

A Comprehensive Computerized Patient Record with Automated Linkage to QMR

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ABSTRACT

The author has developed comprehensive computerized charting software, Dr. Welford's Chart Notes Program, that interprets each portion of a patient record for the 4,653 QMR Findings and exports the identified Findings to a file that can be imported by QMR for immediate case analysis. The QMR Link utilizes a hierarchical Vocabulary System composed of approximately 20,000 terms and a "fuzzy logic" that identifies similar and implicit concepts as well as exact matches to QMR Findings. This system thereby makes it much quicker and easier to utilize QMR in evaluating a patient's illness.

INTRODUCTION

One of the most important capabilities of a computerized patient record is its ability to interface with other clinical software. Such interfacing is challenging because of differences in vocabularies among various programs.

QMR (Quick Medical Reference, Camdat Corporation) [1] is a program that generates a differential diagnosis after the user has entered a list of the patient's Findings (history elements, physical findings, and test results). Version 2.2 contains 4,653 different Findings.

Previous Work

Van Ginneken et. al. [2] mapped exact vocabulary matches in a structured computer-based patient record to a subset of QMR Findings that relate solely to auscultation of the heart. Shiffman et. al. [3] developed a speaker-independent natural language continuous speech recognition interface to 518 physical examination Findings in QMR. Kaplan [4] developed an interface to AI/Rheum that interactively responded to entry of the patient's chief complaints. Bouhaddou et al. [5] entered manually extracted items from patient records into Iliad for preauthorization of three surgical procedures. Feldman et. al. [6] evaluated free-text medical records of patients with ten diseases

to identify core elements present in DXplain, QMR, and Iliad.

Dr. Welford's Chart Notes Program [7,8,9,10,11,12] is a comprehensive computerized patient record that allows the user to create both structured and free-text notes. It assists the user in recording a broad range of information about each patient, such as the patient's current and past history, physical examination, allergies, medications, diagnoses, and laboratory results, and incorporates a large number of other integrated features. Running on IBM-compatible DOS-based microcomputers, it is licensed to over 200 users throughout the United States and abroad. Using the program's accelerated text entry features, the average 323-word history and physical takes 149 ± 115 seconds to enter[13].

The author has developed QMR Link, a feature that interprets the information already stored in the patient record in Dr. Welford's Chart Notes Program and identifies virtually all of the QMR Findings described in the record. QMR Link exports the extracted information to a file that can then be imported by QMR (for Windows or DOS) for immediate case analysis.

METHODS

Vocabulary System

The program's hierarchical Vocabulary System recognizes over 13,000 elemental words and phrases and thousands of additional phrase patterns, including terms with single and multiple component meanings. Within each category, terms are organized in a tree-like structure with four layers of granularity. The user can extend this Program Vocabulary by adding both synonyms to existing terms and entirely new terms and classes of terms. The program also has a Vocabulary Updater that reconciles differences between the User-defined Vocabulary and Program Vocabulary when the Program Vocabulary is updated each quarter.

In creating QMR Link, the author added thousands of terms to the Vocabulary to enable the program to identify essentially all of the concepts implicit in the 4,653 QMR Findings. The Vocabulary includes common medical abbreviations, formal and informal medical terminology, eponyms, generic and brand names of medications, and a host of other medical and non-medical terms.

Parser

The program directs text to the QMR Link Parser sentence by sentence from the various portions of the patient record that have been selected by the user. The Parser examines the entire Vocabulary to assign concept numbers to each word and phrase in each sentence. It analyzes where clauses begin and end and applies various rules to determine where to distribute negation. It recognizes that "not just" and "not only" do not negate the item they precede, and similar subtleties of language.

