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Main Articles

Computerized cochlear implant database system

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Abstract

In an environment of clinical governance with increased demands for accountability it is very important that accurate, reliable and secure data records be maintained for easy retrieval, analysis and presentation when required. A database is a very versatile tool for this purpose. We describe here our experience in designing a database for cochlear implant patients in Cambridge, together with guidance for prospective designers in their chosen sub-speciality.

Key words: Database; Management Audit; Health Care Evaluation Mechanisms

Introduction

The ability to collect, store, retrieve and analyse data is critical in providing a health care system that is timely, efficient and cost-effective.[1] Computer support is essential for such labour intensive work.[2] One useful computer tool is the database management system (DBMS). This provides a conceptual framework to assist in organizing data and can physically store, maintain, retrieve and analyse this data meaningfully.

Healthcare information needs to be shared for: (1) audit; (2) clinical governance; (3) research; (4) finance and (5) data comparison between centres. Quite often various sub-units collect and store the data as is required for their field of work. This produces unnecessary data duplication and fails to recognise the potential for increased efficiency of integrating pertinent information to produce timely and useful reports.[3]

Faced with the problems of data storage and retrieval and recognizing the advantages of a DBMS we set out to design a database of all the patients who had received cochlear implantation at the East of England Cochlear Implant Programme. This has proved to be very useful. The steps for setting up a database are discussed and can easily be applied to other areas of the speciality.

Materials and method of database design

A database is a computer-based information system where the stored data can be used by a wide variety of applications.[4]

Planning and design

The most difficult stage was the planning stage. Careful thought was required when designing the database. As much as possible was planned on paper.[5] It is most important to consider what data will need to be extracted in future. This in turn determines the data to be collected and stored and how they relate to each other. The needs of all potential users were investigated and draft paper copies were circulated for approval by individual members. This exercise in itself streamlined the data acquisition process and spotted several areas of duplication of data. Free text was avoided to minimize ambiguity and confusion. All data was coded (Appendix) using existing nomenclature used regularly in the department.

Choice of software package

Choosing a DBMS which suits the purpose was not difficult. An available existing system usually proves to be cheaper and user friendly because of familiarity and compatibility amongst users. We chose *Microsoft®* Access 2000* as this was freely available on all the computers in the department.

Tables

This is the basic framework for storing information and is the equivalent of a file (Figure 1). Each entity (e.g. patient) is a record and is displayed in horizontal rows. Each attribute that describes the entity (e.g. surname, address, symptom etc) is a field and is displayed in columns. Although entities may

