Use of a computer for producing microbiological reports and for data storage and processing

J. L. FARRAR, T. D. BROGAN, T. MOULDING, R. TAYLOR, AND M. PAGE

From the Department of Clinical Bacteriology, University Hospital of Wales, Heath Park, Cardiff and the Welsh Health Technical Services Organization Computer Centre, Velindre Hospital, Whitchurch, Cardiff

SYNOPSIS A simple 'fail-safe' system is described that produces microbiology reports on a computer teleprinter and stores results on the magnetic tapes and discs of a computer for instant retrieval and epidemiological analysis. The system, which has been in operation for over a year, involves the use of a modified conventional NCR request form. The top portion, which is completed manually by the laboratory staff, is coded by writing numbers in hatched boxes. The data thus written on to the bottom portion are transcribed by punch operators on to paper tape and this data input is verified by double punching. The reports are normally produced automatically by the computer terminal teleprinter, but in case of mechanical failure the manually completed request forms can be returned to wards and outpatient departments. The system permits a wide choice of options for epidemiological analysis, and six programmes are described, one of which produces a digest of the overall percentage antibiotic sensitivities of organisms from various sites.

Microbiological laboratories attached to large hospitals have experienced during the last decade an ever increasing demand for routine investigations. The consequent work-load on such laboratories has given rise to many problems; those connected with organizing teams of technicians who are competent to cope with rising numbers of specimens are soluble if sufficient personnel, apparatus, and laboratory space can be found. However, problems generated by the recording, storage, and analysis of results were hitherto amenable to solution only if office space could be found to accommodate large numbers of bulky filing cabinets and if an adequate number of clerical workers could be employed; and such options are now not always available.

Computers have long been used for data storage and for retrieval and analysis of records. We describe a simple 'fail-safe' system not only for storage of microbiological results with facilities for instant retrieval and epidemiological analysis but also for producing microbiological reports on the computer teleprinter. The system has been in use for over a year in the University Hospital of Wales.

Material and Methods

COMPUTER EQUIPMENT

An International Computers Limited (ICL) 1904S computer of the following characteristics is sited at the Welsh Health Technical Services Organization, Computer Centre, Whitchurch, Cardiff and is linked to the University Hospital of Wales, which is approximately two miles away, by GPO telephone lines. The computer has a core store of 128K and 24 bit words and offers storage facilities on both magnetic tape and disc. The computer is controlled by an operating system 'George III' which is capable of carrying out many operations simultaneously. It is therefore possible to input work from the ICL 7020 terminal while still processing other programs within the computer centre. The ICL 7020 terminal, housed on site at the University Hospital of Wales, has a paper tape reader/punch and a line printer capable of printing 150 lines per minute. The suite of programs is written mainly in Cabol.

INPUT OF DATA

A two-part National Cash Register (NCR) form is used (BA1; fig 1a, b). The top portion is completed by the clinician in a manner similar to a request on a conventional form, and the bottom

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BA1		Lab No.	4	5	6	SOUTH GLAM.A.H.A(T)										Ward	Hosp. No.		Unit No.													
REPORT												95	96	97	98	Consultant	SURNAME (Block)										First Name(s)					
												99	100	101	102		Address															
												103	104	105	106	Hosp./Practice																
												107	108	109	110		D.O.B.										Sex					
												111	112	113	114		90										91	92	93	94	N/L	
												115	116	117	118																	
AER	ANAER	CO ₂	No Growth			Normal Flora			Contaminants			N/L Appearance	Protein										Glucose									
S.	(coag)		Colliform			H. Influenzae						Reaction	Casts																			
Srep. pneumoniae			Proteus									Rbc	/cmm/HPF Epth. Cells										/cmm/HPF									
Srep.			Ps. pyocyanea									Wbc	/cmm/HPF Polys.										% Lymphs.		N/L %							
+ = sensitive ± = part. sens. O = resistant												Mordant Acid Cephalosporin Nitrofurantoin Sulphonamide Ampicillin Tetracycline Trim./Sulph Cloxacillin Gentamicin Kanamycin Carbamycin Erythromycin Fusidic Acid Clindamycin Methylcellulose Flu./Caz. Chloramphenicol Neomycin Paracetamol Streptomycin Chlorpheniramine Nystatin										141 144 147 150 142 145 148 151 143 146 149 152 144 147 150 153 145 148 151 154 146 149 152 155 147 150 153 156 148 151 154 157 149 152 155 158 150 153 156 159 151 154 157 160 152 155 158 161 153 156 159 162 154 157 160 163 155 158 161 164 156 159 162 165 157 160 163 166 158 161 164 167 159 162 165 168 160 163 166 169 161 164 167 170 162 165 168 171 163 166 169 172 164 167 170 173 165 168 171 174 166 169 172 175 167 170 173 176 168 171 174 177 169 172 175 178 170 173 176 179 171 174 177 180 172 175 178 181 173 176 179 182 174 177 180 183 175 178 181 184 176 179 182 185 177 180 183 186 178 181 184 187 179 182 185 188 180 183 186 189 181 184 187 190 182 185 188 191 183 186 189 192 184 187 190 193 185 188 191 194 186 189 192 195 187 190 193 196 188 191 194 197 189 192 195 198 190 193 196 199 191 194 197 200 192 195 198 201 193 196 199 202 194 197 200 203 195 198 201 204 196 199 202 205 197 200 203 206 198 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JONES THO 7 HFOI V EYNNON ABERTRIDWR
HOSP 7001 CRN 204724 WARD F3 DOB 28/04/36 SEX M SPEC NO. 293

