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# Design and development of a web-based application for diabetes patient data management

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### ABSTRACT

A web-based database management system developed for collecting, managing and analysing information of diabetes patients is described here. It is a searchable, client-server, relational database application, developed on the Windows™ platform using Oracle, Active Server Pages (ASP), Visual Basic Script (VB Script) and Java Script. The software is menu-driven and allows authorised healthcare providers to access, enter, update and analyse patient information. Graphical representation of data can be generated by the system using bar charts and pie charts. An interactive web interface allows users to query the database and generate reports. Alpha- and

beta-testing of the system was carried out and the system at present holds records of 500 diabetes patients and is found useful in diagnosis and treatment. In addition to providing patient data on a continuous basis in a simple format, the system is used in population and comparative analysis. It has proved to be of significant advantage to the healthcare provider as compared to the paper-based system.

**Keywords:** computerised medical record, diabetes management system, electronic medical record, medical informatics application, medical information system

## Introduction

Diabetes is a complex, multifactorial disease, which results from an interaction of both genetic and environmental factors; it is known to run in families and clearly has a powerful genetic component.<sup>1,2</sup> Type 1 diabetes is an autoimmune disease and accounts for about 5–10% of all diagnosed diabetes. Type 2 diabetes results from insulin resistance combined with relative insulin deficiency, which accounts for approximately 90–95% of diabetes cases. Prevalence of diabetes in adults worldwide is estimated to rise to 5.4% and the number of adults with diabetes in India is predicted to be 57.2 million by the year 2025.<sup>3</sup>

Local healthcare providers associated with the Diabetic Association of India have multiclinics and pathological laboratories. Several medical practitioners are associated with these organisations. Patients are treated by more than one specialist: a diabetologist, an ophthalmologist, a cardiologist, and so on; availability of the complete patient record would be useful to these different specialists in rendering accurate treatment to the patient. The application described here has therefore been developed with a view to satisfying the requirements of such multiclinics.

Diabetes is a disease where patients need to be monitored continuously for a number of parameters, for

example blood sugar level, cholesterol, triglycerides and so on, in order to ascertain their response to particular medication. Simultaneously, the effect of environmental factors such as nutrition, stress and exercise must also be taken into account in the management of the disease. It would be efficacious if patient data could be monitored for these various aspects in a user-friendly fashion, with the searchable and relational aspects of this application providing particular advantage in collecting, maintaining, comparing and analysing data. Deriving significant relationships simultaneously among the several parameters then becomes feasible. The system described here offers efficient clinical data management while taking into account all the various parameters.

The treatment procedure for diabetic patients involves continuous monitoring, which produces a large volume of data.<sup>4</sup> This makes the paper-based system of patient records unmanageable; therefore computerising patient data is a major benefit for the management of patients with diabetes.<sup>5</sup>

This application provides instant access by authorised healthcare providers to a patient's electronic medical record. The user can access the complete medical record of a patient, including details of family history, medical history, symptoms, associated diseases, treatment and the details of pathology tests, over a period of time. The user can also view the results of various pathology tests in graphical format using bar charts and pie charts. Standard reports of the pathology tests and reports based on the query system can be generated. Such a review of patient medical information enables a healthcare provider to give improved and appropriate treatment to the patient.

## Technical specification

This is a relational database application based on client-server architecture.

## Hardware specification

- Pentium 3
- 256 MB RAM
- 40 GB HDD

## Software specification

- Operating system: Windows 2000 server
- Backend: Oracle 8.0
- Languages: ASP, JavaScript, VBScript
- Client side browser: Internet Explorer 5.0 and above/Netscape 4.7 and above

## Design

### Application design

An overview of the application design is shown in Figure 1.

The Entity Relationship Diagram (see Figure 2) shows only the main attributes of a given entity. The *patient* table holds the personal information about a patient. This table has a one-to-many relationship with the *follow-up* table. The *follow-up* table has data about the date of visit of the patient, the type of diabetes the patient has, and the doctor code of the main diabetologist who is treating the patient; this table has one-to-one relationships with the *symptoms* table, the *diabetes examination* table and the *diet and exercise* table; many-to-one relationships with the *doctor* and *diabetes information* tables, which contain data about each doctor's personal details and diabetes types, respectively. The *follow-up* table has one-to-many relationships with *other examination*, *doctor's feedback*, *patient's feedback* and all the tables that give the details of pathology tests.

