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Selecting and educating safer doctors

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Reducing medical accidents by better selection of medical students or medical specialists is an immensely attractive idea; more rigorous, better targeted selection procedures might, at one fell swoop, have a long-term impact in increasing safety, and raising overall standards of medical care. This at least is a frequently used argument. However, such proposals invite a host of difficult questions. Does selection mean searching for doctors of higher general competence, or is it principally seeking to weed out a few 'bad apples' who are implicitly assumed to be responsible for most medical accidents? Is involvement in medical accidents, or any other kind of accident, a stable individual characteristic? In other words, are some individuals naturally careless or accident prone? Even if such people can be identified, can they be identified at seventeen years of age, prior to medical school entry? And if they can, is it justifiable to reject such an applicant solely on those grounds when they might later change their attitudes and behaviour, and become competent or even excellent doctors?

There is little empirical research to either support or reject the view that safer doctors can be selected, although there is relevant work in related areas. In this chapter we shall argue that attempts to alter medical selection are premature until the underlying assumptions have been thoroughly examined. In particular the feasibility of selection as a policy instrument requires careful investigation, together with the short- and long-term effects and the theoretical and practical limitations. We argue that although selection procedures in medicine show great scope for improvement, selection for safety *per se* should not be a priority. Instead, attention should be concentrated on those defining characteristics which allow the training of a competent doctor; and for post-graduate selection these will vary by specialty. At the undergraduate level they should be for what we call *canonical characteristics* — generic abilities which provide an adequate substrate for medical education, general training, and continuing professional development. Identification, measurement, and validation of the characteristics which correlate with competency will thereby allow the development of selection procedures founded on a secure theoretical and empirical basis.

This chapter will firstly ask whether the concept of accident-proneness as a stable personality characteristic is supported by research data, and whether ıther personality measures are predictive of accident liability. We will then present a theoretical argument to identify the limits of successful selection and compare the advantages to be gained from selection with those that may be achieved by training. These arguments will be illustrated with hypothetical examples of different selection strategies for entry to medical school. The same basic arguments, however, apply in respect of selection for a particular specialty or at any career point.

The concept of accident-proneness?

The reduction of accidents by improved selection requires that the likelihood of having accidents is a relatively enduring individual characteristic. If such a tendency is not fairly stable then selection at age eighteen will have little influence on behaviour twenty or thirty years later. Early studies searched principally for an 'accident-prone personality' which would influence accidents throughout a lifetime.

The concept of accident-proneness dates back to the studies of Greenwood *et al.* (1919), Greenwood and Yule (1920), and Newbold (1926) in factory accidents, who showed that workers' individual accident rates were not a random, Poisson distribution (Fisher, 1973), but were better fitted by a negative binomial model with individuals differing in their propensity for accidents. A recent methodological advance emphasizes that the simple use of accident rates is statistically insensitive to individual differences, and that more power is gained by examining the distribution of time-intervals between events (i.e. accidents); it then seems incontrovertible that individuals differ in their accident liability (Shaw and Sichel, 1971), although this need not be explained in terms of accident-proneness. Alternative explanations are that individuals are, for some reason, differentially exposed to risk and that accidents themselves can alter the risk of future accidents.

The problems implicit in using the concept of accident-proneness as a tool for reducing accidents are seen in the large study of Cobb who studied 29 531 Connecticut drivers during 1931–33 and 1934–46. The results suggested that 4 per cent of drivers caused 36 per cent of the road accidents (Cobb, 1939). Further analysis showed that, compared with those with no accidents in the same period, drivers having four accidents in 1931–33 were nearly seven times more likely to have accidents during 1934–46. Cobb concluded: 'once a group has been established as being predominantly accident-free or accident-liable, its future history as a group can be predicted with astonishing accuracy from its past performance'. However, Forbes (1939) emphasized that only 1.3 per cent of drivers could thus be called 'accident-prone', and that their removal on the basis of accidents during 1931–33 would have decreased accidents during 1934–36 by only 3.7 per cent. As we shall see it is also doubtful, to say the least, that the 1.3 per cent of accident-prone drivers could be identified prior to their involvement in an accident.

The problem with studies such as those of Cobb is their confusion of two separate epidemiological concepts. *Relative risk* assesses how a factor alters the likelihood of an outcome for an individual (e.g. in hypertensives, smoking doubles the cardiovascular mortality), whereas *attributable risk* assesses the population risk of a condition due to a factor (e.g. in a group of hypertensives, there will be seven excess deaths due to smoking per 1000 patient years). As has been emphasized (Rose and Barker, 1986), it is attributable risk and not relative risk which should be the guide to management and policy decisions. Here then is the crunch for using accident-proneness as a tool for selection; although the relative risk of some individuals having accidents may be really quite high compared with other individuals, the attributable risk due to these individuals is only a small proportion of the total number of accidents. To put it another way, the sensitivity of the test may be high, but its specificity may be low.

McKenna (1983) has argued that the concept of accident-proneness is conceptually confused and should be replaced by 'differential accident involvement', a term that '...does not prejudge the issue.... It is an area of study not a set theory'. Differential accident involvement accepts that some individuals may be more liable to error or accident at certain periods, perhaps in response to life-events, depression, or mood-shifts (Irwin, 1964); and it would indeed seem that life-events (Selzer and Vinokur, 1974; Alkov and Borowsky, 1980; Stuart and Brown, 1981; Whitlock *et al.*, 1977), and mood (at least as indicated by prior suicidal intentions (Kaplan and Pokorny, 1976)) do relate to accidents. The duration of such periods of accident vulnerability, their relation to accidents in subsequent periods, and the personality correlates which might eventually allow the identification of a syndrome of accident-proneness, are left open. Instead, emphasis is placed on understanding the mechanisms that might underlie differential accident involvement, and McKenna suggests that such a knowledge of the psychological processes underlying human error would encourage training where appropriate, selection when necessary, and redesign of equipment or working environment where possible.

