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# DMSS—A Computer-Based Diabetes Monitoring System

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*This paper describes a microcomputer-based decision support system (DSS) for diabetes monitoring. The system's basic functions include a patient management subsystem, an electronic logbook, a nutrition and exercise module, a dictionary for diabetes-related terminology, a diabetic-physician data transfer module and an on-line help capability. DMSS (Diabetes Monitoring Support System) provides a data capturing capability, trend analysis, and nutrition/exercise decision support to improve the monitoring and maintenance of diabetes. It was designed to be used by both a physician and a patient and can also serve as a useful teaching aid for a new diabetic. Its basic advantages lie in its comprehensiveness and flexibility. It is also user-friendly, easy to operate, and does not require any previous computer experience.*

## INTRODUCTION

The advent of personal computers and the rapid rise in their use have brought about a potential means of providing a fast and accurate diabetes monitoring support system.[1,2] A computer-based decision support system (DSS) can prove useful to both a physician and a patient in maintaining control of diabetes. For a patient, it will enable data collection, promote trend analysis, provide significant guidance to support diet and exercise planning and maintain a comprehensive personal history.[1,3,4] For a physician, it can provide a record-keeping mechanism for patient histories, facilitate the analysis of trends and create a database for research.[5] Moreover, if both a physician and a patient use the same system, it can provide an effective communication mechanism for data transfer between them. Thus, a computer-based automated DSS can add the flexibility and knowledge needed to improve the monitoring and control of diabetes.

The use of decision support systems for diabetes monitoring and control is not new.[1–3,5] Figure 1 illustrates decisions that diabetics face.

Commercially available computer-based data management systems (i.e., Data Manager by LifeScan, Merlin by Boehringer/Mannheim, Glucometer M by Miles Laboratories, and Romeo by Diva Medical Systems) provide support to some of these decision

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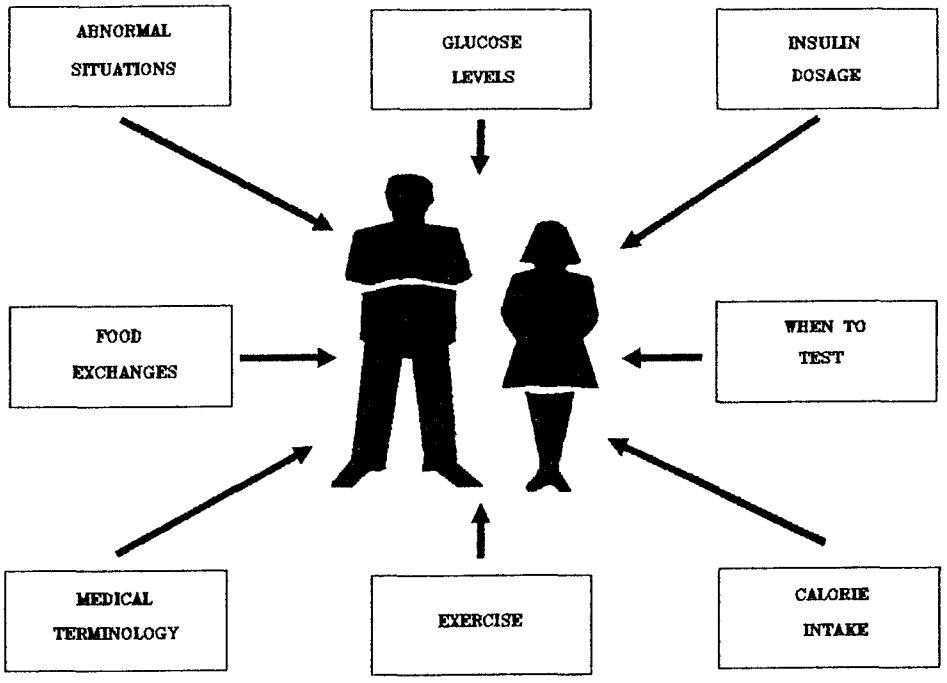



Figure 1. Decisions faced by diabetics.

situations.[6] The problem with these systems is their limited scope. The majority of them provide only an electronic logbook for glucose readings and varying degrees of trend analysis. Most of them, however, are limited with respect to diet and exercise management, do not provide a dictionary for diabetes-related terminology and, thus, fail to provide a comprehensive solution for diabetes monitoring.[2,6,7]

The DSS proposed in this paper is not a commercial package, but rather an elaboration of the concept of a comprehensive and user-friendly diabetes monitoring system into a working DSS. It was basically designed to assist new diabetics in coping with their disease and the changes in life style it imposes on them. Its basic features provide a user with the capability to handle a multiple patient database, record glucose readings and insulin dosage through an electronic logbook, perform trend analysis, plan for diet and exercise, enhance the knowledge of the relevant medical terminology through an electronic dictionary and enable data transfer between a patient and a physician using a built-in communication mechanism.

## DESIGN CONSIDERATIONS FOR A DIABETES MONITORING SUPPORT SYSTEM

The basic design considerations for the proposed system focus on a comprehensive, flexible and user-friendly system, that will support most decisions faced by a new diabetic and prove useful for both a physician and a diabetic. Thus, a system should be constructed to encompass the following capabilities:

1. Automate the collection and storage of glucose readings and insulin dosages.
2. Provide reports, graphical displays and statistical information of blood glucose levels for trend analysis, exception reporting and diagnostic control.
3. Provide the ability to display and print food exchange charts as an aid for meal planning.
4. Provide an automated menu planning function. This will allow the user to select food from a food exchange database and input those values directly into daily menus that can be stored or printed. Such menus should provide calorie, nutrient, serving size and exchange information.
5. Provide exercise charts to display caloric expenditure for various activities based on actual body weight.
6. Provide an ad-hoc dictionary of relevant medical and diabetic-related terms.
7. Support the communication and data transfer between a diabetic and a physician.
8. Be user-friendly and easy-to-use.

A system based on these considerations could provide a diabetic with the ability to self-monitor glucose levels and better cope with his or her disease.

## DMSS—SYSTEM CHARACTERISTICS AND COMPONENTS

DMSS—(Diabetes Monitoring Support System) is an interactive DSS that was developed to enable physicians and diabetics with limited computer experience to monitor and maintain control of diabetes. It was designed as a comprehensive system that could consolidate decisions from the three major diabetes regulatory factors: insulin/glucose maintenance, nutrition management and exercise management into a single application. The system was developed for an IBM PC and can, therefore, be easily implemented on any IBM PC or compatible.