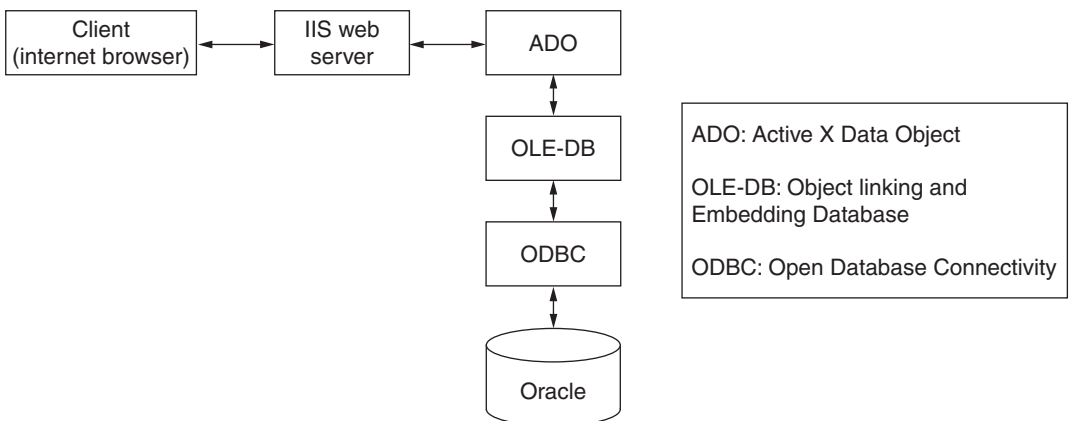


Figure 1 An overview of the application design

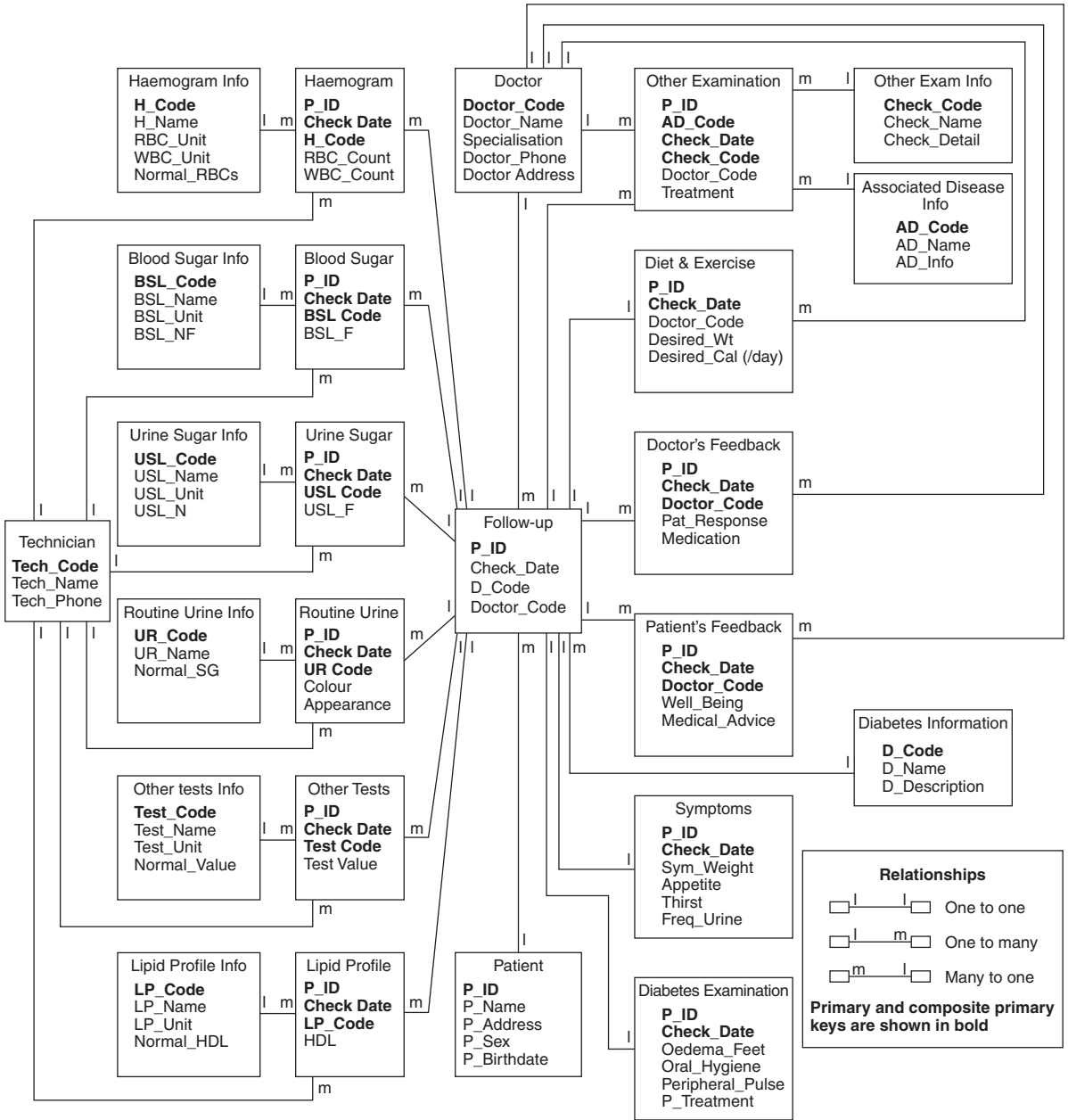


Figure 2 Entity Relationship Diagram

Information about the treatment rendered to the patient is stored in two tables – *diabetes examination* and *other examination*. This helps in providing an overview of the nature of any complications being treated, the line of medical treatment, and also the identity of the physician concerned. This set of information would be of great use in evaluation and analysis of the treatment of individual cases.

### Database access and usage

This application has two modules – one is for data entry and the other is for database maintenance. Both

the modules are menu-driven and form-based, and are accessible only to authorised users.

The data entry module (see Figure 3) provides the interface for entering patient details such as personal details, family history, disease information, symptoms, medical history, associated