

training may be seriously disrupted. The patient and his family may have to be helped to accept less ambitious aspirations than they had formerly held. However, the wide range of opportunities available through adult education schemes and Government training centres provides ways and means of overcoming this kind of handicap.

The attitudes of those close to the patient are of crucial importance. Lack of self-respect, apathy about the future, depression, and resentment often reflect the way others see him. Such pathological attitudes and symptoms are also found in the long-term unemployed and physically disabled and can be the largest single factor preventing rehabilitation. Emotional flattening, poverty of ideas, and social withdrawal are clinical components of the illness, but such symptoms are always more severe in patients who have had the misfortune of poor social care from those with hopeless attitudes about this kind of illness. Prevention of these secondary handicaps is far easier than cure.

FAMILY LIFE

An early follow-up study showed that relapse was more common in patients discharged from hospital to live with family members with whom there were likely to be close emotional ties than in

patients discharged to lodgings, where there was probably more restricted social contact. Subsequent studies have indicated that high emotional involvement is not in itself harmful, but more the kind of emotion expressed by the family. Only when the family were openly critical of the patient was relapse more likely. This was especially so when there was much face to face contact between the patient and his family (more than 35 hours per week). This does not inevitably lead to the conclusion that doctors should encourage patients, whose family life may be harmful, to break strong bonds which exist with parents or spouse. Work with the patient's family aimed at reducing dissatisfaction and emotional tension may reduce the likelihood of deterioration and recurrence of psychotic symptoms. Helping the family to recognize that too much contact can be harmful might be therapeutic if it allows the patient more freedom to retreat when necessary.

Some patients, particularly the old and paranoid, may have no social contacts in the community. Isolation rather than over-involvement is their problem. A wide range of hostel accommodation, day hospitals, and other social facilities are necessary to maintain these patients in the community. Zealous policies for early discharge of patients from hospital can do more harm than good if they are not linked with adequate facilities for social care.

Occasional Survey

Diagnosis of Hypothyroidism: A Comparison of Statistical Techniques

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Summary

From replies to a postal questionnaire used in a radioactive iodine follow-up scheme patients had to be classified as either "suspected hypothyroid" or "euthyroid." A comparison has been made of the effectiveness of published statistical techniques in making this classification.

Two main conclusions emerged. Firstly, all except one of the methods identified an acceptable proportion of the hypothyroid patients, and, secondly, the results given by these methods were remarkably similar. Thus the simplest, which required only a count of the number of symptoms present, was selected for use.

Introduction

The introduction of computers into medicine has brought increasing interest in statistical methods of diagnosis. A variety of these "diagnostic" methods have been devised and applied to

clinical problems such as congenital heart disease,¹ thyroid disorders,^{2,3} jaundice,⁴ and abdominal pain.⁵ The philosophies and assumptions underlying the methods differ, and it might be expected that their diagnostic abilities also differ. We report here our comparison of the performance of some published methods when applied to the same data.

Data and Methods

The data for the investigation were obtained from the Birmingham follow-up of thyrotoxic patients treated with radioactive iodine. The follow-up scheme depends on a serum protein bound iodine (P.B.I.) measurement carried out at intervals of 21 months, and a postal questionnaire which is sent to each patient nine months before the P.B.I. measurement is due.⁶ At the time the follow-up was initiated the P.B.I. was the best biochemical measure of thyroid function available for large-scale use, but it has been replaced by more specific and sensitive measures. The replies to the questionnaire (fig. 1) indicate the presence or absence of nine symptoms of hypothyroidism, the presence of symptoms being inferred from negative answers to the first and third questions and positive answers to the remainder. From these replies a diagnosis of "euthyroid" or "suspected hypothyroid" is made. For patients with the former diagnosis no action is taken until their next P.B.I. measurement becomes due nine months later. Patients with suspected hypothyroidism are referred immediately for P.B.I. measurement, and thereafter if either the P.B.I. is below 3.3 pg/100 ml or the questionnaire reply is known to be associated with a high frequency of hypothyroidism the patient is referred back to the consultant responsible for the initial treatment. If, as a result