After the sentence evaluation, the Parser identifies all of the QMR Findings that partially or completely match the concepts expressed in the sentence. It utilizes the hierarchical structure of the Vocabulary System to make inferences within classes. For example, a sentence stating that a patient is on phenobarbital triggers the QMR Finding regarding previous administration of a barbiturate, since phenobarbital belongs to the class of barbiturate drugs. The Parser also utilizes a "fuzzy logic" that allows it to identify more implicit information. For example, a sentence stating that a patient is producing sputum generates QMR Findings regarding cough, even though "cough" (a symptom) and "sputum" (a bodily substance) are not stored in the Vocabulary in the same category or class. The Parser links these together and thus "understands" that a patient producing sputum is implicitly having a cough.

The Parser adjusts the questions presented to the user based upon the user's previous responses. For example, a user who indicates that the patient has chest pain is asked more specific questions about the chest pain to determine which QMR Findings related to chest pain are present. If the user indicates that the patient lacks chest pain, the more specific chest pain questions are not generated. The Parser avoids

posing questions that are mutually exclusive and thus could not be present in the patient simultaneously. The Parser also avoids asking the user the same question twice, further saving the user time.

The Parser adjusts some numeric quantities before evaluating their meaning. For example, a sentence stating that the leukocyte count is 15.2 is interpreted in the same manner as a sentence stating that the count is 15,200 and generates the QMR Finding, "WBC 14000 to 30000".

The Parser primarily recognizes Findings which are declared to be present in the patient, but it also acknowledges the absence of a number of Findings when they are declared not to be present.

Performance Analysis

Hardware. QMR Link performance was tested on an IBM 755C 486/DX4 notebook computer.

Software. QMR Link was tested using Dr. Welford's Chart Notes Program version 2.7B and QMR for DOS version 2.2. Statistical analysis was performed using SPSS for Windows Release 5.0.

Performance Tests. The author, a general internist, assembled the initial hospital admission notes from 25 of his patients who presented with uncertain diagnoses and were eventually diagnosed definitively. Five patients whose final diagnoses were not in the QMR database were then excluded. A wide variety of internal medicine cases were used, including common (acute myocardial infarction, deep vein thrombosis) and uncommon (leptospirosis, left atrial myxoma) diseases. The history, physical, and test results in each patient's admission note stored in Dr. Welford's Chart Notes Program were used, except that any definitive test result mentioned in the note was removed. The author manually entered Findings into QMR based on each note, recording the time elapsed, the number of Findings entered, and the rank and score within QMR of the patient's actual diagnosis after Case Analysis. The author then used QMR Link on the same notes, recording the same parameters. Cases in which QMR did not rank the correct diagnosis were given scores of 0.

Statistical analysis. Elapsed times, numbers of Findings generated, and QMR scores were

compared using two-tailed t-tests for paired samples. QMR ranks were analyzed using Wilcoxon matched-pairs signed-ranks test.

RESULTS

User Interface

The QMR Link User Interface is an integral part of the program's menu system. QMR Link Menu choices include Append file, Create file, Options, and Run QMR.

Options. The Options screen allows the user to specify which portions of the patient's record to evaluate for export to QMR. (Figure 1). The user

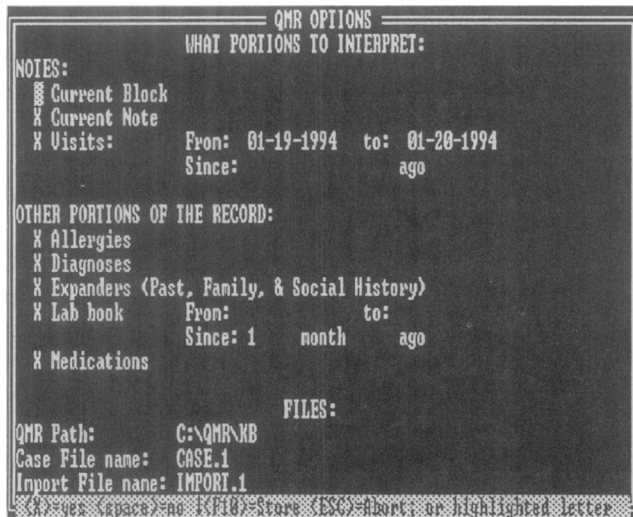


Figure 1. QMR Options

can specify a particular starting date for the patient's illness or an interval backward from today's date. The user can choose to export the Findings both directly to QMR and also to a "case file" that records the information in a different format that can be imported by other programs (such as a database program). The user can skip setting the Options and use the default or previously stored settings.

