 175 computerized protocol encounters, 6.9% contained at least one data entry error. Out of 2010 data items recorded, 22 (1. 1%) were incorrectly entered. Assistant A had an entry error rate of I . 18% and assistant B an error rate of 0.75%. It was felt by the assistants that most of the errors were the result of learning to use the system. Considering only those encounters after the first 10 of each protocol, the remaining 155 encounters contained only two errors. There were no cases where the assistants failed to collect or enter data prompted by the computer. No attempt was made to measure the assistant's ability to accurately collect the data prompted by the computer.

In comparing the decisions to perform a throat culture with the actual culture outcomes (Table II), a slightly higher success rate was noted from the computerized protocol. Of the patients seen during the study, four were determined by culture and follow-up visits to have beta hemolytic strep infections. All four received culture suggestions by the protocol. Comparison of the antibiotic treatment decisions between the assistants and the ENT-URI protocol where cultures were performed and where therapy was intended to cover possible strep

infections was also done. Using the subsequent culture results as a standard (Table II). all four strep infections were treated by the assistants with 30 antibiotic prescriptions given. The protocol suggested that two out of the four be treated on the first visit with eight false-positive antibiotic therapy suggestions. The two remaining patients who later proved to have strep infections received the protocol suggestion "WAIT FOR CULTURE RESULTS BEFORE ADMINISTERING ANTIBIOTICS."

Comparison of the referral decisions by the assistants and the protocols demonstrates a slightly more

TABLE II

COMPARISON OF PROTOCOL AND ASSISTANT DECISIONS BASED ON CULTURE RESULTS AND PHYSICIAN REVIEW

| | Correct | False + | False - |
|---|---|---|---|
| CULTURE | | | |
| Computer protocol | 4 | 39 | 0 |
| Assistants | 3 | 39 | 1 |
| ANTIBIOTICS | | | |
| Computer protocol | 2 | 8 | 2 |
| Assistants | 4 | 30 | 0 |
| REFERRALS | | | |
| Computer protocol | 8 | 4 | 1 |
| Assistants | 5 | 0 | 4 |

conservative approach to triage by the system. Out of 109 upper respiratory-ear, nose, and throat encounters, I2 were referred to physicians by the protocol and five were referred by the assistants (Table II). None of the 97 patients where the protocol did not suggest a physician referral returned to the clinic with serious or potentially serious sequalle in the subsequent two months. The single false-negative referral error was the result of a middle-aged female with an ear infection and no significant symptoms of serious complications, but whose emotional state concerning her problem reflected the need for physician consultation. The false-positive referral decisions (4) were the result of patients with long standing symptoms, such as a stiff neck or headache, that did not reflect a potentially serious complication to their acute problem.

Sixty patients taking the self-histories were randomly asked to answer the questionnaire concerning their involvement. Only two patients reported having problems using the computer terminal. Fifty-five patients (92%) felt the self-history had adequately expressed their problems to the provider. The same number (55 or 92%) felt the computer was an acceptable method of collecting their historical symptoms. Most of the negative answers to the question concerned with the adequacy of the history matched negative answers to the question concerned with whether the self-history was an acceptable tool. Fifteen patients (25%) were concerned that they had answered a question incorrectly. Generally, most patients were over-sensitive to the self-history. As a result, most patients appeared to have at least one false-positive response. No false negative errors were noted during the study (cases where the patient indicated a problem to a provider but not to the computer).

During interviews, both physicians' assistants expressed concern over any system, paper or otherwise, which would prompt unnecessarily. After their experience, both felt the interactive protocol system had prompted only when the assistant had neglected data. Both assistants also felt they could adequately treat and triage patients with upper respiratory-ear, nose, and throat problems without protocol or physician help. In contrast, the chronic disease protocols were considered more valuable, primarily because the assistants felt they had had little or insufficient experience in these areas. Neither user expressed any objections to the method or effort required for computer data entry. At the beginning of protocol use, dissatisfaction was voiced by both assistants over the fact that key words and data text did not coincide with their customs. Since the system

provides a means for easy text and key word modification, the suggested changes were quickly implemented. Neither assistant felt that the time required for using the system was excessive. Occasional equipment failures were annoying, particularly if data were lost or a program was interrupted.

The computer system required an average of 10.3 minutes of connect time per patient visit-including the self-history, audit and prompting, and report generation. On the average, less than two minutes per patient was spent at the terminal by the assistants.