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PLEASE ANSWER YES OR NO TO THE FOLLOWING QUESTIONS

(1) Do you feel as well as you did a year ago?	Answer	<input type="checkbox"/>
(2) Do you now feel the cold more than ever before, so that you cannot get properly warm?	Answer	<input type="checkbox"/>
(3) Is your appetite as good as it was a year ago?	Answer	<input type="checkbox"/>
(4) Do you feel less energetic than usual?	Answer	<input type="checkbox"/>
(5) Do you think you have put on weight in the last year?	Answer	<input type="checkbox"/>
(6) Have you, or any of your family or friends, noticed that your voice has recently become huskier or weaker?	Answer	<input type="checkbox"/>
(7) Are you getting any fuller in the face?	Answer	<input type="checkbox"/>
(8) Has the skin of your arms or legs become more dry or rough during the past year?	Answer	<input type="checkbox"/>
(9) Has your hair recently become unruly or more difficult to manage?	Answer	<input type="checkbox"/>

Postal questionnaire for ascertainment of hypothyroidism.

of the consultation, long-term thyroid replacement therapy is instituted the patient is classified as hypothyroid.

The analyses we performed were based on questionnaires received since the inception of the scheme in 1968 until the end of 1972. The questionnaire was slightly modified in the middle of 1969 and so the data were considered in two parts—1968-9 and 1969-72. The 1968-9 data comprised 263 completed questionnaires of which 48 came from patients subsequently shown to be hypothyroid, and the 1969-72 data comprised 754 questionnaires of which 56 came from hypothyroid patients.

None of the nine symptoms elicited by the questionnaire is specific to hypothyroidism. Each can occur in patients who have other disorders or who are ageing. Questionnaires cannot therefore be identified as coming from hypothyroid patients merely by the presence of a certain symptom. It is necessary to consider a more complex form of diagnosis which will depend upon the symptom combinations present in any individual.

With two possible answers to each of the nine questions there are 2⁹ (512) different patterns of response to the questionnaire as a whole. These 512 responses must be divided into two sets (referred/not referred) such that hypothyroid patients are mostly in the first set and euthyroid in the second. The number of ways of dividing 512 responses into two sets is extremely large, however

—in fact, 2⁵¹² or about (one million)²⁵. Thus the most effective division cannot be determined from systematic investigation of each one, and with so many possible divisions it seems likely that there will be marked differences in the performance of different statistical techniques.

The techniques we compared were the multinomial,⁷ assumption of independence of symptoms,^{1,2,8} the linear discriminant function^{3,9}—upon which the diagnostic index for hypothyroidism devised by Billewicz *et al.*¹⁰ was based—the multiple logistic function,¹¹ stepwise rules,^{12,13} nearest neighbour procedures,¹² a method based on combinations of symptoms,¹⁴ and summation of the number of symptoms. A description of the techniques may be found in Gardner and Barker.¹⁵ Each was applied to the 1969-72 data (the “analysed” data) to formulate a referral rule, and this rule was then applied to the 1968-9 data (the “independent” data).

Results

The frequency of the nine symptoms in questionnaires from the 104 hypothyroid patients and the 913 euthyroid patients is shown in table I. The findings show the low sensitivity and specificity of the symptoms as elicited by the questionnaire. The most sensitive symptom was cold intolerance (question 2), which occurred in 73% of hypothyroid patients. Its specificity, however, was low in that it occurred in 40% of euthyroid patients. Conversely, loss of appetite (question 3) had the highest specificity, occurring in only 16% of euthyroid patients, but a low sensitivity since it was shown by only 33% of hypothyroid patients. Fullness of the face (question 7), not a classical symptom of hypothyroidism, and cold intolerance were associated with the highest degree of relative risk* of the disease.

The selected techniques were applied to the questionnaires with two objectives: firstly, to refer 70% of the hypothyroid patients for P.B.I. measurement and, secondly, to minimize the number of euthyroid patients unnecessarily referred. The limitations of the postal questionnaire made it necessary to accept that referral of 100% of hypothyroid patients would be accompanied by unacceptably high referral rates of euthyroid patients. The results of using the different techniques to obtain rules which referred 39 (70%) of the 56 hypothyroid patients in 1969-72 are shown in table II, and the methods are ordered according to their effectiveness in minimizing referrals of euthyroid patients. The referral rules derived for each technique in the analysed data were applied to the independent data (1968-9), and the number of referrals that would have been made are shown. In the analysed data there was a wide range in the numbers of euthyroid patients incorrectly referred. Not

*The degree of relative risk was calculated as the proportion of hypothyroid patients among all those with the symptom/proportion of hypothyroid patients among all those without the symptom.