Next, the user generally chooses Create file, which activates the Parser to examine the portions of the patient record specified in the Options. As the Parser works, it presents two types of questions interactively to the user: Verifications and Clarifications.

Verifications. Verifications are questions that are generated when there is a virtually identical match between the text in the patient's record and a QMR Finding (Figure 2). The user is

shown the Finding and asked to verify that this patient indeed has this Finding before sending it to the file. The user at this point can choose Yes to send the Finding, No to not send the Finding, Change to NOT Present to send the negation of the Finding, See Sentence to view the sentence upon which the question was based, and Abort to stop the QMR Link process altogether.

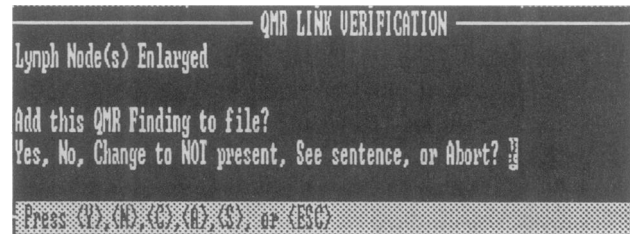


Figure 2. QMR Link Verification

Clarifications. Clarifications are questions that are generated when the Parser identifies a close but not identical match between the information contained in the patient record and one or more QMR Findings (Figure 3).

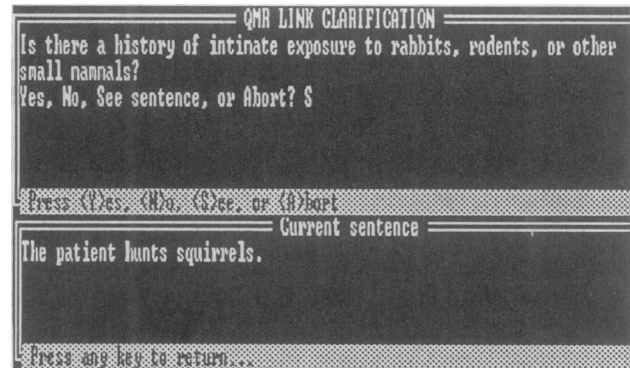


Figure 3. QMR Link Clarification

Clarifications are generated when the user's statements are inherently ambiguous, as well as when the user's statements are unambiguous but insufficiently specific to determine which QMR Findings are present in the patient. For example, if the user's statement indicates that the patient has diarrhea (without further modification), QMR Link asks Clarifications regarding whether the diarrhea is acute, chronic, profuse and watery, and intermittent, each of which is a separate QMR Finding. As with Verifications, the user can answer Yes, No, See Sentence, or Abort.

Running on an 80486 microprocessor, the program generates Clarifications and Verifications almost without pause, so that the

user does not have to spend significant time waiting between questions for the next one to be generated.

The user can choose Append file to add more Findings to a QMR export file that had previously been created. The Run QMR menu choice causes the program to terminate but stay resident as it jumps to QMR. Upon leaving QMR, the user is returned to Dr. Welford's Chart Notes Program in the previous location.

QMR Use

Inside QMR for DOS, choosing Utility\Import imports the file created by QMR Link. The user can then choose Case\View to verify the accuracy of the Findings that were imported and edit the list further if necessary. Case\Analyze Case can then be activated in order to generate a differential diagnosis. In QMR for Windows, File\Open achieves all three of these steps. The user is spared the necessity of using the QMR Term Completer to enter those Findings already entered into the patient record, but can use the Term Completer to enter any additional Findings that were not stated in the patient record.