PROTEIN GLUCOSE REACTION CASTS/HPE RBC/HPE EC WBC/HPE
 ++ NIL ACID 100 50

	Malic Acid	Cephalaxin	Microflurantin	Sulphonamide	Ampicillin	Tetracycline	Trim/Sulph.	Colistin	Cephalexidine	Carbenicillin	Kanamycin	Gentamicin	Penicillin	Erythromycin	Fusidic Acid	Chlindamycin	Methicillin	Flu/Cloz.	Chloramphen.	Franycein	Neomycin	Paramomycin	Moxycilin	Streptomycin	Chlorphenesin	Mycin
1	+	+	+	+	+	+	+	+																		
2																										
3																										

+ = sensitive
0 = resistant
ORGANISM
1 E COLI
2
3

VIABLE COUNT >1000000 orgs/ml
BACTERIOLOGY DEPARTMENT DATE COLLECTED 22/10/74 MSSU

Fig 2 (b) Example of a computer-printed report on a mid-stream specimen of urine. The patient's name and address are printed in an agreed shortened form together with his hospital registration number (CRN) and date of birth (DOB); other abbreviations have the following meanings:

HPF high powered field of microscope
RBC/WBC red blood cells/white blood cells
EC epithelial cells

These reports conform to the locally agreed size and format for inclusion in patients' notes of hospitals of the South Glamorgan AHA(T).

first prints a list of errors before it produces the results of the morning data input. This error list consists of unacceptable codes and rejected data that have been transmitted to the computer as a result of mistakes by laboratory personnel. Errors are corrected before the terminal prints the laboratory reports (fig 2a, b) which are produced in ward order to facilitate rapid sorting. In addition to the ward reports, the terminal produces a summary in alphabetical order of all results reported during the last 14 days. This day book enables results of investigations carried out during the last 14 days to be found instantly; results of reports older than 14 days are obtained from the computer by a request form and these are printed in the same way as a normal report.

With the present system, there is a wide choice for retrieval of epidemiological data and, to date, six programs are in operation. Monthly and quarterly digests are produced of the number of isolations of 10 common pathogens in each of the wards together with a monthly and quarterly report of the

frequency with which the predominant type of a particular species occurs (table II). In addition to this a monthly and a quarterly digest are produced of the overall percentage antibiotic sensitivity of organisms from various sites (table III).

Ward C1

Organism	Test Name	Test Result	Repeat Types
Ps pyocyanea	Pyo type	1	5
Staph aureus	Phage type	52 52A 79 80 84	1
	Phage type	52 52A 80 42E 83	1
	Phage type	52W x 100 RTD	1
	Phage type	71 RTD	1
	Phage type	85 RTD	2
BHS (presumed A)	Phage type	NT	5
	Strep grp	Lancefield A	6
	Strep grp	Lancefield G	1
	Strep grp	Not Groupable	1

Table II Example of a quarterly report, printed by the computer terminal, on the type predominance of various organisms isolated from a dermatology ward of the University Hospital of Wales