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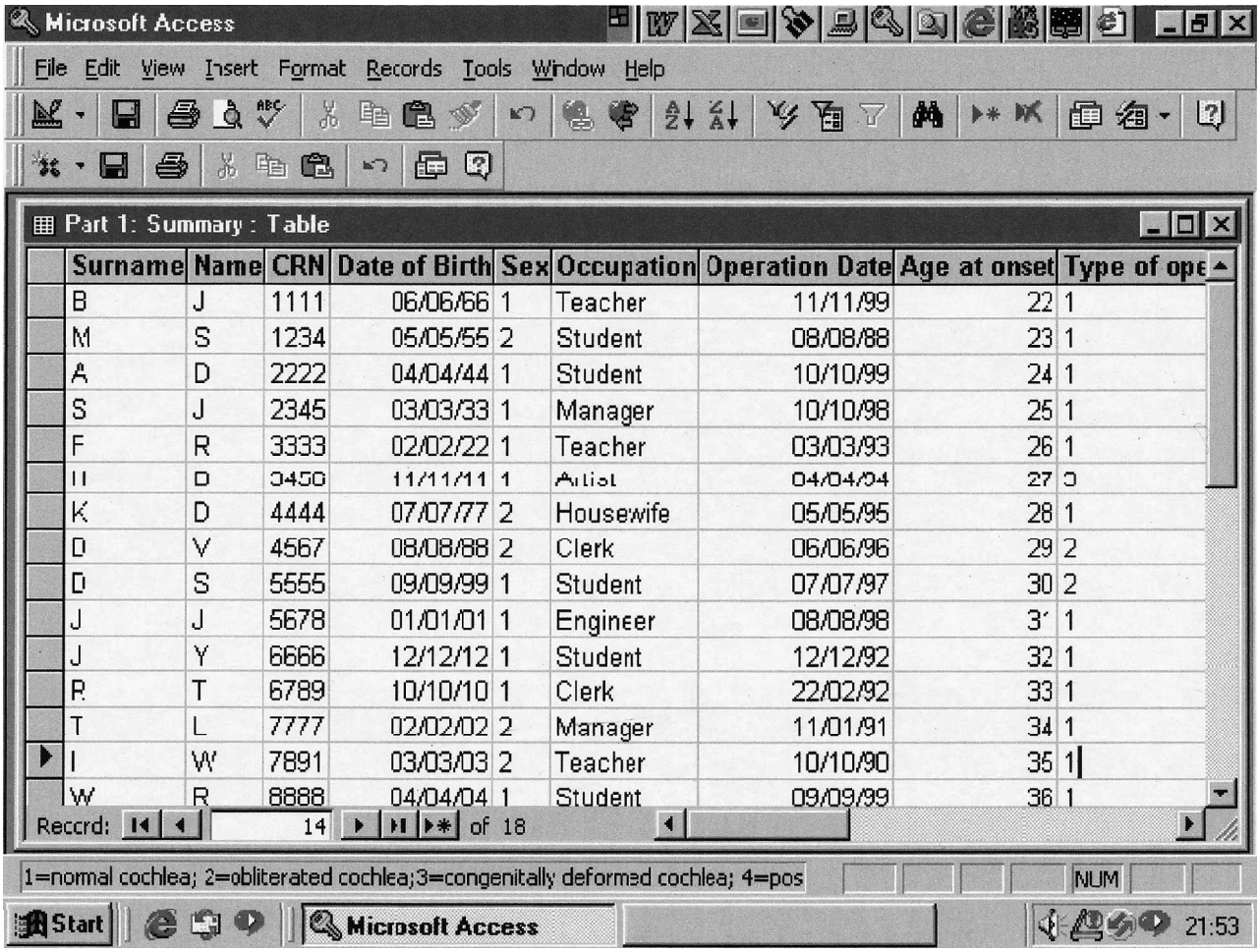

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FIG. 1
Table structure.

share attributes, a unique attribute (called the primary key is used to identify an entity. The primary key serves a very important purpose that will be seen later. We have used the patient's hospital number (CRN) as the primary key.

The nature of information needed and collected by different sub-units of the department are different. Therefore, instead of storing information in one large table it is much more convenient for inputting and storing if this is broken up into smaller tables. A master table holds the summary of patient details and forms the minimum core dataset (Appendix) by which an individual patient or groups of patients can be identified. The smaller tables contain only certain aspects of the patients' dealings with the department. We divided our tables broadly according to the sub-units (Figure 2) which deal with the patients separately e.g. patient details, audiology, radiology, surgery, complications, switch-on and tuning. Sections on follow-up were dealt with separately and repeated at each follow-up visit. Adults and children were also dealt with separately due to the difference in the test battery.

*The Microsoft® Access 2000 trademark belongs to the Microsoft Corporation.

Forms

Consideration must be given to the needs of each individual user who will collect and input the data. Forms (Figure 3) were designed to view, input, edit, control and present data easily. The ease of inputting data is important and simple forms to facilitate this ensures compliance amongst users and keeps the database up to date.

Relationships, primary key and referential integrity

A database with multiple tables needs to be cohesive and therefore a relationship has to be established between the tables. Relationships can be one-to-one, one-to-many or many-to-one. We used the commonest relationship i.e. 'one-to-many'. Thus all the smaller tables were linked to the master table (Figure 2). This implies that a record from the master table can have more than one matching record in a second table but the reverse cannot happen e.g. one patient can have many test results but each test result matches only one patient. This has been ensured by establishing what is called referential integrity. Referential integrity helps to synchronize data in related tables and prevents the data from getting out of step. This is crucial for