Performance Analysis

The 20 patient records had a mean length of 2992 ± 705 characters. The author entered a mean of 17.8 Findings per case into the QMR Term Completer, in a mean of 337.7 seconds. QMR Link generated a mean of 43.4 Findings from the identical free text in a mean of 182.8 seconds. (Of this time, a mean of 30.7 seconds was taken by QMR Link to generate questions, and the remaining 152.1 seconds was the time required by the author to respond to these questions.) QMR Link thus generated Findings about 4.5 times faster than using the Term Completer manually. The rank and score of the correct diagnosis after Case Analysis were not significantly different using each method. (Tables 1 and 2).

In two cases, QMR did not present the correct diagnosis using either method. One was a patient with an atypical presentation of a left atrial myxoma. Another was a patient with a gastric ulcer who presented with prolonged exertional chest pain unrelieved by antacids. Both methods ranked acute myocardial

infarction as the most likely diagnosis, which actually fit the patient's Findings better than the ultimate diagnosis. In a third patient with right colon angiodysplasia, QMR Link ranked this diagnosis #13 and manual entry did not rank the diagnosis at all. In a fourth patient with rheumatoid arthritis and a target diagnosis of hypervitaminosis D, manual entry ranked hypervitaminosis D as #6, whereas QMR Link correctly ranked rheumatoid arthritis as #1 but failed to rank hypervitaminosis D (and was counted as a failure to rank the target diagnosis).

	Findings	Time (secs)	Score correct diagnosis
QMR Link	43.4 ± 6.1 (S.D.)	182.8 ± 53.2	144.6 ± 99.1
Manual entry	17.8 ± 4.7	337.7 ± 67.5	149.7 ± 101.0
P	<0.01	<0.01	0.682 (NS)

Table 1: QMR Link vs. Manual Data Entry

	Among top 5	Below 5 on list	Not on list
QMR Link	65%	20%	15%
Manual entry	60%	25%	15%

Table 2: Rank location of correct diagnosis (P=0.477)

DISCUSSION

The full potential of a computerized patient record lies in its ability to extend the physician's ability to deliver high-quality care by providing tools that perform useful clinical functions. These tools often require interfacing the patient record with other clinical software, such as QMR.

QMR Link saves the user considerable time in utilizing QMR. By presenting virtually all of the relevant QMR Findings contained in the patient record as simple yes or no questions, the user can create a QMR case file much more quickly and completely than by using the QMR Term Completer. Thus, the user is not spending time typing statements into the Term Completer that were just entered into the patient record. Furthermore, the physician can enter the patient note as free text, and does not need the high

degree of familiarity with QMR Findings necessary to correctly identify and enter the same Findings using the Term Completer.

The author is an experienced QMR user and types at 60 words/minute. Inexperienced QMR users or slower typists might take longer than 6 minutes to enter a case into QMR using the Term Completer. On the other hand, using QMR Link only requires that the user press the "Y", "N", or "C" keys in response to a series of questions, so that the time necessary to use QMR Link is not likely to exceed 3 minutes on a 3000-character note. Of course, users may spend additional time using other QMR features to refine the diagnosis once the case has been initially entered.

QMR Link has certain opportunities for further development. QMR Link evaluates laboratory results using only the units implicit in QMR's own Findings. For example, QMR has a set of Findings describing blood glucoses in mg/dl. If the user of Dr. Welford's Chart Notes Program refers to blood glucoses in some other system of units, QMR Link does not currently translate the number into the equivalent number of mg/dl before exporting the Finding. QMR Link does not parse for seven of the 4,653 QMR Findings. Although QMR Link is limited to interfacing with QMR's vocabulary, the same principles could be applied to mapping to other applications, such as the UMLS Metathesaurus. The performance analysis could be improved by using a larger number of randomly selected cases and a broad range of users.

The linkage between Dr. Welford's Chart Notes Program and QMR is an example of how free text can be successfully interpreted and transferred between two different programs to perform a very useful function that enhances the quality of patient care. Such applications make computerized patient records increasingly essential in providing outstanding health care.

ACKNOWLEDGMENTS

The author wishes to thank Ms. Andrea Welford for her invaluable assistance with this project, Ms. Andrea Doughty for statistical analysis, and all of the users who have contributed many suggestions in the program's development.

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