Personal characteristics predisposing to accidents

Although medical accidents are little studied, road traffic accidents (RTAs) have been extensively investigated and may act as a provisional model for some kinds of medical accidents. In this section we will draw heavily upon the reviews and research of West and his colleagues (French *et al.*, 1992; West *et al.*, 1992a, 1992b).

RTAs have been related to several personality measures, including extraversion (Pestonjee and Singh, 1980; Fine, 1963), sensation-seeking (Loo, 1979), neuroticism (Shaw and Sichel, 1971), type A behaviour (Perry, 1986; Evans *et al.*, 1987), and risk-taking behaviours (Jonah, 1986), although not all studies have supported these findings (Wilson and Greensmith, 1983; Singh, 1978; Craske, 1968). Additionally it has been suggested that accidents are associated with increased aggression, seeking of prestige, and competitiveness (McGuire, 1972). There is therefore some evidence for differential accident involvement, although it is not clear how such characteristics might manifest in a medical environment. Decision-making strategies, however, have an obvious relevance to clinical medicine.

Decision-making style and accidents. West has argued that since many accidents involve errors of decision-making, then individuals may vary in their characteristic decision-making style, which in turn may predict accident rates in particular situations. Similarly Jensen (1982) has emphasized that 80–85 per cent of flying accidents are attributed to 'pilot error', and that probably 50 per cent of these are due to errors of judgement. West has developed the Decision Making Questionnaire (DMQ) (West *et al.*, 1992b; French *et al.*, 1992) which has 21 questions representing seven independent factorial dimensions, called Thoroughness, Control, Hesitancy, Social Resistance, Perfectionism, Idealism, and Instinctiveness. The dimension of Thoroughness (deliberate and logical decision-making, planning well ahead, working out pros and cons) was inversely correlated with six different measures of driving style, in particular with a tendency to excessive speed, and hence with frequency of accidents.

Instinctiveness (relying on 'gut feelings', sticking by decisions come what may) also correlated with accident frequency, although not with other driving behaviours. Other dimensions also related to driving behaviour, but not to accidents *per se*. West *et al.* (1992a) found that thoroughness was a significant prospective predictor of accident rates over a two-year period. The psychological nature of thoroughness is not clear, but it might reflect a more global trait such as impatience, particularly since type A behaviour, extraversion and sensation-seeking, which all correlate with accident involvement, all contain components which could be described as impatience (French *et al.*, 1992).

It is worth noting that in the study of West *et al.* (1992b) the two–year test–retest correlation of thoroughness is 0.46, and that the correlation of accident rates in one period with the next is only 0.08. Temporal stability in the measured characteristics is not therefore high. The result is that the correlation between thoroughness and accident rate cannot be high, and is in fact only −0.18. However, disattenuation of the correlation between accident-rate and thoroughness, taking the low reliability of each measure into account, gives a correlation of –0.938. Thoroughness might therefore be a strong predictor of accident involvement if both could be measured reliably. The implication is that the measures are tapping an important causal origin of some relatively constant component of accident proneness, although the majority of variance in number of accidents is probably due to other factors (see Chapter 1).

Social attitudes and accidents. Road traffic accidents have frequently been associated with a variety of variables which are broadly encompassed under the heading of 'mild social deviance' (West *et al.*, 1992a); thus links have been found with 'expression of hostile impulses' (Conger *et al.*, 1959; Barmack and Payne, 1961; Harano *et al.*, 1975; Schuman *et al.*, 1967; Hertz, 1970), 'eccentricity, impulsivity, or mild psychopathy' (McFarland, 1968), and 'social deviance' (Suchman, 1970). West *et al.* (1992a) developed a 10-item questionnaire, the 'Social Motivation Questionnaire', which assessed the extent to which individuals would take part in behaviours that could be construed as minor social deviance (e.g. parking on double yellow lines, travelling on public transport without paying a fare, or not declaring cash payments to the Inland Revenue). The measure was correlated with driving speed and deviant driving behaviour, and also with low thoroughness on the DMQ. Additionally, it was correlated with accident rates, and only part of that relationship was explained by higher driving speeds. The psychological substrate of mild social deviance is not clear, but West *et al.* (1992a) suggest that it probably reflects 'greater emphasis on the need to make good progress with less consideration of the adverse consequences of an accident'. It should also be noted that mild social deviance was less in females than males.

Although there are a few members of any profession who breech its rules and so could be described as deviant, it might seem that 'mild social deviance' has little relevance in a medical context. However, acting on impulse without sufficient regard for the consequences might well lead to accidents. There is certainly evidence that the confidence of some junior doctors far exceeds their abilities in some areas (see Chapter 7), and an attitude of 'medical machismo' which leads to a determination to handle any emergency oneself (whatever the costs to the patient) has been documented for decades by medical sociologists (see, for example, Merton *et al.*, 1957; Coombs and Stein, 1971; Becker *et al.*, 1961; Bloom, 1973). Where a junior doctor feels that calls for assistance might be regarded as evidence of weakness or incompetence, this tendency is exacerbated still further.