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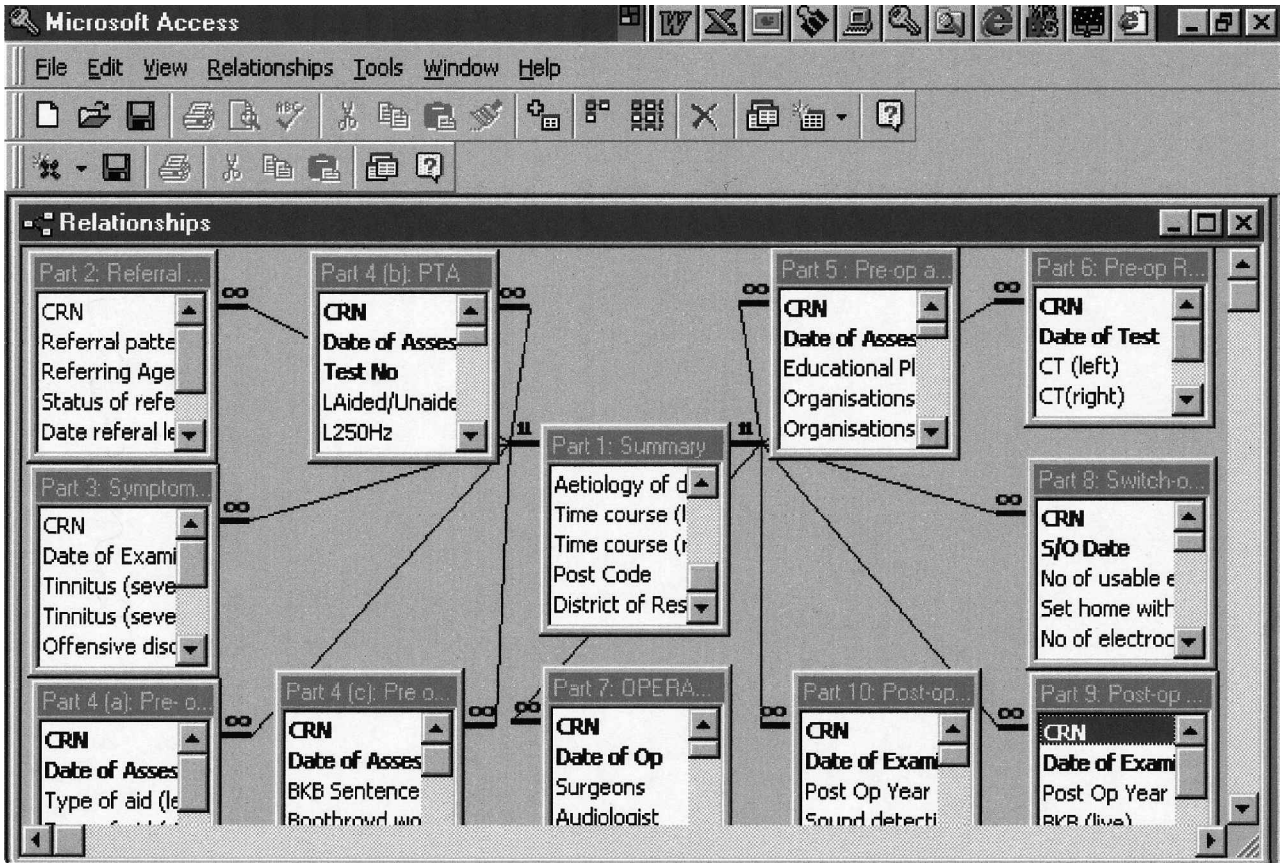

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FIG. 2

Various tables and their relationships.

accuracy and reliability. It also prevents deletion of data from the master table by any editing in the peripheral tables. In our database the backbone of relationships and referential integrity has been the primary key (patient hospital number). This set up also helps to trap duplicates at the point of entry thus maintaining accuracy.

Confidentiality

The final aspect that is of paramount importance is the issue of confidentiality and security. This has been resolved by utilizing a unique user password to determine who has access to the data. It can be taken one step further by organizing users into groups and setting security levels. However, ours being a small cohesive unit this was unnecessary. At present the database exists on password secure laptop computers that are easily transportable to assessment, operative and rehabilitation sites. The data thus collected is subsequently transferred to a main computer which is owned by the Implant Programme under overall supervision of the programme manager and maintained by the IT department of Addenbrooke's Hospital.