DMSS is comprised of six subsystems, as illustrated in Fig. 2.

a. The *Patient Record* module allows a physician to maintain a multi-patient database, consisting of personal information, detailed medical history and dietary information.

b. The *Electronic Logbook* enables data collection of glucose readings and insulin dosages, as well as a remarks section to record problems and exceptions. It also provides a variety of trend analysis functions.

c. The *Nutrition application* is used for diet planning. It contains a database of USDA food charts and diabetic food exchange charts that can be accessed for planning menus or calculating caloric content and determining their nutritional content (fats, proteins, carbohydrates, etc.).

d. The *Exercise application* containing a database for determining caloric expenditures for various aerobic exercise activities.

e. The built-in *Dictionary* provides an on-line query facility for diabetes-related terminology.

f. The *Communication* facility enables data transfer between a patient and a physician using DMSS.

As in every typical DSS,[8–10] the three generic components of DMSS include a

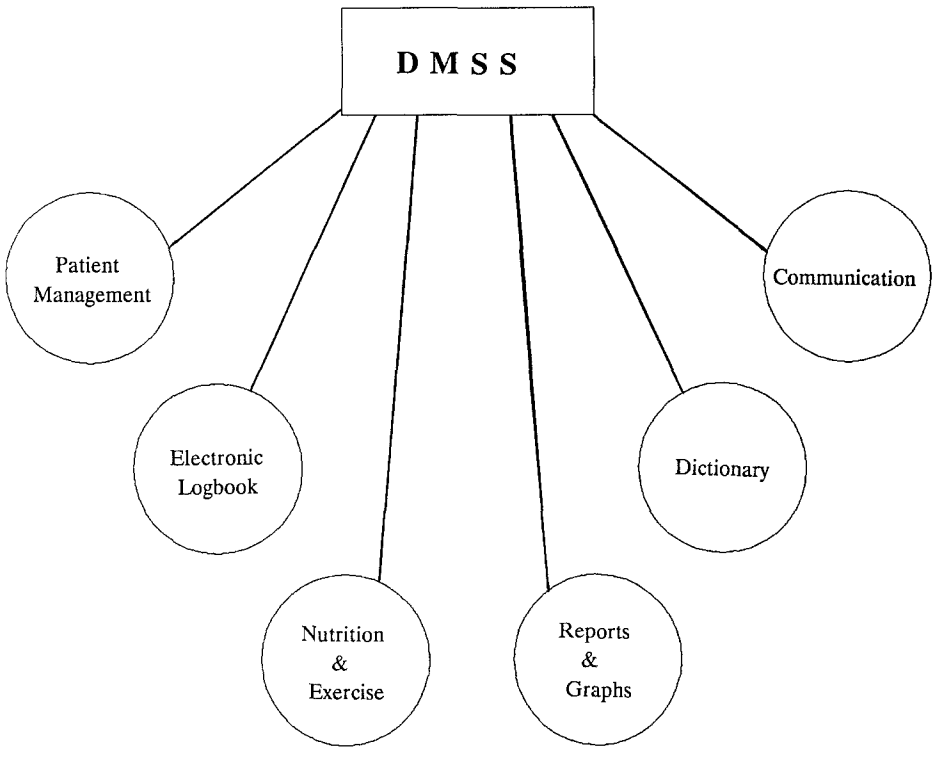



Figure 2. DMSS subsystems.

database module, a model base and a dialogue subsystem which serves as the interface between a user and the system.

## The Database

DMSS database is based on a relational database and incorporates nine primary relations that provide reference, trend analysis and storage functions for the system's records. In addition, several auxiliary relations serve as validity-checking mechanisms that are activated through table look-up functions.

1. Patient—contains individual patient records (personal information, medical history, diet and remarks).
2. Logbook—an electronic logbook containing individual patient glucose readings, insulin dosages, dates and remarks. The data for the glucose trend analysis graphs are extracted from this table.
3. Foodex—consists of more than 200 food composition records[11,12] for diabetic food exchanges. This table is used both as a reference and as a look-up table for meal planning.
4. Foodcomp—contains over nine hundred food composition records,[13–15] used as a reference source.
5. Mealrecs—contains patient menu records.

6. Dictionary—a reference dictionary that contains useful medical, diabetes-related, terminology.[15,16]

7. Exercise—contains information on caloric expenditures for specific body weights and exercise activities,[17] used as a reference source.

8. Profiles—contains information on a patient's individual menu profile.

9. Menudate—contains the date a menu was prepared and look-up data from the Foodex relation.

## The Model Base

DMSS model base consists of analytic models, statistical functions and graphical display models that support glucose trend analysis. The models were constructed using a 4th generation language (Paradox 3.0 by Borland) and are supported by data contained in the Logbook relation. Access to the model base can be accomplished in one of two ways:

1. Ad hoc—using Paradox's query-by-example feature. Ad hoc trend analysis is only available when operating directly under the supervision of the Paradox 3.0 DBMS.

2. Predefined—graph selections that are embedded in the Trend Analysis and Reports/Graphs modules allow the glucose data to be analyzed by data or meal.

## The Dialogue

DMSS dialogue subsystem consists of a menu-driven user interface with a built-in help function. The menus and screen formats guide a user through the functional options of the various activities supported by the system. Help selections are available at each menu level to help a user in operating the system.

# DMSS—System Organization and Function

Figure 3 portrays DMSS main menu, which provides access to all system selections, including input screens, reports, graphs and associated functions.

## Patient Management

The Patient Management option is used by a physician to manage a multi-patient database. It provides a capability to build and manage a patient database by adding new patients, modifying or deleting data items from existing patient records, viewing data and producing a variety of reports.

A patient record consists of three sections: personal data, medical information and diet information.

The personal data section contains basic personal details (name, address, phone, SSN, birth date, etc.), height and weight values and dates for last and next (planned) clinic visits. Another data item; "Last Updated," holds information about the last time this patient's data were updated and allows a physician to determine how recent is the information for each patient.