Characteristics of doctors involved in medical accidents. There are few studies which have related the likelihood of medical accidents to stable individual characteristics of doctors. The sole exceptions, which are of some importance, are two recent studies of malpractice experience (Sloan *et al.*, 1989; Kravitz *et al.*, 1991). These studies examined the qualifications and training of doctors involved in accidents, hypothesizing that such factors might relate to accident involvement. However, doctors with more prestigious credentials, who were board-certified, who were from the top third of US medical schools, or had degrees from North American universities were no less likely to have malpractice claims than other doctors (Sloan *et al.*, 1991); neither did experience with medical research or teaching relate to rate of malpractice claims. 'The general conclusion is that past claims experience is only modestly predictive of intrinsic claims proneness. Although physicians incurring large numbers of claims in the past are more likely, on the average, to incur large numbers in the future, predictions about individuals based on past claims experience are probably not accurate enough to identify most claims-prone physicians or to allow reliable judgements about an individual's propensity to practice negligently in the future' (Rolph *et al.*, 1991).

In both studies, however, female doctors had lower claim rates than males (Sloan *et al.*, 1991; Rolph *et al.*, 1991). Women, it should be noted, also have lower rates of road traffic accidents (Evans, 1991; Maycock *et al.*, 1991). The reasons for sex differences in behaviour are complex (Maccoby and Jacklin, 1975; Halpern, 1992) and not yet fully understood. Nevertheless it is possible that the difference in malpractice claim rates (and by implication, medical accidents) relates to an underlying personality characteristic that is stronger in men — impulsivity would seem to be a strong candidate. However, there is only a small overlap between accidents and negligence claims; most cases of negligence do not result in claims and many claims are filed in the absence of any negligence (see Chapter 2). It may therefore be not so much that women are less liable to be involved in accidents but that they are less likely to be sued. This is broadly the conclusion of Sloan *et al.* (1989) who suggest that the result 'reflects a patient-physician practice style [by women] that is less conducive to claims' (Sloan *et al.*, 1991).

To summarize, certain personality traits and decision-making styles, perhaps reflecting an underlying dimension of impatience/thoroughness, might predispose to accident involvement. Other dimensions may be revealed in subsequent research. In medicine we know only that female doctors are less likely to be sued, which may mean that they are involved in fewer accidents; this may be because they are more thorough, or it may reflect differences in communication style with both colleagues and patients. The next section examines whether, if stable predictors of accidents could be identified, it would be feasible to select for them.

The selection process

There is an extensive literature on selection procedures, dating from the early years of the century. After a period of pessimism and decline in the 1950s and 1960s, interest has grown steadily both in industry and in academic circles, and the usefulness and validity of some selection procedures has been established (see, for example, Schmidt *et al.*, 1992). A great variety of selection procedures has been developed, some of the main ones being: interviews (both structured and unstructured); interviews in which candidates are asked to predict their behaviour in certain situations; tests of intellectual ability, perceptual-motor skills, personality and attitudes; tests which simulate or involve the work to be done; computer-assisted tests; taking up references; graphology; and peer assessment (Robertson and Smith, 1989).

In establishing the validity of any selection procedure it is first necessary to define outcome measures, the desirable or essential skills or abilities which are assessed when selection procedures are evaluated. In medicine this might involve assessing clinical knowledge, diagnostic skills, technical competence, ability to communicate with staff and patients and any other characteristic that would enhance clinical standards and, in our case, promote safety. The validity of selection is established by comparing the results of the selection with candidates' later scores on the outcome measures. Selection procedures with the best predictive accuracy are work sample tests and tests of general intellectual ability and, where applicable, psychomotor ability. Supervisor/peer assessments, assessments centres, biographical data, and general mental ability are the best remaining methods. References, interviews, personality assessment, and interest inventories are very poor predictors (Robertson and Smith, 1989). Selection for medical school is initially based on examination results, probably a reasonable reflection of general mental ability and thus a useful part of the selection process. In the UK results in A-level examinations are the best predictors of success during selection (McManus and Richards, 1984; McManus *et al.*, 1989b), and they are also to some extent predictive of success later during the medical course (McManus and Richards, 1986). Medical student selection also relies extensively on interviews and references, which are among the least valid of all selection procedures (Robertson and Smith, 1989); nevertheless, evidence suggests that medical school shortlisters and interviewers can at least be reliable in the judgements that they make (Richards *et al.*, 1988; McManus *et al.*, 1989a; McManus and Richards, 1989).

Selecting for safety. Our comparatively positive view of the use and validity of selection procedures does not extend into the area of safety, although one might think that this would be a prime concern in industry. In a survey of research on outcome measures in selection, Landy and Rastegary (1989) found that only four studies out of 408 reviewed examined accident rates. Their comments on this state of affairs are worth quoting in full:

> The simple fact is that virtually no one is studying accidents from the perspective of individual differences among incumbents. There is certainly a great deal of discussion

about safe behaviour in environments such as nuclear power plants, air traffic control towers and airplane cockpits. Nevertheless, the published literature on these topics from a selection procedure is non-existent. Needless to say, the number of industrial deaths and lost time injuries remains unacceptably high. It is hard to believe that applied psychologists have run out of ways to study or understand safety behaviour. It may be that the differential psychologist has simply deferred to the human factors psychologist to solve the problem. This may be a little premature. At best the answer to safe behaviour is likely to come from the joint efforts of the personnel psychologist and the human factors psychologist rather than from the unique contribution of either of them.