diseases and follow-up information about treatment and pathology tests. This module is accessible to medical specialists and laboratory technicians.

The screen in Figure 3 is displayed when the user logs in by entering a login name and password. In the main menu, under patient data, options for viewing and adding patient data as well as printing pathology test details are present. Using the ‘view’ option, the

user can view the patient records and the 'find' option can display the entire record of a particular patient by inputting the patient number. The 'graphs' option enables the user to generate and print graphs by selecting appropriate sub-options. The 'add' option enables the user to add patient information and follow-up information (see Figure 4).

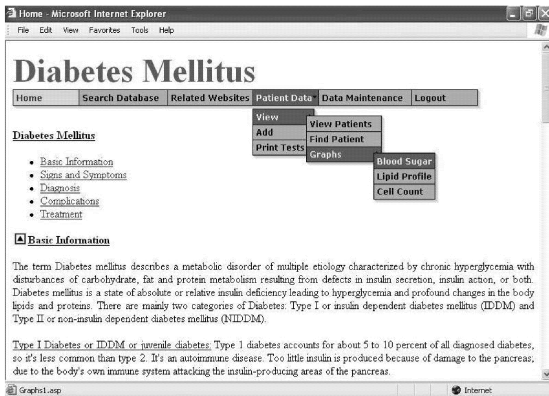


Figure 3 The 'view' option menu

Figure 5 displays the input screen for patient personal information and Figure 6 displays the screen for inputting follow-up information.