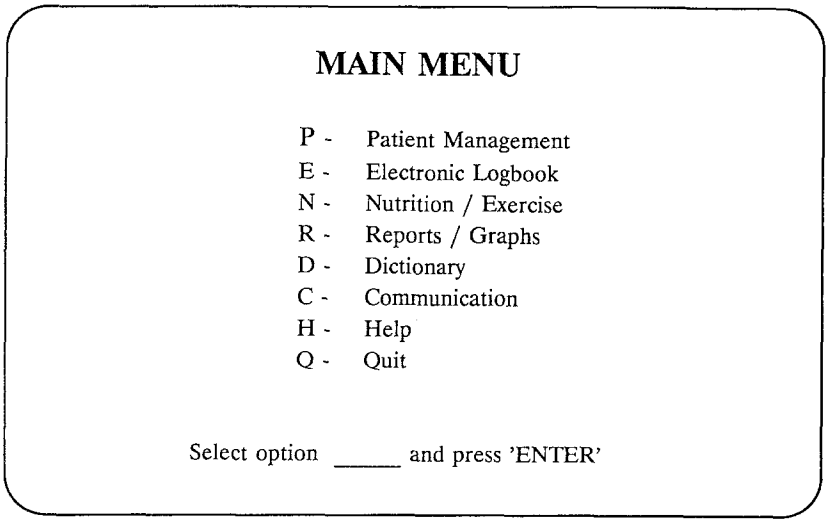



Figure 3. DMSS main menu.

The medical history section holds a summary of a patient's medical background. Example of the data items in this section include:

> Age of Onset, to indicate how long the patient has had diabetes. This information is important in order to determine the types of medical problems that might exist or develop.
> Normal glucose range and hypoglycemic values, to provide information on the normal glucose range and when to expect hypoglycemic reactions.
> The two most recent hemoglobin A1c readings are provided to remind the physician of the amount of control over the last 6 months.
> Types of insulin used are provided in case an insulin reaction occurs.
> The three most significant diseases and medications are provided to enable a physician to determine which medications are appropriate.
> A free-format remarks section is provided for a physician to add any comments to a patient's medical information.

The use of the medical section is not to replace a comprehensive patient file, but rather to provide a physician with handy and easy-to-retrieve information about a patient's diabetes and other diseases for which an individual may be under treatment. It also holds critical information on medications to avoid conflicting treatments.

The last section, diet information, holds information on a patient's diet and contains a summary of a patient's diet regimen. The daily caloric intake is provided along with an indication whether a patient is on a low-fat or sodium restrictive diet. The patient's cholesterol is broken into both high and low density cholesterol. Again, a free-format remarks section is available. Figure 4 outlines a summary printout of a patient record.

## Electronic Logbook

Developments in diabetes management during the last decade show that improved glycemic control can be attained through self-regulation of blood glucose levels by insu-

September 21, 1989 — Patient Background Information — Page 1

**Patient Data**

SSN: 123-45-6780
Last Name: Smith
First Name: John
MI: B.
Age: 35
Address: 124 Oak St.
City: Monterey
State: Ca
Zip: 12345-5000
Last Visit: 8/23/89
Next Visit: 11/23/89
Phone: (408) 123-4567
Birthday: 1/01/55

**Medical History**

Last Updated: August 27, 1989
Age of Onset: 16
Ideal Glucose Range: 80 to 120 dl/ml
Hypoglycemic below: 40
Last Hb A1c: 9.6 Date: August 23, 1989
Previous Hb A1c: 10.1 Date: June 21, 1989
Type Insulin 1: Humulin NPH
Humulin REG
Diseases 1: Hypertension
2:
3:
Medications 1: Benzedrine
2: Epinephrine
3:
Remarks: Patient has good attitude & maintains rigorous exercise program and diet. Glucose stable over past 6 months.

**Diet Information**

Height: 62.0 In. cm.
Weight: 183.0 Lb. kg.
Daily Calory Intake: 1500 cal.
Low Sodium Diet: Y
Low Fat Diet: Y
Cholesterol LDL: 140 HDL: 31
Remarks:

Figure 4. Summary printout of a patient record.

lin-dependent diabetic patients.[18] This improved control is accomplished by means of home monitoring of glucose levels and self-adjustment of insulin dosage based on these results. The Electronic Logbook option provides a computerized aid for maintaining a file of glucose readings and insulin dosages and facilitates trend analysis. A selection of this option in the main menu provides access to a second-level menu, which channels a user to either the update or the trend analysis selections.

The Update Logbook option is used to update and maintain an individual's glucose readings and insulin dosage logbook. Each update screen represents one day and includes information about glucose readings, insulin dosages and a remarks section. Both glucose readings and insulin dosages are grouped by time of day, i.e., breakfast, lunch, dinner and night time. A user is expected to key-in glucose readings, as well as the types of insulin (Regular or NPH) and amounts injected. A remarks section is provided to allow a user to indicate reasons for deviations or exceptions to either insulin dosages or high or low glucose values. Logbook records are keyed on the patient's name and the date with the data listed in order of date.

The Trend Analysis selection provides a capability of analyzing the Logbook data at various levels and facilitates visual interpretation of long-term trends and periodic phenomena. Trend analysis can be performed on glucose readings for a specific time of the