We can illustrate this lamentable state of affairs by briefly commenting on the selection of pilots. The selection of pilots has always attracted great attention, due to the high costs of training and the serious consequences of accidents. Typically the outcome measures for validation are performance in training or post-training probationary flying, rather than a specific assessment of errors or of unsafe behaviour. Although a range of pencil-and-paper and computer-based tests have been used, the utility or validity of these is often assumed rather than proven. Detailed studies suggest that validity is often present only when the tests are close in time to outcome measures, and/or share their characteristics (as for instance with a computerized aircraft landing task for selecting trainee pilots (Fowler, 1981); as Bale *et al.* (1973) suggest, it is difficult or impossible to find tests which generalize across a broad range of validation criteria. The result is that selection measures are almost unrelated to outcome measures at the end of training (Bale *et al.*, 1973). Occasionally psychometric tests do show differences between successes and dropouts during training, although the sensitivity is poor. The result is that failures can only be eliminated at the selection stage by rejecting large numbers of probable successes.

Given that selection procedures in other fields have been relatively successful, we do not wish to suggest that selection for safety is a lost cause. Landy and Rastegary (1989) argue that, although research on selection in relation to safety is non-existent, the attempt to select for safety should certainly be made. What benefits might we gain from attempting to select safer doctors? Is the project worthwhile, or could the effort involved be better directed at some other accident-reducing endeavour? The next sections consider these fundamental questions in some detail.

Medical student selection and training: a theoretical model

The limits of selection. Student selection illustrates well the subtleties of a seemingly straightforward process. In essence, selection is extremely simple. A number of students, N, applies to study medicine, and a smaller number M is

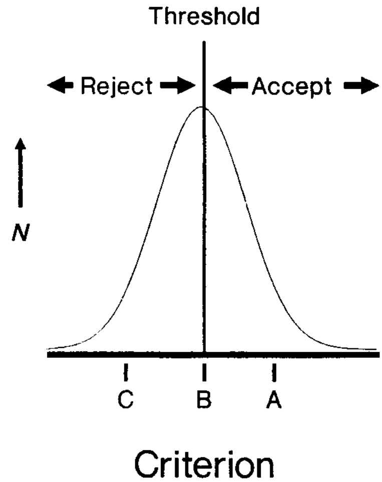

Figure 6.1 Selection on a single criterion. Individuals differ in their scores on the criterion, with individual A scoring high, B average, and C scoring low. Selection involves the setting of a threshold, those above the threshold being selected and those below being rejected; thus A is selected, C is rejected and B is marginal.

accepted as medical students; the figure *N/M* is known as the *selection ratio.* Although, in the UK at least, the selection ratio for individual medical schools is high (between 5 and 20), the selection ratio for the system as a whole is much lower because each candidate applies to four or five medical schools. In fact there is overall approximately one reject for every student selected and we will assume in our discussion that the selection ratio is 2. This selection ratio is far lower than is generally thought to be these case; thus it is *not* the case that 'medical schools have been blessed with an army of applicants' (Anon., 1992).

Consider a system using *single criterion selection* (usually academic or intellectual ability, although other measures might be used). Typically, scores will be normally distributed in the population; if 50 per cent of candidates are to be selected then selection will simply involve choosing those half of the applicants with the highest scores (see Fig. 6.1).

If selection is on the basis of two criteria (such as 'academic ability' and 'ability to communicate') then the situation is more complex. Assume that the two abilities are uncorrelated (a condition that can always be met by considering their principal components). In Fig. 6.2(a) a set of individual candidates, assumed distributed as a bivariate normal, are shown as points on the graph. Selection can take several forms. Figure 6.2(b) shows *inclusive selection*, in which candidates are selected only if they score above a certain level on *both* criteria, whereas Fig. 6.2(c) shows *exclusive selection* in which