TABLE I—Frequency of Symptoms in Questionnaire from 104 Hypothyroid and 913 Euthyroid Patients 1968-72

Question No.:	1	2	3	4	5	6	7	8	9
No. (%) of hypothyroid patients with symptom	49 (47)	76 (73)	34 (33)	72 (69)	59 (57)	37 (36)	60 (58)	56 (54)	42 (40)
No. (%) of euthyroid patients with symptom	239 (26)	366 (40)	145 (16)	430 (47)	316 (35)	164 (18)	233 (26)	229 (25)	211 (23)

TABLE II—Use of Different Methods to Refer 70% of Hypothyroid Patients in Analysed Data and Application of Resulting Referral Rules to Independent Data

Method	Analysed Data (1969-72) No. of Referrals		Independent Data (1968-9) No. of Referrals	
	Hypothyroid	Euthyroid	Hypothyroid	Euthyroid
Multinomial	39	36	7	14
Nearest neighbour procedures:				
order 1	39	138	25	56
order 2	39	197	34	78
Stepwise procedure	39	149	24	53
Combinations of symptoms	39	179	27	69
Linear discriminant function	39	189	29	80
Assumption of independence	39	191	30	83
Multiple logistic function	39	205	30	84
Number of symptoms	39	214	32	87
Total number of patients	56	698	48	215

unexpectedly the multinomial method referred markedly fewer than any other method since no assumptions underlie it and the referral rule obtained depends solely on the particular set of data. When this referral rule was applied to the independent data, however, it gave the worst result in that only seven of the 48 hypothyroid patients were referred. The remaining seven methods performed similarly to each other, identifying between 24 (50%) and 34 (71%) of the hypothyroid patients and incorrectly referring between 53 (25%) and 87 (41%) of the 215 euthyroid patients. The simplest method, that of counting the number of symptoms present, gave results which were comparable with those of the more complex techniques.

Discussion

The development of statistical techniques for classifying individuals on the basis of symptoms, signs, and laboratory tests has potential value in diagnosis, treatment, and screening. There are few diseases for which the prognostic significance of different combinations of symptoms, signs, and measurements has been quantified. Many techniques have been proposed and used in particular clinical problems, but few comparisons of their performance have been made. Crucial to such comparisons is the application of diagnostic or referral rules derived in one set of data to a second independent set of data.

The result of our study was surprising. The simple method of counting the total number of symptoms present was, in this situation, as effective in determining a referral rule as more complicated methods. The simplicity of the rule, which refers patients with four or more symptoms, and its lack of dependence on complex calculations and computers make it the method of choice.

This may be disquieting to both clinician and statistician. For the clinician the thought that the presence of any four of these nine symptoms indicate the need for referral may conflict with his clinical impression that some combinations of symptoms of hypothyroidism are diagnostically more important than others. For the statistician there may be disappointment that sophisticated methods do not produce a better result. It would be interesting to see whether simply derived diagnostic rules are usually as effective as those determined by complex techniques.

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Clinical Topics

Microcephaly Following Baby Battering and Shaking

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Summary

Three cases of microcephaly following the rough handling of babies are described. If detailed social and psychiatric information had not been available, these three children would have become part of the large proportion of individuals in subnormality hospitals who have unsatisfactory and incomplete diagnoses.

Introduction

Most textbooks in subnormality do not consider child abuse as a direct cause of subnormality of intelligence, but one case of microcephaly following bilateral subdural haematomas is pictured and described by Holmes *et al.*¹ Many publications on

battered babies nevertheless suggest that a high proportion of battered children are left with permanent brain damage, and a proportion of these children are rendered mentally retarded.²⁻⁴ The extent of very severe abuse of children in north-east Wiltshire is at least one new case referred per year per thousand children under 4 years old. Twelve out of 38 children studied suffered skull fracture. Sixteen out of 38 suffered intracranial haemorrhage or other brain injury, usually in the first year of life.⁵

Three cases are here described from subnormality hospitals in N.E. Wiltshire in which the brain had been damaged by the shaking, swinging, hitting, or throwing of a baby. Mental retardation ensued. The rate of growth of the head circumference suddenly decelerated, or almost ceased, after the abuse. Previously normal children became microcephalic and severely mentally retarded.

Case Reports

CASE 1

A girl healthy at birth (2 weeks postmature, normal delivery, birth weight 8 lb 2 oz (3685 g), placenta healthy) developed normally until

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