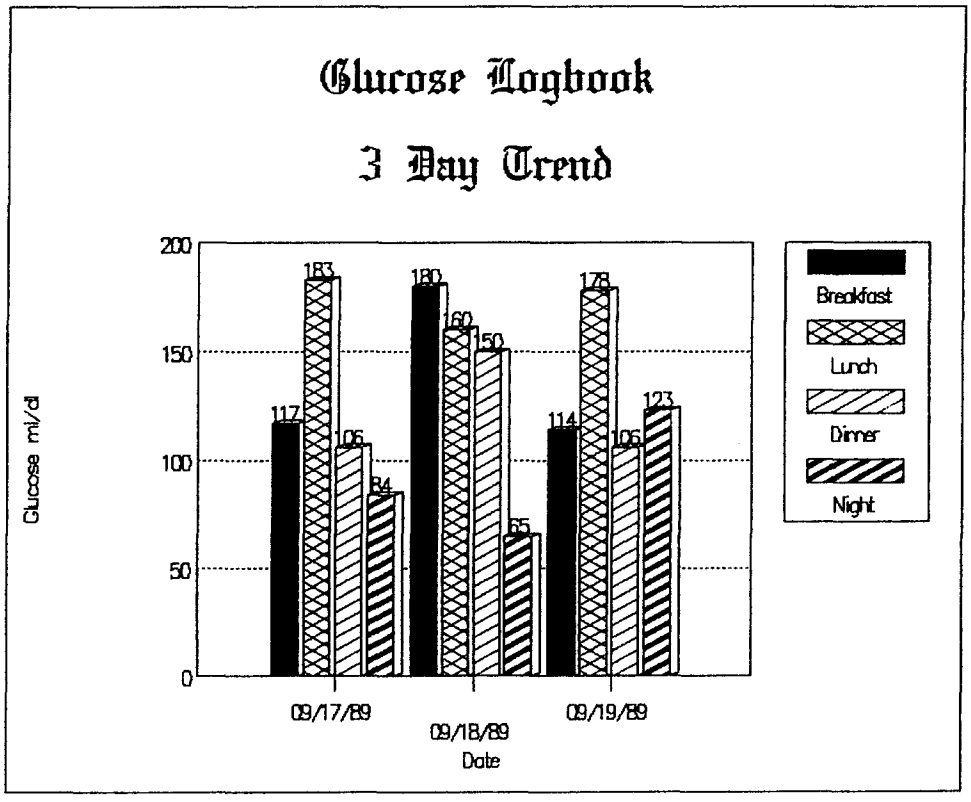



Figure 5. A 3-day trend analysis of glucose readings.

day (breakfast, lunch, etc.), for the entire day and for periods of 3, 7, and 14 days. All results are graphically displayed on the screen and a hard copy can be produced.

Figures 5–8 provide examples of trend analysis graphs. Figure 5 displays a bar-graph of a three day trend analysis, encompassing all glucose readings for these dates. The Y-axis displays the glucose range in ml/dl and is automatically scaled based on the highest value present in the sample. The X-axis displays the dates. A key is provided that is used to differentiate the glucose readings by meal. Figure 6 provides a seven-day analysis for a specific meal, consisting of glucose readings taken only at breakfast time. Figure 7 demonstrates DMSS flexibility by providing the same information using a line-graph representation. Figure 8 depicts a 14-day analysis of night-time readings.

Additional detailed analysis is provided through comprehensive lists which are produced for any given period and display all glucose readings, insulin dosages and related comments. These reports also provide basic statistics (high and low values, deviation from target range, means and standard deviation) so more complex analyses can be performed by the examining physician.

## Nutrition/Exercise

The Nutrition/Exercise selection supports decisions regarding diet and exercise management and provides access to nutritional information, dietary planning and exercise

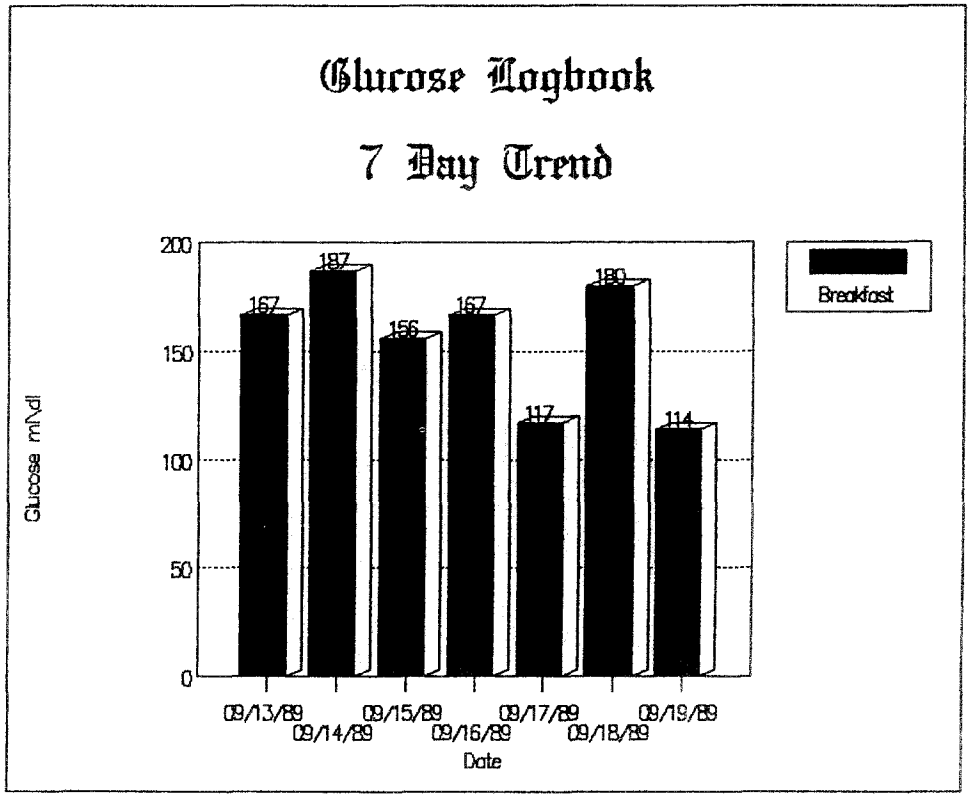



Figure 6. A 7-day trend analysis of glucose readings at breakfast time, using bar graph.