## DISCUSSION AND CONCLUSIONS

Although the impact of a computerized protocol system on the quality of care provided in a rural clinic is difficult to project, a handful of protocols could support the nonphysician providers in a large proportion of encounters by providing more adequate records, auditable data, and uniform, consistent decisions and data collection according to established standards. The upper respiratory-ear, nose, and throat protocol covered 50% of the encounters audited at the Castledale clinic. Eighty nine percent of the upper respiratory-ear, nose, and throat encounters in the study were accurately handled by the protocol-aided assistants without the need for physician help. Data entry error rates associated with computerized protocol use were considerably lower than those reported by users of paper-based protocol systems (5, 9). Because of the computer execution of the algorithms, protocol logic was accurately followed and decisions accurately reached based on the data provided by the assistant. No alienation of the physicians' assistants with respect to their use of the protocol system was noted. Neither assistant expressed objections to the method or effort required for computer data entry. For those complaints with which the assistant was very familiar, little computer interaction was required. For those problems where the assistant was less familiar or specifically interested in the computer's responses, more prompting was done. The only significant complaint was computer unreliability.

The successful use of such a computerized protocol system in other locations would depend first on the applicability of the protocols to be used to a large fraction of patient visits. This would help ensure two factors: (1) the successful integration of the system into day-to-day routine and (2) justification of the effort and expense of implementation. In addition, the clinic would need to be dedicated to the use of physicians' assistants and the control of the quality of care they provide. The most appropriate use of the system might involve a clinic situation where no immediate physician consultation or review is available-such as a rural ambulatory care facility using a remotely deployed physician's assistant with only periodic physician support. The HELP system allows protocols to be down-loaded from the LDS Hospital to relatively inexpensive Data General NOVA minicomputers which could be on-site at such a rural clinic. Standards of care are becoming better defined. More emphasis needs to be placed on methods of quality control, particularly for nonphysician providers. Using technology such as interactive computerized protocol systems, physicians' assistants can be effectively and reliably utilized to handle the bulk of ambulatory care-reducing both the need for patient travel and the physician expense for rural areas.

## REFERENCES

1. SPITZER, W.O., *et al*. The Burlington randomized trial of the nurse practitioner. *New Engl. J. Med.* **290,** 251 (1974).
2. KOMAROFF, A.L., *et al.* Protocols for physician assistants: management of diabetes and hypertension. *New Engl. J. Med.* **290,** 307 (1974).
3. VICKERY, D. Evaluation of a physician-extender clinic for minor illness. In "Proc. Am. Fed. for Clin. Res. at Boston. Mass. January 1974."
4. Progress Report: The Ambulatory Care Project. 13A. Lincoln Laboratory at M.I.T. and the Beth Israel Hosp., Boston. 1975.
5. SOX, H.C., JR., SOX, C.H., AND TOMPKINS, R.K. The training of physician's assistants: The use of a clinical algorithm system for patient care, audit of performance and education. *New Engl. J. Med.* **288,** 818 (1973).

6. CHARLES, O., et al. Physician's assistants and clinical algorithms in health care delivery *Ann. Int. Med.* **81,** 773 (1974).
7. Final Contract Report, Executive Summary of the Ambulatory Care Project (1969 to 1976). 15A. Lincoln Laboratory at M.I.T. and the Beth Israel Hosp., Boston, February. 1976.
8. DOMAROFF, A.L. Protocols for paramedics: A quality assurance tool. *In* "Quality Assurance of Medical Care," Monograph. Regional Medical Program Services, 1973.
9. WINICOFF, R.N., *et al.* "Protocols as Quality Assurance Tools." Project Report: ACP-35. Lincoln Laboratory at M.I.T. and the Beth Israel Hosp., Boston. lune, 1975.
10. SHERMAN, H. "Patient Differences in Upper Respiratory Infection Encounters at Multiple Sites." Project Report: ACP-38, Lincoln Laboratory at M.I.T. and the Beth lsrael Hosp., Boston, December. 1975.
11. The CAPO Project: "A Final Summary Report on an Assessment of the Utility of Computer Aids in the Physician's Office (July 1971 to January 1974)." Bolt, Beranek, and Newman, Boston, 1974.
12. BOLINGER, R.E., PRICE, S., AND KYNER, l.L. Use of a computerized clinical decision system in a diabetic clinic. In ACM Ann. Conf. Proc. Atlanta, Georgia. August. 1973."
13. Executive Summary: "Computer-based Paramedic Support and Audit." Dartmouth PROMIS Laboratory, Dept. of Medicine, Dartmouth Medical School. New Hampshire. 1975.
14. WARNER, H.R., *et al.* Integration of computer support for institutional practice: The HELP system. *In* "Proc. of the Computer Applications in Health Care Delivery Symp., 7th Ann. Meeting of the Soc. for Adv. Med. Sys. Houston, 1976."