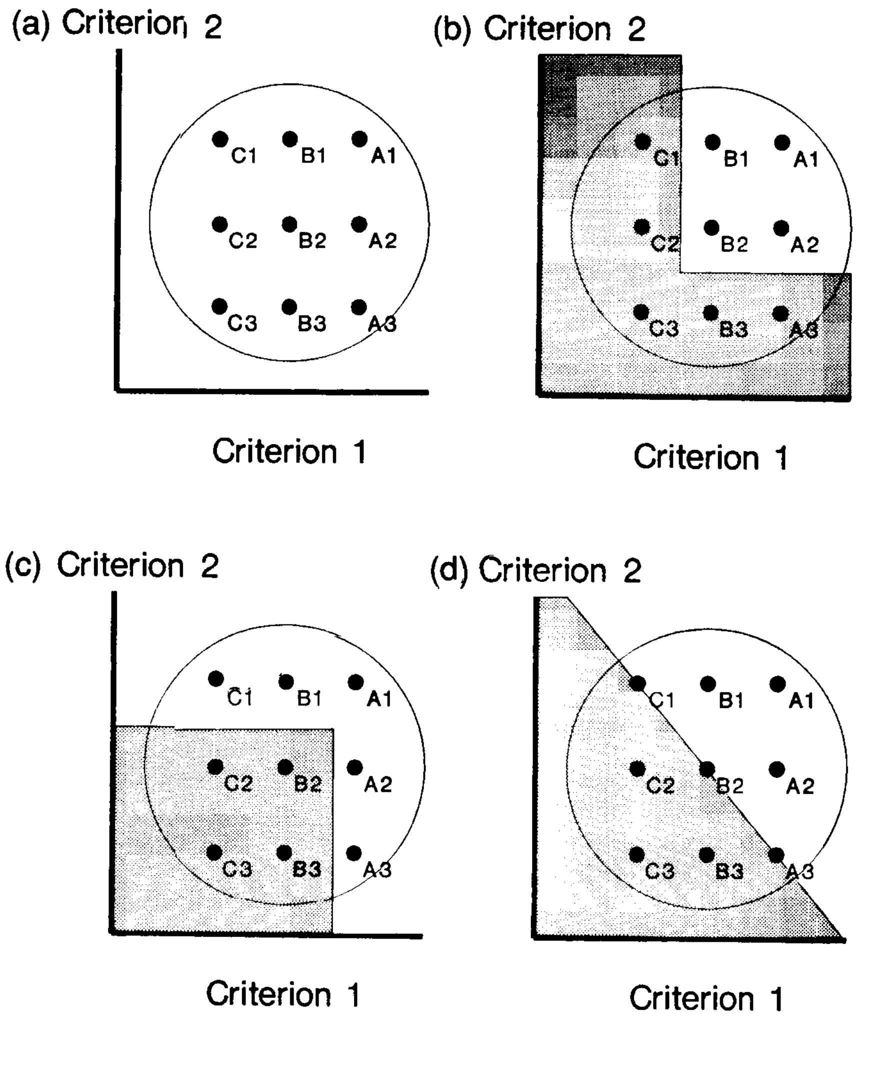

Figure 6.2 Selection on two independent criteria, each scored on one of the two axes. Individual candidates are shown as points: A1, A2, and A3 score highly on criterion 1, A1, B1, and C1 score highly on criterion 2; candidate A1 scores highly on both criteria, and candidate C3 scores poorly on both criteria. In inclusive selection (b), candidates are selected if they score highly on criterion 1 *and* criterion 2; the individuals in the shaded area are therefore rejected. In exclusive selection (c), candidates are selected if they score highly on criterion 1 *or* criterion 2. In compensatory selection a relatively poor performance on one criterion is compensated by better performance on the other criterion.

candidates are selected who score above a certain level on *either* criterion; finally, Fig. 6.2d shows *compensatory selection* in which a relatively high score on one criterion offsets a relatively low score on the other criterion. There are, of course, also selection strategies which can be seen as combinations of the methods just described.

The addition of a second selection criterion has important effects which are different for each of the selection methods.

1. *Inclusive selection*. The minimum standard set on *each* criterion (Fig. 6.2(b)) has to be *lower* than if only a single criterion had been used; thus candidate B in Fig. 6.1 is borderline, whereas candidate B2 in Fig. 6.2(b) is safely admitted, despite each candidate being average on each criterion. Inclusive criteria therefore reduce the average standards on each criterion, but with the advantage of ensuring that all entrants satisfy all of a range of minimum standards.

2. *Exclusive selection*, in contrast, means that *some* entrants score very highly on each criterion but at the expense of generally scoring very poorly on the other criterion; thus candidate B2 would be rejected as not being outstanding on *either* criterion, whereas candidate C1 is accepted because of their high score on criterion 2, despite having a score on criterion 1 which would have led to outright rejection under the single criterion selection process of Fig. 6.1. Exclusive criteria therefore result in high variance between candidates, who always perform at a high level on at least one criterion, but typically perform poorly on the other criterion.

3. *Compensatory selection* is a compromise between inclusive and exclusive selection. Candidates who perform *very* poorly on one criterion are only selected if they also perform *very* well on the other criterion. The method still accepts some entrants who are particularly poor on one or other criterion; thus candidate C1 is now borderline, whereas under single-criterion selection they would have been rejected; and candidate A3 is also borderline despite being clearly accepted under single-criterion selection.

All three methods for using two selection criteria have a single feature which is necessarily common to all; *the average performance of entrants on any one of the criteria will be less than if that criterion had been the sole basis for selection*. To put it more concretely; if one wishes to select candidates who are not only academically able but are also selected for their communicative ability, empathy, dexterity, or other possible correlates of lower rates of medical accidents, then that is only possible by selecting candidates with lower overall levels of academic ability than would have been achieved if academic ability were the sole criterion for selection. Exactly the

Table 6.1 The effects of selection on multiple criteria upon selection on one of those criteria. Using a selection ratio of 2, the table shows the proportion of candidates selected on one of the criteria (1) as the number of criteria increases.

Number of selection criteria	Proportion entrants rejected on criterion 1
1	Bottom 50%
2	Bottom 29.3%
3	Bottom 20.6%
4	Bottom 15.9%
5	Bottom 12.9%
6	Bottom 10.9%
10	Bottom 6.7%
20	Bottom 3.4%
50	Bottom 1.4%

same arguments apply when candidates are being considered for post-graduate training in surgery, general medicine, psychiatry, or other specialties. The use of multiple criteria might therefore be counter-productive.

Multiple selection criteria. Lists of the desirable characteristics that potential doctors should have are often lengthy. Using multiple criteria during selection exacerbates the effects found with only two criteria. Consider the case of inclusive selection, where all candidates meet minimum standards on all criteria. If 50 per cent of candidates can be selected overall, then the top 70.7 per cent must be selected on criterion 1 *and* on criterion 2 (Fig. 6.2(b)). Only the bottom 29.3 per cent of candidates on each criterion are rejected, compared with 50 per cent with only one criterion. With three criteria only the bottom 20.6 per cent on criterion 1 will be rejected; and so on, as shown in Table 6.1. As the number of criteria increases so the effect is to exclude a progressively smaller and smaller number on each criterion. The consequence is that with the low selection ratio that is found in medical student selection, the use of multiple selection criteria cannot result in entrants who are *well* qualified on *all* criteria but instead only results in the rejection of candidates who score *particularly badly* on *at least one* criterion.

Selection and performance. If selection is to reduce medical accidents by selecting individuals with lower scores on a personality or other measure then individuals with that personality should have lower accident rates. We now consider a hypothetical example to illustrate the problems inherent in attempting to select for a particular outcome — in this case a reduced accident rate.