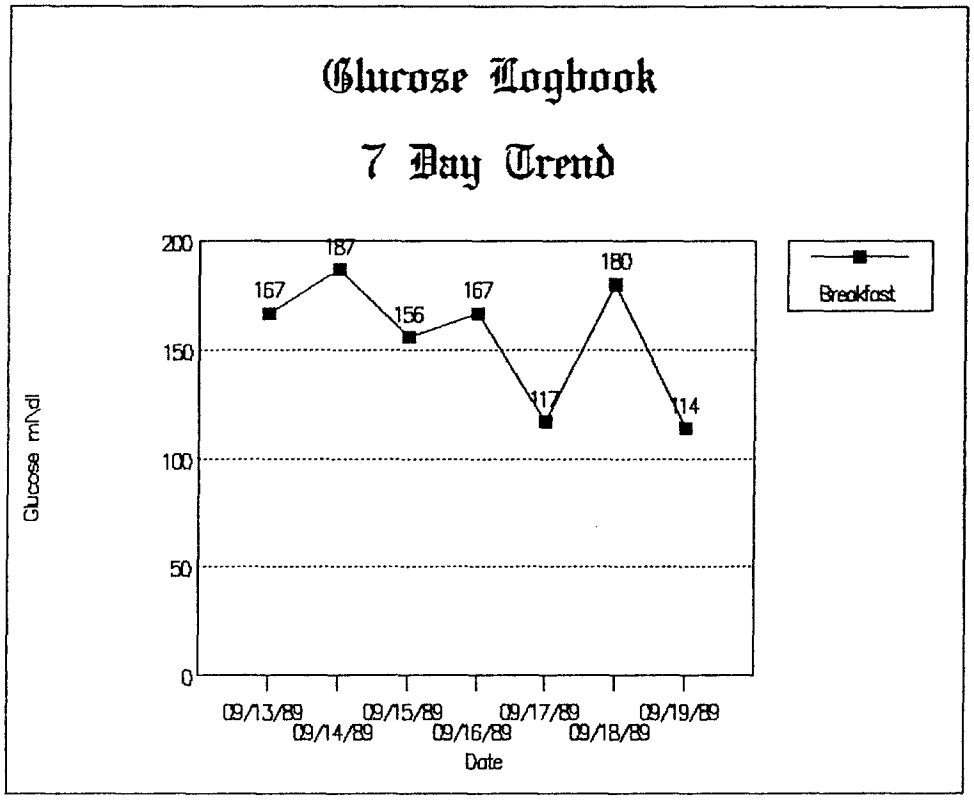



Figure 7. A 7-day trend analysis of glucose readings at breakfast time, using line graph.

management. By selecting this option, a variety of decision support functions can be performed to include:

1. View, edit, data entry, and print of food exchange charts.
2. Design, edit, delete, and print personal daily menu plans.
3. View, edit, and print USDA food composition values.
4. View, edit, and print exercise activity charts.
5. View on-line help screens, available at each menu level.

Selecting the Nutrition/Exercise entry in the main menu directs a user to a second-level menu, from which Nutrition or exercise options can be selected.

## Nutrition

Dietary planning is an essential element of diabetes control since the food a diabetic eats has an immediate impact on blood glucose levels. The nutrition selection of DMSS provides access to the USDA food values and food exchange charts and supports diet and meal planning decisions. The first module, USDA food values, provides a user with easy access to the entire database of USDA Home and Garden Bulletin 72,[14] supplying comprehensive information about nutritious value of more than 900 FDA food items. The food

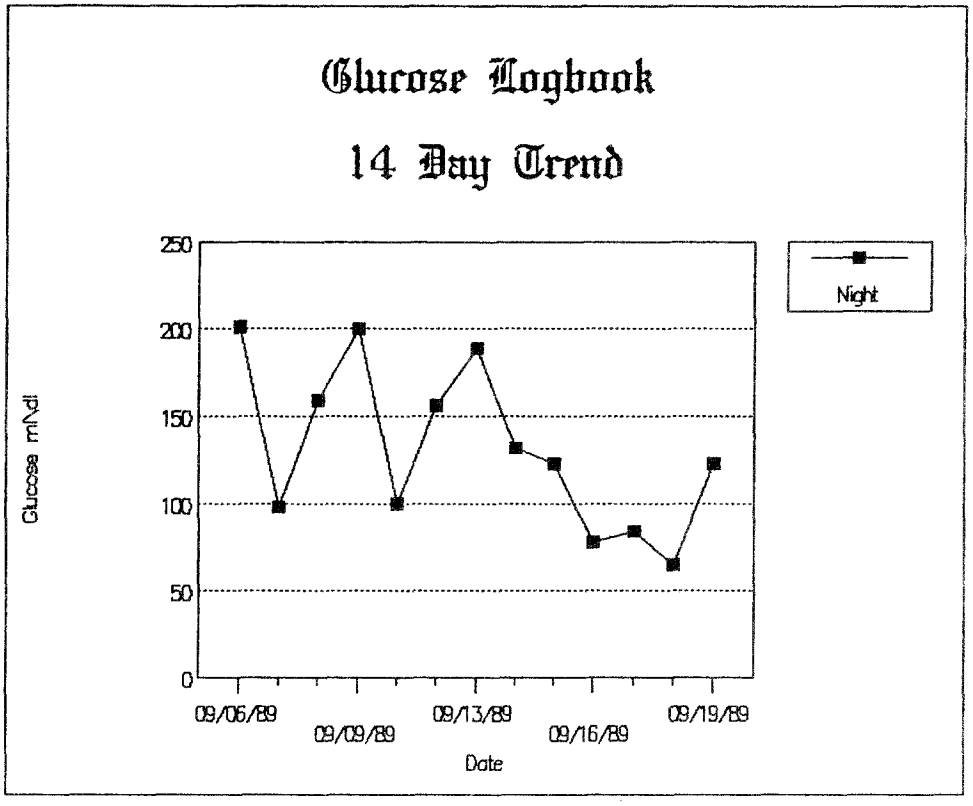



Figure 8. A 14-day trend analysis of glucose readings at night time.

exchange option is helpful in meal planning and allows a user to query and maintain the food exchange relation (Foodex) of DMSS database. Based on the American Diabetes Association recommendations,[11] Netzer[12] and Travis;[15] it provides standard measures of food portions, each of which is described in terms of total calories and nutrient content. Figure 9 depicts an example for a food exchange chart. The meal planning section allows a user to design personal daily menus.[19] Default entries and look-up tables are provided to reduce the amount of information that must be keyed-in. Figure 10 displays a user's dietary profile through the basic menu information screen. A sample menu design for breakfast is outlined in Fig. 11.