Figure 7 is the screen that is displayed when the user clicks on the 'add' button of the follow-up form. This screen has links to add other details about the patient – disease details, symptoms, associated disease details, pathology test details and so on. When any of these options are clicked, for example 'Add Disease Details',

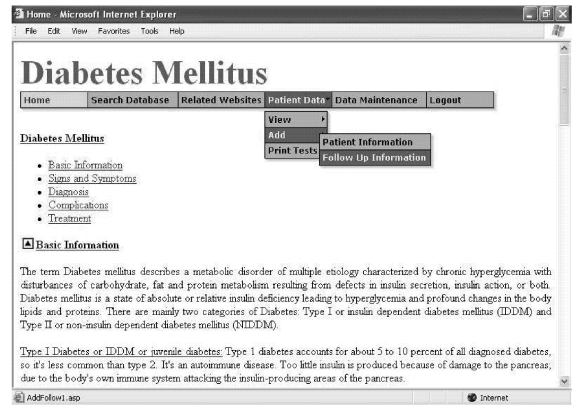


Figure 4 The 'add' option menu

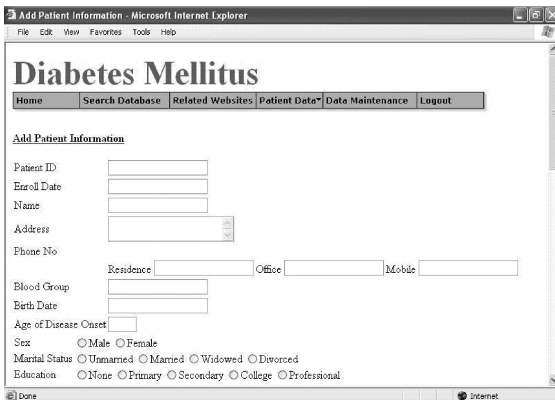


Figure 5 Personal information screen

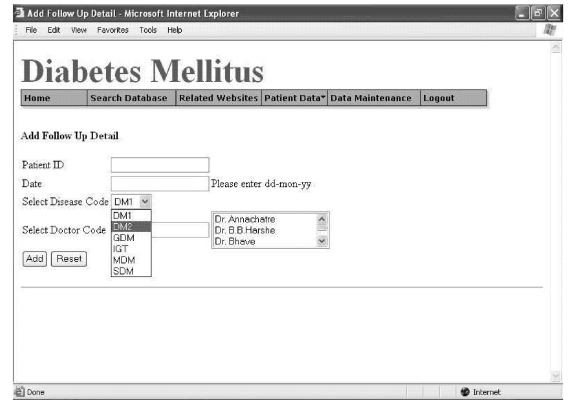


Figure 6 Follow-up information screen

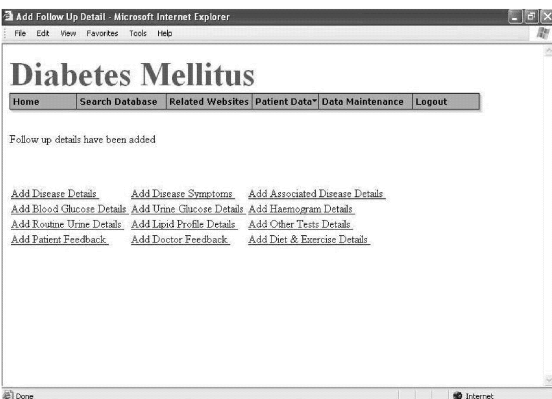


Figure 7 Detailed clinical data screen

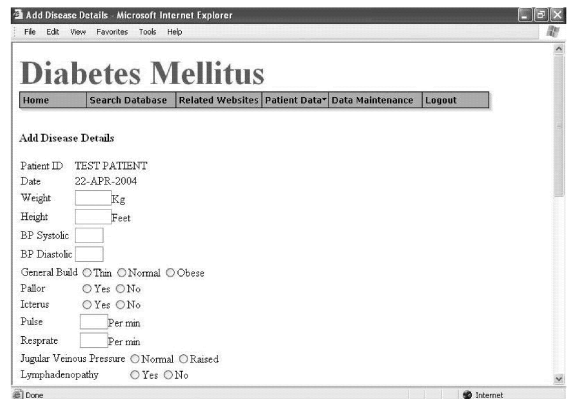


Figure 8 Disease details screen

the input screen for that option is displayed (see Figure 8). The patient ID and the date need not be entered again; it remains the same as that entered in the follow-up form and remains till the user has entered all the information about that patient. Figure 9 is the input form for Associated Diseases.