Figure 6.3(b) shows the distribution of some accident-related personality measure in the population, and Fig. 6.3(a) shows that the likelihood of an accident (taken arbitrarily over some time period) is three times greater in those with high proneness who are 2 standard deviations above the mean

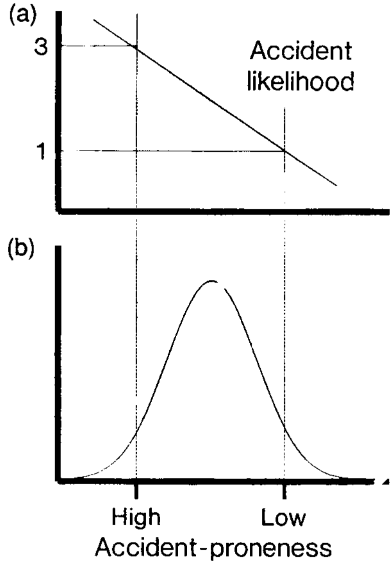

Figure 6.3 Variation in accident-proneness and its relation to the likelihood of accidents (hypothetical data). In (b) is shown the distribution of accident-proneness in the population, the dashed vertical lines indicating individuals on the 2.5th and 97.5th percentiles. In (a) is shown the relative likelihood of an accident for individuals of different proneness.

than in those with low proneness who are 2 standard deviations below the mean. One high-risk individual therefore causes as many accidents as three low-risk individuals. Nevertheless, because 95 per cent of individuals are between these extremes, the effect of selection upon the total accident rate is low. Using the numerical values quoted, the bottom 10 per cent of individuals cause only 15 per cent of accidents; and hence if those individuals were excluded from practising and replaced with others with a lower rate of accidents, then 94 per cent of accidents would still occur. Similarly, excluding from practice the bottom 20, 30, 40, or 50 per cent of individuals on this scale would reduce the number of accidents to only 90, 84, 81 and 78 per cent of their initial rate.

The potential effects of selection upon eventual accident rates are therefore quite small. To obtain even a 22 per cent reduction in accidents would require 50 per cent of applicants to be excluded (a figure equal to the selection ratio, and thereby implying selection on this criterion alone). This result means that selection would not be occurring on any other criterion (such as academic ability) — and that, of course, might result in *higher* rates of accidents for other reasons.

The conclusion seems to be that any realistic personality-type measure which could be used at the time of selection for differentiating applicants with a high risk of accidents would have only a small effect on the overall accident rate, and that to have a larger effect it would need to preclude any other form of selection, which might itself adversely affect the accident rate. This does not mean that selection is unimportant in relation to safety, only that safety *per se* should not dictate the selection criteria. Of course a concern with safety could and should be incorporated as a part of training. The effects of training must be considered in the next section.

The effects of training. Medical students enter medical school with almost zero ability to practice medicine (excluding a few rudimentary skills at first aid). Students will differ in their rate of acquisition of appropriate knowledge and skills, so that by the end of their five years of study they will differ in their ability to practice medicine competently. A small number, perhaps 10 per cent or so overall, will have insufficient knowledge and skills to pass exams at the end of various courses and will leave the school; the majority, however, will qualify. Figure 6.4 models the rate of growth of knowledge in individual students, two of whom fail at various stages of their course.

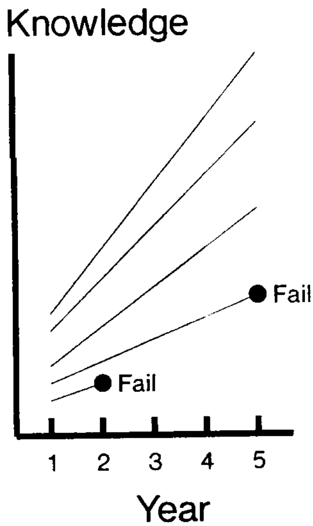

Figure 6.4 A model of the rate of growth of the absolute amount of medical knowledge in relation to time in the medical school. Two candidates acquire knowledge at a sufficiently low rate to mean that they are required to leave the medical school, either at the end of the second year or the fifth year. Amongst the three students who qualify there is a variation in the amounts of knowledge attained.

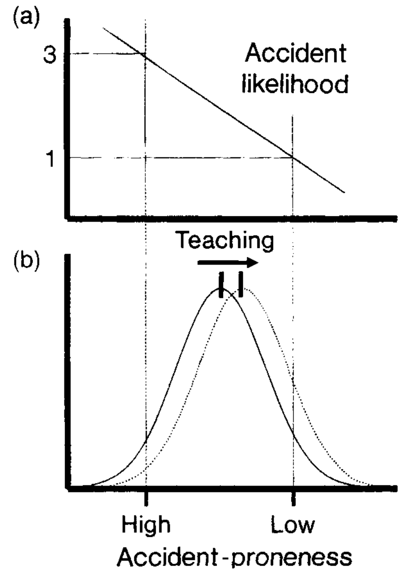

Figure 6.5 As in Fig. 6.3, individuals differ in their accident-proneness. The effect of training is to shift the distribution of proneness to the right, from the dotted to the solid line. The result is to reduce the overall likelihood of an accident.