## Exercise

Exercise management plays an important role in diabetes monitoring. Lack of exercise can cause an increase in body weight, thus, causing an increase in the amount of insulin required. At the other extreme, excessive exercise can cause a rapid absorption of insulin, causing a drastic drop in blood glucose levels. In addition, cholesterol levels are also affected by the amount of exercise. The exercise module provides customized exercise charts to display caloric expenditure for various activities, based on the actual body weight of a patient. This caloric expenditure is calculated for a variety of exercises, using

Exchange Charts Grouped
By Food Exchange

| Food | Measure | Cal | Exchg Units Per Food P M F V O B | Chls | Sod |
|---|---|---|---|---|---|
| FOOD EXCHANGE: B | | | | | |
| BAKED POTATO | 1.00 ea.small | 75 | 0 0 0 0 0 1 | 0 | 16 |
| BREAD | 1.00 slice | 75 | 0 0 0 0 0 1 | 0 | 138 |
| BREAD,Low calorie | 2.00 slice | 75 | 0 0 0 0 0 1 | 0 | 300 |
| BREADCRUMBS,Dry | .25 cup | 75 | 0 0 0 0 0 1 | 1 | 184 |
| CEREAL,Cooked | .50 cup | 75 | 0 0 0 0 0 1 | 0 | 0 |
| CEREAL,Dry | .75 cup | 75 | 0 0 0 0 0 1 | 0 | 0 |
| CHEESE TIDBIT CRACKER | 1.25 cup | 120 | 0 0 0 0 1 1 | 0 | 0 |
| CORN,Ear | 1.00 ea.med | 75 | 0 0 0 0 0 1 | 0 | 13 |
| CORNSTARCH | 2.50 tbsp | 75 | 0 0 0 0 0 1 | 0 | 0 |
| FLOUR | 2.50 tbsp | 75 | 0 0 0 0 0 1 | 0 | 0 |
| GINGER SNAPS | 5.00 each | 75 | 0 0 0 0 0 1 | 0 | 150 |
| GRAHAM CRACKER | 1.00 ea.long | 75 | 0 0 0 0 0 1 | 0 | 58 |
| GRANOLA BAR | 1.00 each | | 0 0 0 0 0 1 | 0 | 110 |
| HAMBURGER BUN | .50 bun | 75 | 0 0 0 0 0 1 | 0 | 0 |
| HOT DOG BUN | .50 bun | 75 | 0 0 0 0 0 1 | 0 | 0 |
| MACARONI | .50 cup | 75 | 0 0 0 0 0 1 | 0 | 1 |

Figure 9. An example of a food exchange chart.

a patient's actual body weight (based on personal data from the patient record), caloric cost information from the exercise relation in DMSS database[17] and an energy expenditure model[17] (p. 177) from the system's model base. Thus, helping a diabetic in making decisions regarding exercise planning.

***Reports/Graphs.*** The Reports/Graph module enhances DMSS flexibility by allowing a user to produce hard copies of any report or graph that DMSS features. For a user requiring a hard copy report or graph, this option serves as a central output mechanism and eliminates the need to go through the specific functional options of the system.

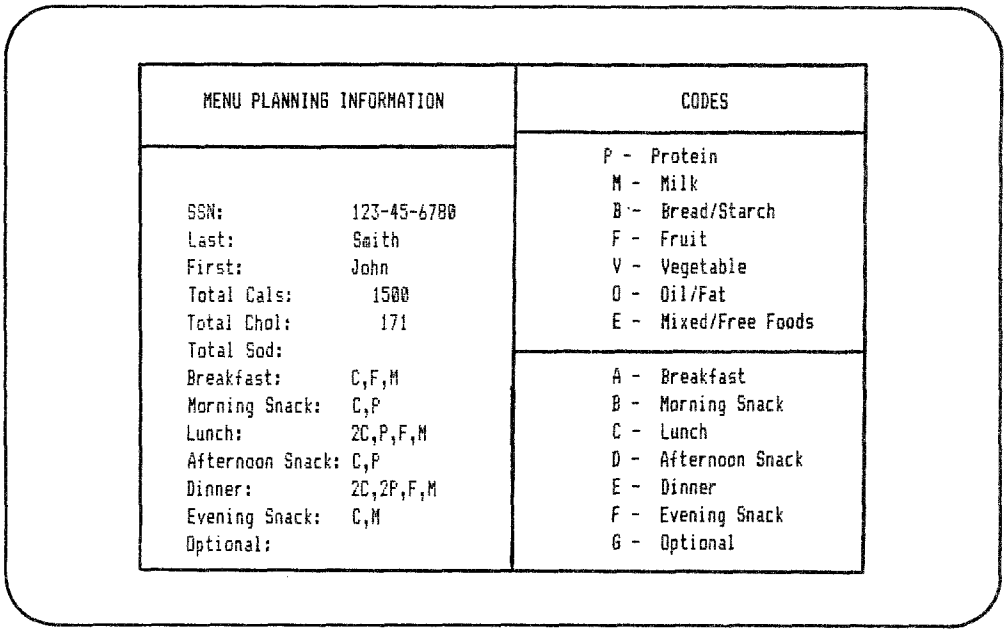
***Dictionary.*** The Dictionary entry in the main menu provides access to a dictionary of relevant medical and diabetic-related terms. The dictionary is based on Travis[15] and *"Diabetes: A to Z"*,[16] to encompass most diabetes-related terms. Selection of this entry allows a user to systematically review the entire dictionary or to retrieve a specific term. Figure 12 illustrates the output screen for the search of the term "INSULIN."

***Communication.*** The Communication part of DMSS enables data transfer between a patient and a physician—both using DMSS. Data transfer can be performed in two modes: electronically or manually. Electronic data transfer requires a modem and the SIMPC communications software for both the patient and the physician. Assuming that these requirements are met, a selection of this option leads to the following steps:

The patient is required to define the period for which data are to be transferred (by starting and ending dates).

DMSS logbook is searched for data regarding the defined period.

A transfer file is created, consisting of a header (user-ID, starting date, ending date, number of records), logbook records (for the relevant period, one record for each day) and a trailer (user-ID, number of records).



| MENU PLANNING INFORMATION | | CODES | |
|---|---|---|---|
| | | P - Protein | |
| | | M - Milk | |
| SSN: | 123-45-6780 | B - Bread/Starch | |
| Last: | Smith | F - Fruit | |
| First: | John | V - Vegetable | |
| Total Cals: | 1500 | O - Oil/Fat | |
| Total Chol: | 171 | E - Mixed/Free Foods | |
| Total Sod: | | | |
| Breakfast: | C,F,M | A - Breakfast | |
| Morning Snack: | C,P | B - Morning Snack | |
| Lunch: | 2C,P,F,M | C - Lunch | |
| Afternoon Snack: | C,P | D - Afternoon Snack | |
| Dinner: | 2C,2P,F,M | E - Dinner | |
| Evening Snack: | C,M | F - Evening Snack | |
| Optional: | | G - Optional | |

Figure 10. A user's dietary profile.