The 'view graph' example is shown in Figures 10 and 11. The user can select options as shown in Figure

10 and a graph is generated (see Figure 11). The 'print tests' option enables the user to print the pathology test reports by entering the patient ID and the date (see Figure 12).

The database can be queried by selecting appropriate options. Figure 13 gives an example of a query form and Figure 14 is the output of the query.

Figure 9 Associated diseases screen

Figure 10 Options for graph generation

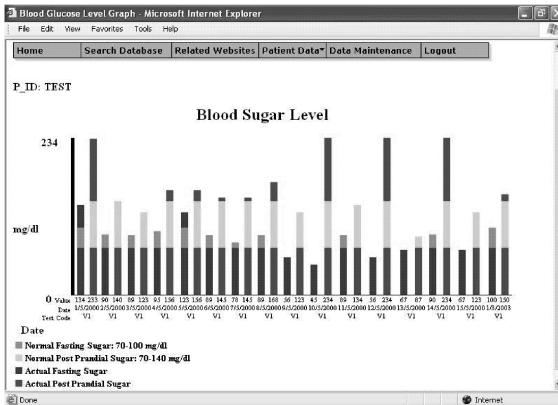


Figure 11 Graphical display generated

Figure 12 Print pathology details

Figure 13 Query generation form

| Patient ID | Age | Sex    | Disease Name  | History                |
|------------|-----|--------|---------------|------------------------|
| 2551       | 28  | Male   | Type2 (NIDDM) | History of Patient2551 |
| 2578       | 24  | Male   | Type2 (NIDDM) | History of Patient2578 |
| 2581       | 22  | Female | Type2 (NIDDM) | History of Patient2581 |
| 2622       | 27  | Male   | Type2 (NIDDM) | History of Patient2622 |
| 2648       | 23  | Male   | Type2 (NIDDM) | History of Patient2648 |

Figure 14 Query output

These queries have advantages over the paper-based system, as preparation of these types of reports is very time-consuming with paper. Other examples of possible queries are:

- response to a particular drug/diet/exercise regimen with reference to a particular patient or group of patients
- disease symptoms related to age of onset of disease
- associated diseases with respect to age/sex/type of diabetes.

The data maintenance module is accessible only to the database administrator. This module serves to edit patient information (see Figure 15). If any data entry error is made, it has to be reported to the administrator who eventually corrects it. For example, for editing Disease Symptoms, the administrator can go to the particular record by entering patient ID and date, edit and save the record. It also provides data maintenance utilities, such as adding a user, updating disease codes and pathology test codes. For example, Figure 16 shows the screen for adding associated disease information. The disease code entered here appears in the drop-down list of the 'Add Associated Disease' information form. Updating disease codes and pathology test codes follow the same logic. These codes can then be used in database queries; for example, the following query gives information about a patient with type 2 diabetes whose age of onset of disease is less than 30 years.

Query: Select distinct patient. P\_ID, P\_OnsetAge, D\_Code from Patient, Follow\_Up where P\_OnsetAge < 30 and D\_Code='DM2' and Patient.P\_ID= Follow\_Up.P\_ID

Both the modules offer the facility to generate graphs (see Figure 11) and reports (see Figure 12) according to the criteria entered, such as patient ID, date, test code and so on. The database can be queried on various criteria such as age of onset, sex, symptoms and medication (see Figures 13 and 14 for examples).

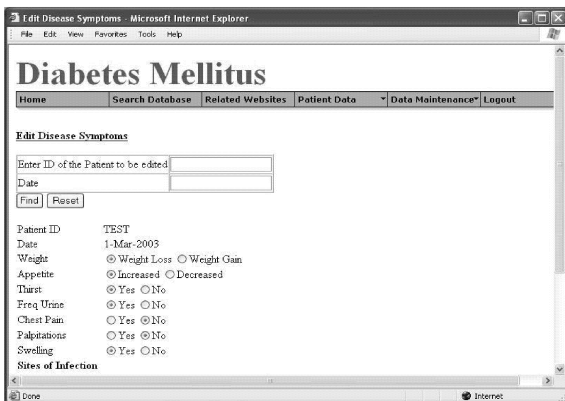


Figure 15 Editing patient information

Validation checks and appropriate error messages are incorporated on each form to maintain data accuracy; for example, if alphabetic characters are entered where actually a numeric value or date should be entered, an error message is displayed and the user is unable to add and save the data.