The effect of good training and education is to encourage students to acquire more knowledge and, in particular, more *appropriate* knowledge, which is useful and applicable. We will assume that students who acquire appropriate knowledge are therefore less likely, on aggregate, to have accidents. The process can be modelled by assuming, as in Fig. 6.3, that individuals two standard deviations above and below the mean level of knowledge differ in their likelihood of an accident by a factor of three. The effect of training (Fig. 6.5(b)) is to increase the amount of knowledge and thereby to shift the distribution of accident proneness to the right, thereby making accidents less likely. If the shift to the right is by the fairly small amount of half a standard deviation (i.e. an individual on the 5th percentile acquires the knowledge of an individual on the 13th percentile) then the rate of accidents overall decreases to 75 per cent of its previous level; and if the shift is by one standard deviation, in which the individual on the 5th percentile achieves the knowledge level of an individual on the 26th percentile, then the accident rate falls to 57 per cent of its previous level.

Training even at relatively reasonable levels can therefore have effects upon the accident rate which can only be achieved through selection by concentrating selection upon a single criterion, and which would be difficult to achieve due to the scarcity of validated criteria selection measures. Training also has other advantages: it can be focused on the specific problem areas where accidents occur, so that skills, knowledge, and attitudes can be provided which are directly valid for the particular end-point. Selection can still proceed using other criteria that are not directly safety related. However, selection and training may interact; we may be able to select those doctors who are willing to learn and to practice safely.

Selection for training. Successful training requires an interaction between trainer and trainee. Motivation, learning experience, and study skills will all affect the efficiency and effectiveness of training, and to a large extent these attributes will be independent of simple intellectual or academic ability. Thus although medical school entrants may enter medical school with a *tabula rasa* for specific medical knowledge, they are not identical in ability to acquire that knowledge.

Figure 6 schematizes a situation in which entrants differ in ability to acquire knowledge and skills through training. In the first year this results in some differences in their eventual knowledge and ability. However, since understanding of a discipline provides a springboard for further learning, helps the integration of knowledge between different areas, and helps to motivate trainees for further learning then the greater gains of some students

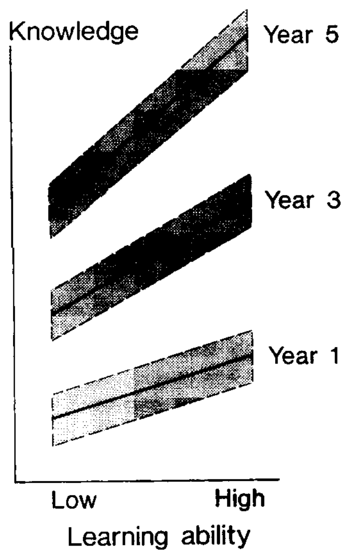

Figure 6.6 The absolute amount of medical knowledge acquired in individuals in their first, third, and fifth year at medical school. In each year there is variability, indicated by the shaded area, but those individuals with higher learning ability tend to acquire more knowledge than those with lower learning ability. These differences become accentuated across the years as later training becomes contingent upon more successful earlier training.

at the end of year 1 will be compounded during year 2, and so on. The result is that by the end of the course there can be relatively large differences between students.

The effects of selection are two-fold. Firstly, by selecting entrants who are in the upper part of the distribution for learning ability, the overall knowledge and ability of the students is increased. Secondly, the variability between students will be reduced, thereby helping to promote a 'culture' or 'ethos' in which independent, self-motivated learning is the norm, so that new knowledge continues to be acquired throughout post-graduate training. Selection for ability to be trained therefore has a 'multiplier effect', over and above that of simple personality differences, and makes it a particularly powerful form of selection.

What are the canonical characteristics to be found by selection?

We have argued that selection for specific, safety-related personality characteristics is unlikely to be an effective way of reducing accidents, and may indeed be counterproductive by reducing the average level of entrants on other criteria, such as academic ability. In contrast, training can have large effects on the likelihood of accidents, and can be progressively adapted and updated for the specific needs of particular students. If selection does have a role then it is likely to be principally in terms of selecting for 'ability to be trained', rather than in terms of personality measures. If that is the case then what are the *canonical characteristics* on which selection should be based? Here we are searching for a small number of broadly uncorrelated characteristics that can be measured, and which predict independent aspects of the ability to be trained at medical school, and to perform as a medical student and doctor.

At present the most important criterion used during student selection is academic ability (as measured by GCSE and A-level results in the UK). That is a sensible criterion, probably reflecting both intellectual ability and motivation to learn. Medical students have to learn prodigious quantities of information and must study for frequent exams, so that previous ability to study and pass exams is likely to be a useful predictor of success. Achievement at academic examinations is also correlated with general intellectual ability and there seems little doubt that IQ is a good measure of ability to be trained and to respond to diverse problems and challenges (McManus *et al.*, 1990).

Of course that is not to say that academic ability and intelligence should be the only criteria of selection. Although A-level results do correlate with success in university-level training, the correlation is not high, either in general (Bagg, 1970; Entwistle and Wilson, 1977; Choppin, 1979), or specifically in medicine (Savage, 1972; Mawhinney, 1976; Tomlinson *et al.*, 1977; Richardson, 1980; Lipton *et al.*, 1988). In part that reflects the reduced correlation that results from 'restriction of range' (Ghiselli *et al.*, 1981), but it also indicates that other measures are important. Studies of achievement in university students in general suggests that approaches to study are good predictors of success, and are independent of previous achievement (Entwistle *et al.*, 1979; Entwistle and Waterston, 1988; Biggs, 1978, 1985; Newble and Gordon, 1985). In particular, 'deep learning' seems to be a good correlate of achievement in academic disciplines, and 'strategic learning' of achievement in applied professions. 'Surface learning' in all subjects seems to be predictive of failure, and it is an approach which often seems to be encouraged by the type of curriculum found in medical schools (Coles, 1985; Tooth *et al.*, 1989). Learning ability, and in particular deep or strategic learning, are therefore good candidates as selection criteria. Much selection uses biographical information about individuals (biodata) (Asher, 1972), and in general such measures show adequate reliability and validity (Herriot, 1984; Asher, 1972; Owens *et al.*, 1966; Owens, 1976; Reilly and Chao, 1982; Asher and Sciarrino, 1974). In so far as they may also be indirect indicators of learning style they could also be useful selection criteria in medicine. In particular, extensive achievement in hobbies, be they musical, sporting or other, indicates self-motivation and an ability to direct one's study which probably correlates with strategic learning. And similarly, interest in and participation in community activities, particularly those involved with medical or para-medical activities, probably also indicates an ability to assign priorities and be self motivated.