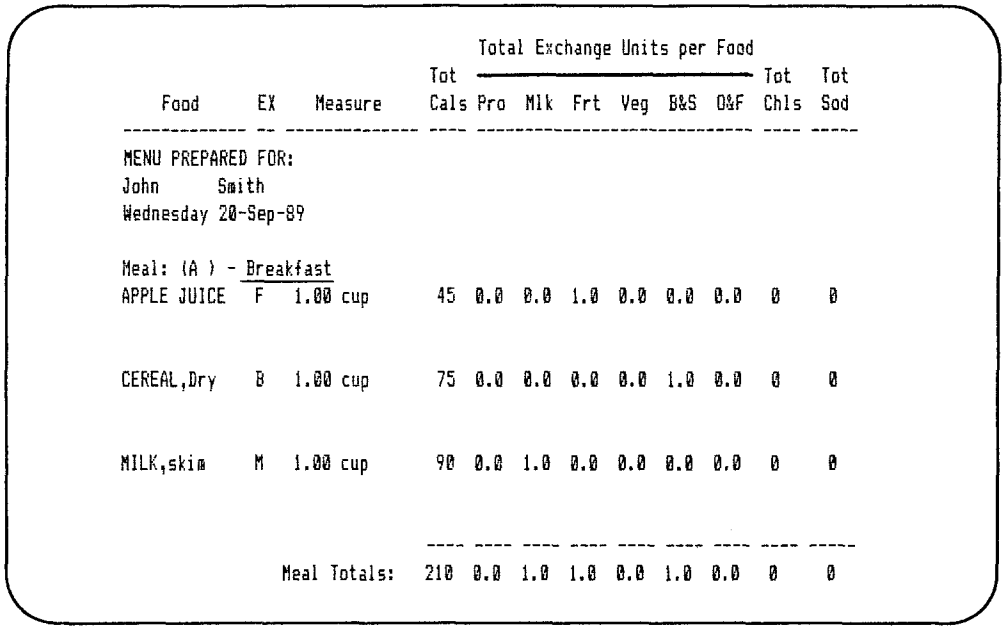
DMSS forwards control to the DOS operating system and a predefined, SIMPC batch file, is executed. The communication software dials to a physician's computer (physician's phone number resides in the batch file), the communication channel to the physician's computer is activated and the file is transferred.

With the manual data transfer capability, a user is required to define the relevant period for which data are to be transferred, relevant data are extracted from the logbook and a file is created on a floppy disk. This file can, then, be downloaded to a physician's system and its contents are made available for analysis by a medical professional.

## USES OF THE DIABETES SUPPORT SYSTEM

DMSS is a comprehensive diabetes monitoring DSS that offers a number of advantages to both diabetics and health care professionals. The major advantage of the system is its comprehensiveness. It provides a central location for the vast amount of information needed by the diabetic and the medical center in an easily usable form. By centrally locating the information, the system can be used as a primary tool for diabetes self-monitoring[1,20,21] as well as a teaching aid for a new diabetic.[4,22]

The system can also be used in a hospital or a clinic to help make a patient become comfortable with the daily routine of diabetes maintenance. This would build a patient's confidence quickly and allow a physician or teaching nurse to monitor a patient's progress. DMSS structure is relatively simple and the system can be easily used by people with



| Food | EX | Measure | Tot Cals | Total Exchange Units per Food: Pro | Milk | Frt | Veg | B&S | O&F | Tot Chls | Tot Sod |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MENU PREPARED FOR: | | | | | | | | | | | |
| John Smith | | | | | | | | | | | |
| Wednesday 20-Sep-89 | | | | | | | | | | | |
| Meal: (A ) - Breakfast | | | | | | | | | | | |
| APPLE JUICE | F | 1.00 cup | 45 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0 | 0 |
| CEREAL,Dry | B | 1.00 cup | 75 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0 | 0 |
| MILK,skim | M | 1.00 cup | 90 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 |
| Meal Totals: | | | 210 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 0.0 | 0 | 0 |

Figure 11. A sample menu for breakfast.

limited computer experience. Thus, DMSS is designed to help diabetics to cope with their disease.

The Patient Data section can be used by the physician to provide easy-to-retrieve background information on a patient. It provides essential information on medical history and diet needed for each visit. The Electronic Logbook allows both a patient and a physician to monitor the progress with glucose monitoring and insulin manipulation. Having available printouts and graphs of the last three months of glucose readings and insulin dosages, a physician can easily identify trends without leafing through pages of a hand-written logbook. A patient is also able to use these features to self-monitor daily trends and make needed adjustments. The key to diabetes is control of the blood sugars.[15] Being able to identify the need for changes enables better control to be maintained.[1,3,16,23]

The Nutrition component can also be used by a physician, dietician or a patient for meal planning and discussions about food exchanges and caloric intake. With DMSS, a patient has the ability to plan and printout daily menus to aid in calorie intake and nutrition requirements. This allows better exchange of information for an essential element in diabetes control.

The Dictionary section has an educational role and is aimed at clarifying diabetes-related terminology at a patient level. At this time, no other diabetes data management system is reported to have this feature.[2,6,7]

Another major advantage is the flexibility of the system. Most systems on the market are very structured and allow only certain information to be input, and in a strict, pre-determined, format. The use of free-format remarks sections in DMSS allows a physician, dietician or diabetic to add specific comments and amplify additional information. The remarks section used in the Electronic Logbook section also eliminates the need for a patient to remember codes that are supposed to explain various glucose readings. Using