Current position

After the above steps had been carried out the database was ready for entering and storing information. As the Cochlear Implant Programme at Cambridge had been in existence for more than 12 years, an enormous amount of data had to be transferred from the files to the database. But once the backlog had been cleared it became easy to update records of every consecutive patient that joins the programme. At present this is done on the coded paper hard copy of the forms. The data is then transferred manually onto the computer by the database manager at the earliest opportunity. With increased familiarity amongst users data can be directly entered into the computer using the form view.

With the system up and running information can now be extracted, analysed and presented in a meaningful manner using the built in facilities of Report and Query wizard.

Discussion

The usefulness of databases in clinical practice is already well recognized and the 'Impeval Data-ease' database used for the evaluation of the National Cochlear Implant Programme in 1990–94 is a prime example.[6] The Head and Neck Database developed recently by the British Association of Otolaryngologists and Head and Neck Surgeons is another example.

A good database must provide (1) Data integrity i.e. ensure that the data is accurate, consistent and reliable (2) Data security i.e. data should not be lost (3) Data accessibility i.e. data should be available in

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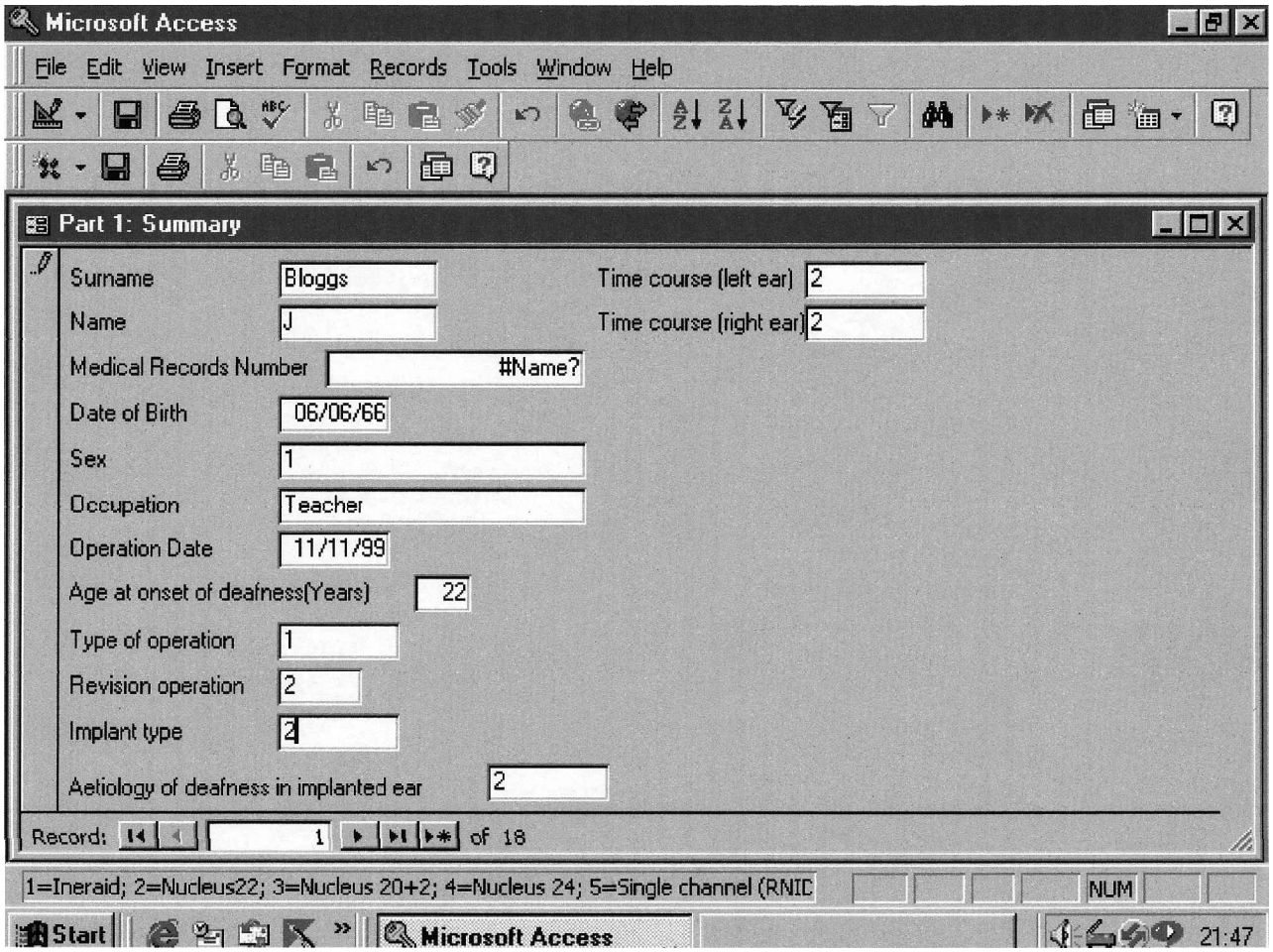