## Report generation

The system generates reports based on given criteria; for example, a blood sugar report under a specific medication over a period of time can be generated. Such reports are used by the medical practitioners while treating a patient, for example to decide on and regulate the dose of insulin. The system also generates day-to-day reports such as a Lipid Profile report, Haemogram and other pathology tests.

## Database security

Multiple levels of security ensure confidentiality of patient data. Users are required to supply a valid user name and password before they can gain access to the database. Users can be limited to specific program areas determined by their user name. Maintaining a single central repository for all patient-based data minimises physical data security issues.

## Testing and evaluation

Alpha-testing of the application was successfully carried out. Scientists and medical professionals carried out beta-testing, which was satisfactory. The system at present holds records of 500 diabetes patients and the

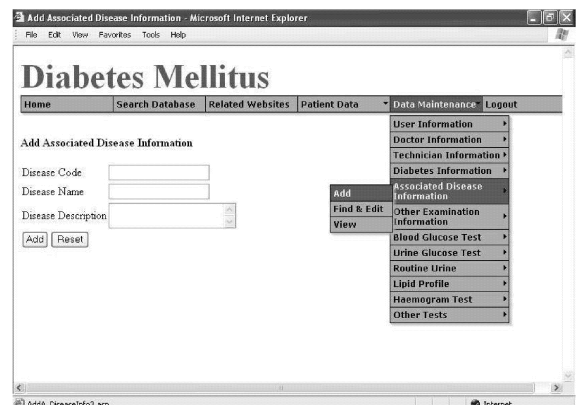


Figure 16 Add Associated Disease Information

accuracy and correctness of each entry has been validated.

## Implementation

This system has been implemented in a multiclinic where several medical specialists (diabetologist, cardiologist, podiatrist and so on) provide treatment for patients with diabetes. It also has a pathology laboratory associated with it. The primary users of the system in this multiclinic are medical practitioners and laboratory technicians.

The medical practitioner can monitor a patient on a regular basis; with the help of graphs, patterns of changes are visible. Responses of a patient to a particular drug are visualised simultaneously by different medical specialists by accessing the entire patient record at once. With the use of this application, the management of the data has become simple, appropriate and requires less effort than the paper systems. The graphical utility offered by the application has proved to be significant to the medical practitioners for easy monitoring of their patient profiles and for making comparative assessments. The accuracy of the data entered has to be maintained with stringency, and this depends on the competence of the user entering the data, although validation checks and appropriate error messages are incorporated on each form. The correctness of the data entered by the technician is verified by an authorised person in the pathology laboratory and the entries made by the medical practitioners have to be authenticated. However, a data entry error can be rectified by notifying the database administrator. Patients are allowed to view their own data, if they wish, by permission of the medical specialist concerned; moreover, patients could receive the treatment report and pathological test reports in the form of printouts regularly.

## Discussion

This application enables healthcare providers to render suitable and precise treatment to patients with diabetes, and enables continuous monitoring with the help of graphical representation and query generation to show, for example, the response of a patient to a particular drug over a period of time. Pharmaceutical companies, pharmaceutical professionals, research and development laboratories, population researchers and nutritionists can also use this database for various research purposes. Population researchers can accurately

keep follow-up information about patient cohorts for the required period. This database is currently being used for research in the areas of epidemiology/population genetics and clinical studies related to diabetes by geneticists and statisticians as it also holds information about family history of the patients, and it is fully searchable using particular criteria such as age of onset, sex, symptoms, associated diseases, severity and so on. Hospitals, healthcare personnel, diabetologists and pathologists are finding the database extremely useful since it provides comprehensive and multicentre follow-up.

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## CONFLICTS OF INTEREST

None.

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