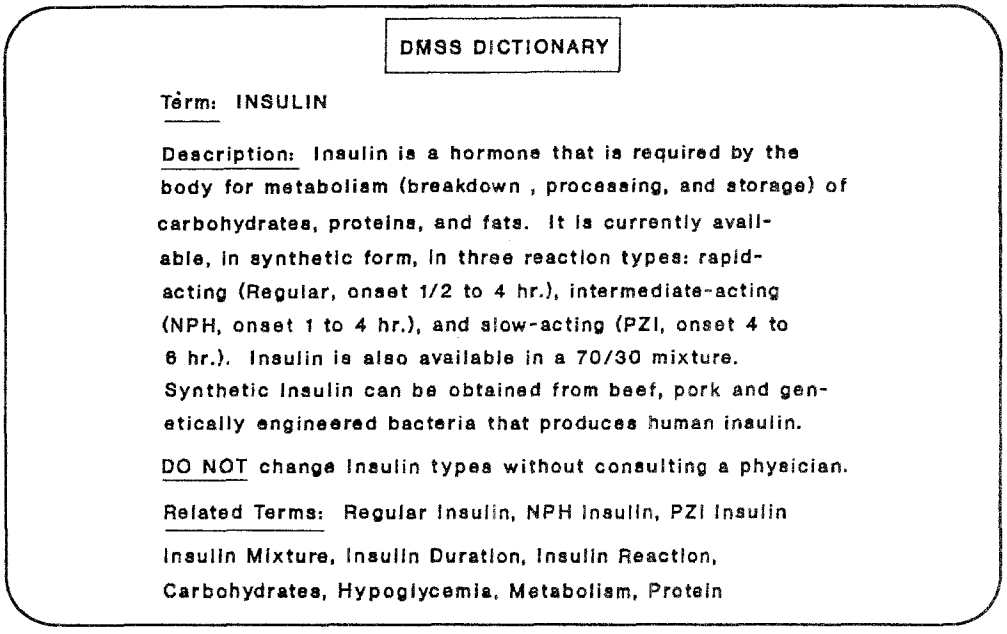



Figure 12. DMSS Dictionary output for the term "INSULIN."

these remarks sections, a physician has more information available about the patient's attitudes, habits and medical history (such as other diseases and types of medication a patient is taking) to avoid conflicting treatments.

The system also has the capability of being used as two stand-alone applications. The system can be used as a total diabetes support system with all its features or the Nutrition/Exercise section can be used separately. This will allow a dietician to maintain information pertaining only to diet on another computer or access only the portion needed. This feature would give a Type II diabetic a stand-alone Nutrition/Exercise section that would be of most use to him.

## CONCLUSION

This Diabetes Monitoring Support System shows that a comprehensive, personal-computer based, decision support system can be applied to diabetes control and maintenance, enabling better treatment and more comprehensive care.

DMSS can also be used as a teaching aid and a management tool to reduce much of the administrative work load of the medical staff in diabetes clinics. The application allows easy maintenance of patient records as well as specific trend analysis, meal planning, exercise programs and data transfer among systems. Having much of the data needed to manage diabetes organized in a single application, valuable time can be saved for more critical needs. Moreover, in high volume clinics, physicians do not have as much time to spend with each patient as they would like. By being able to access a patient's history and personal data in a timely manner, a physician can improve the impression of personal involvement the patient sees. This will reinforce the patient's feeling that someone cares about his progress, encouraging him or her to maintain the strict regime.

## ACKNOWLEDGMENT

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## REFERENCES

1. Rodbard, D., Jaffa, M.L., Beveridge, M., and Pernick, N., A data management program to assist with home monitoring of blood glucose and self-adjustment of insulin dosage for patients with diabetes mellitus and their physicians. in *Proceedings of the 8th Annual Symposium on Computer Applications in Medical Care* (G.S. Cohen, ed.), New York, IEEE Computer Society Press, 1984.
2. MacDonnald, F., Computer applications in diabetes management and education. *Computers in Nursing* 5(5):181–185, 1987.
3. Bolinger, R.E., Price, S., and Kyner, J.L., Computerized management of the outpatient diabetic. *J. Am. Med. Assoc.* 216(9):1779–1782, 1971.
4. Engel, S.S., and Villeneuve, M., Teaching clinical decision making to patients using computer assisted analysis of blood glucose monitoring. *Diabetes* 34(Suppl. 1), 36A (Abstract 141), 1985.
5. Shane, L.L., Ross, J.M., and Curtis, G.B., A microcomputer system for clinic management and analysis. *Diabetes* 34(Suppl. 1), 113A (Abstract 438), 1985.
6. Feder, A.S., and Kelly, C., Counting on computers. *Diabetes Forecast* 41(11):38–42, 1988.
7. Blow R.A., and Albert, S.P., *A Personal-Computer Based DSS for Diabetes Control and Monitoring*. Unpublished M.Sc. Thesis, Naval Postgraduate School, Monterey, California, 1989.
8. Sprague, R.H., Jr., and Carlson, E.D., *Building Effective Decision Support Systems,* Prentice-Hall, Englewood Cliffs, N.J., 1982.
9. Ariav, G., and Ginzberg, M.J., DDS design: A systematic view of decision support. *Commun. ACM* 28(10):1045–1052, 1985.
10. Turban, E., *Decision Support and Expert Systems,* Macmillan, New York, 1988.
11. American Diabetes Association, *Exchange Lists for Meal Planning,* American Diabetes Association Inc., 1986.
12. Netzer C.T., *The Complete Book of Food Counts,* Dell, New York, 1988.
13. United States Department of Agriculture, *Nutritive Value of Foods in Common Units,* Handbook Number 451, Superintendent of Documents, U.S. Printing Office, Washington, D.C., 1988.
14. United States Department of Agriculture, *Nutritive Values of Foods,* Home and Garden Bulletin #72, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 1981.
15. Travis L.B., *An Instructional Aid on Insulin-Dependent Diabetes Mellitus,* Stafford-Lowdon, Fort Worth, Texas, 1985.
16. American Diabetes Association, *Diabetes: A to Z,* American Diabetes Association Inc., 1988.
17. Galub J., *Fitness Program for Women,* Prentice-Hall, Englewood Cliffs, N.J., 1979.
18. Brownlee M., Intensive insulin regimens. *Hosp. Practice* 18(2):13–19, 1983.
19. McMahon, P., and Travis, L.B., *Your Daily Meal Plan,* University of Texas Medical Branch Galveston, Texas, 1988.
20. Leung, F.D., and Hwang, P.C., A computer management program for diabetes mellitus. *Diabetes,* 34(Suppl. 1), 34A (Abstract 136), 1985.
21. Pernick, N., Jaffa, M.L., Esteran, N., Sung, S., and Rodbard, D., Microcomputer programs to assist with home monitoring of blood glucose and self-adjustment of insulin dosage using flexible, customized algorithms. *Diabetes* 34(Suppl. 1), 35A (Abstract 138), 1985.
22. Cook. G.B., The microcomputer: An extension of the diabetes educator. *Diabetes Ed.* 7(1):12–14, 1982.
23. Galatzer, A., Fainmesser, P., Elbag, Y., Flexer, Z., Faiman, G., Karp, M., Rappaport, M., and Laron, Z., Use of a computer program to improve compliance and control of diabetic patients. *Diabetes* 34(Suppl. 1), 35A (Abstract 139), 1985.