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FIG. 3
Form view for entering, viewing and editing data

a meaningful way to all users who need it and (4) Data confidentiality i.e. protect it from access and alteration by unauthorized users.[5] Microsoft® Access* fitted these requirements very well. Access is a very powerful DBMS and can store limitless amount of information yet it is easy to use with tremendous flexibility and control over data. It allows dynamic data exchange (DDE) and compatibility with other applications such as spreadsheets with basic statistical applications (e.g. Excel®) and slide presentations (e.g. Powerpoint®). The feature of object linking and embedding (OLE) can be used to include scanned images (e.g. X-rays, scans, operative photographs). These can be projected directly from the database during presentations and can also prove very useful in medicolegal issues.

Well-structured forms prevent things from being forgotten[7] and ensures staff acceptance and compliance thus achieving a comprehensive data entry.[8] This is important because completeness and accuracy of the data entered determines the quality of the database.[9] In designing our tables and forms we have used drop down boxes to provide prompts on the coding system used. This allows direct entry of data without the need to refer to paper copies. A numeric coding system also facilitates easy data entry and retrieval.[10] The initial apathy of transferring data on to the computer has now passed and user friendly forms with prompts have ensured compliance even amongst the most reluctant users.

The use of the patients hospital number as the primary key has ensured data accuracy. To avoid data duplication only the hospital number recorded in the notes of the cochlear implant programme is used and any other number from other hospital files are ignored.

At present the database is not linked to the hospital information system for reasons of hospital data protection and is held on a main computer under overall responsibility of the manager of the implant programme. In future it might be possible to have a central database with multiple user terminals with high level of integration with hospital information systems[11] and with varied user data access security levels. The eventual aim would be to integrate comparable databases at different cochlear implant programmes.

As newer equipments, tests and surgical procedures continue to emerge the designs of the forms and tables can easily be edited to encompass changing data collection needs without affecting the existing data.

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Conclusion

The data that is used by an organization is one of its valuable resources and is expensive and time-consuming to gather. It is therefore essential that the data be organized and arranged so that best use can be made of it.

A database system is accurate, robust, timeless, time-saving and convenient to use with ease in generating reports. Now that computers in the workplace are a fact of life it will not be long before databases for storing and maintaining data become a necessity rather than a luxury.

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Mr R. Gray takes responsibility for the integrity of the content of the paper.
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Appendix

Numeric coding system used for entering data

Summary Table

Surname:	
First Name:	
Medical records number (CRN):	
Date of Birth:	
Sex:	1 = Male 2 = Female
Occupation:	
Operation date:	
Age at onset of deafness:	
Age at operation:	
Type of operation:	1 = Normal cochlea 2 = Obliterated cochlea 3 = Congenitally deformed cochlea 4 = Post-CSOM fat obliteration of middle ear
Revision operation:	1 = Yes 2 = No 3 = Explant
Implant type:	1 = Ineraid 2 = Nucleus 22 3 = Nucleus 20 + 2 4 = Nucleus 24 5 = Single channel (RNID) 6 = Single channel (Medel) 7 = Other
Aetiology of deafness in implanted ear	0 = Not recorded 1 = Congenital idiopathic 2 = Meningitis 3 = Congenital progressive 4 = Otosclerosis 5 = Head injury 6 = CSOM 7 = Ototoxicity 8 = Syndromal
Time course of deafness	
Left ear	0 = Not known 1 = Congenital 2 = Sudden 3 = Progressive
Right ear	0 = Not known 1 = Congenital 2 = Sudden 3 = Progressive

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