SITE: Mid-stream urine

Organism	Overall No. of Isolates tested		Naladixic Acid	Cephalexin	Nitrofurantoin	Sulphonamide	Ampicillin	Tetracycline	Cotrimoxazole	Colistin	Carbenicillin	Gentamicin
<i>Proteus</i> species	86	Sensitive	83	73	3	75	80	3	85	1	0	0
		Non-sensitive	2	13	83	10	6	83	1	84	0	0
		% Sensitivity	98	85	3	88	93	3	99	1	0	0
<i>Streptococcus faecalis</i>	47	Sensitive	2	17	47	12	45	17	43	2	0	0
		Non-sensitive	45	30	0	35	2	30	4	45	0	0
		% Sensitivity	4	36	100	26	96	36	91	4	0	0
<i>Staphylococcus albus</i>	55	Sensitive	6	55	55	50	26	29	44	5	0	0
		Non-sensitive	49	0	0	5	17	26	11	50	0	0
		% Sensitivity	11	100	100	91	60	53	80	9	0	0
<i>Coliform</i> species	479	Sensitive	457	389	433	355	307	340	458	453	9	13
		Non-sensitive	21	89	45	123	172	139	21	21	6	2
		% Sensitivity	96	81	91	74	64	71	96	96	60	87
<i>Pseudomonas aeruginosa</i>	20	Sensitive	0	0	0	0	0	3	0	20	16	20
		Non-sensitive	20	20	20	20	20	17	20	0	4	0
		% Sensitivity	0	0	0	0	0	15	0	100	80	100

Table III Example of a quarterly antibiotic sensitivity report printed by the computer terminal, on the likely proportion of antibiotic-sensitive strains in five groups of organisms commonly isolated in significant numbers from urine specimens

The numbers in the lines of the table headed 'sensitive' and 'non-sensitive' indicate the numbers of isolates subjected to direct disc sensitivity tests. '% Sensitivity' indicates the likely proportion of sensitive strains of the organism or groups of organisms to the various antimicrobial drugs tested.

Discussion

The system for computerized reporting and data processing of clinical microbiology results that we have described makes use of a conventional request form, thus permitting instant reversion to manual reporting should mechanical failure occur within the computer system. Furthermore, other hospitals in a large area health authority use the same form and will be able to adopt the system as and when computer facilities become available. A simple method of coding has been employed that is easy to learn and allows further inclusion of an almost limitless number of specimen types, organisms, investigations, etc. that future medical practice may yet demand. The double punching system enables automatic verification of computer data input, thus virtually eliminating errors from this source. This obviates the necessity for using manually punched cards as described in the Report on Data Processing in Clinical Pathology (1968); coding errors are therefore mostly confined to mistakes in coding that can be made by technicians at the bench and these usually become apparent to the consultant who is responsible for reporting. Instant retrieval of current results is made possible by a retrospective 14-day narrative 'day book' which also enables laboratory staff to assess present results on any particular patient against results yielded by recent microbiological investigations.

Information is stored centrally at the Welsh Health Technical Services Organization Computer Centre for an indefinite period on magnetic tape or

on discs, thus dispensing with the need for bulky files from which it is rarely possible to retrieve epidemiological information. Programs can be written for the system we have described that will yield epidemiological data from the stored information. To date, we have confined programs to assessment of the incidence of pathogen isolation in our wards and to determining the average antibiotic sensitivity of recently isolated pathogenic bacteria. This has enabled us to counsel clinicians more effectively than before on the likely efficacy of an antimicrobial agent before definitive sensitivity tests are available. We are currently planning to assess the incidence of postoperative sepsis by computer program since we are now convinced that this most important epidemiological information can be produced as accurately as, and more efficiently than, by the manual methods that we have used hitherto.

Computerization of results as an exercise separate to that of using the terminal for reporting has been criticized by Whitby (1969), who described a system that uses several cards relating to various groups of specimens. Andrews and Vickers (1974) have devised a system of computer-assisted microbiology reporting that makes use of a separate marked-sense work sheet. Our system uses one single filing card (BA1) that is the bottom portion of a normal NCR request form and thus does away with the necessity for cards relating to groups of specimens or, in fact, for punching or processing separate computer cards. Additional information, such as 'phage types of staphylococci, pyocine typing of *Pseudomonas*

aeruginosa, etc., can be reported to the clinician and stored against the patient's name by the simple expedient of completion of form BA2 by the laboratory staff. We thus consider that the system we have devised has considerable versatility and could be expanded to report and store an infinite variety of microbiological investigations. In addition, the system is 'fail-safe' should mechanical breakdown occur.

We should like to acknowledge our many colleagues in the clinical bacteriology laboratories of the University Hospital of Wales and in the Welsh

Health Technical Services Organization without whose help the production of this system would not have been possible.

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