A third candidate for canonical selection characteristics is communication ability. There is little doubt that successful medicine in most specialities requires not only technical knowledge and scientific expertise but also an ability to relate to patients and to empathize with them; and many medical accidents result not so much from technical failure but from failures of doctor–patient or inter-professional communication. If students are to be trained in communication skills (and there seems little doubt that they can be so trained and benefit from so doing (Simpson *et al.*, 1991, General Medical Council, 1991)), then it makes sense to concentrate training on those who already show a certain minimum level of ability. Whether medical school interviews can assess communications ability is not clear. Certainly those schools which do interview would claim it as an objective of interviews, and that seems more likely to be successful when 'ability to communicate' forms an explicit part of the ratings made for each interviewee.

Medical training

Just as one can define canonical characteristics for potential doctors, so one can define canonical skills and attitudes that should be learnt and encouraged during training. Clearly, a certain number of operations need to be seen, skills practised and patients clerked (although there is much variation in this (McManus *et al.*, 1993)). Can we discern any underlying themes of training that might make for safer medicine? Medical training is a vast area which we can hardly begin to consider here in its full richness. Defining clinical competence and the skills that underlie it is a complex and difficult task (Wakeford *et al.*, 1985; Neufeld and Norman, 1985), so that here we will consider just a few aspects of training which are often neglected, and which we believe may be especially relevant to errors and accidents.

Decision making. Doctors continually make decisions about patients, concerning diagnosis, aetiology, treatment, and management. It is surprising, therefore, how little effort has been put into *teaching* the process of decision making. Few medical schools have formal courses on diagnosis, or attempt to examine the process itself beyond mere exhortations to 'think', or the setting of example merely by apprenticeship. And likewise few doctors, at any level of specialization, are conversant with formal aids to decision making in medicine (Macartney, 1987; Thornton *et al.*, 1992; Schwartz and Griffin, 1986), despite the existence of computer software for aiding and making explicit the process. If faulty decision making is a key process in the genesis of medical accidents then the teaching of medical decision making should be an important part of the medical curriculum (Elstein, 1982; Elstein *et al.*, 1982).

The setting of objectives for training. Much emphasis in medical training is put upon the need for students to acquire a wide range of experience of different conditions. However, this experience is seldom actually assessed, with the result that by the end of their studies, medical students vary immensely in the experience they have gained of medical conditions and of practical procedures (Jolly and Macdonald, 1989; Dent *et al.*, 1990; McManus *et al.*, 1993). If experience is important then it should be possible to systematize the nature of the experience that particularly matters. The use of 'log-books' or 'checklists' (Hunskaar and Seim, 1984) can ensure that a sufficiently broad range and depth of experience is obtained, thereby setting minimum standards for all students. If combined with a curriculum that sets out specific learning objectives from such experiences, coupled with educational support in the form of tutorials and seminars, then experience will be far broader than that attained in the uncontrolled and unsystematic chance way that is typical of most medical schools.

The setting of objectives in examinations. There is a dictum in educational psychology that it is the mode of assessment which determines the method by which students study and learn. Conventional final medical examinations have many problems (Weatherall, 1991): they are often poorly organized, haphazard in their assessment of knowledge, ignore attitudes and skills, and typically do not observe the details of processes such as history-taking, examination, and diagnostic testing. The result is that students feel those processes are unimportant, and that the sole objective of learning is to be able to answer an examiner's questions, rather than to become self-critically competent. That effect is compounded by medical examinations being *summative* (i.e. occurring only at the end of the course for the purpose of assessment) rather than being *formative* (i.e. occurring repeatedly and with the intention of providing information to students on their progress), and they are typically *norm-referenced* (i.e. students are compared with their peers and a fixed percentage failed) rather than *criterion-referenced* (i.e. absolute standards are set, whereby in principle all students can pass or all can fail) (Turnbull, 1989). The development of OSCEs (Objective Structured Clinical Examinations), particularly if in the context of *Skills Labs* has helped students to concentrate on the structure of clinical tasks, ensuring that seemingly minor details, which are often concerned with safety, are not overlooked (Harden *et al.*, 1975; Black *et al.*, 1986; Newble *et al.*, 1981). A more widespread use of such assessment methods is likely to help increase safe behaviour by doctors.

The study of safety. It is rare for safety to be taught as an explicit part of clinical teaching. The result is that examinations rarely ask about safety *per se*, or about how to maximize it, how patients respond to accidents, and about the actions that should be taken by doctors when patients are injured. Now that medical schools are beginning to design core curricula, with specific educational objectives, it would seem reasonable to include such aspects within the objectives of medical courses. And then of course they would also require assessment.

Conclusions

In this chapter we have assessed the role that selection might play in reducing the numbers of medical accidents and mishaps. Although superficially attractive as an idea, our analysis of the potential reduction in accidents that might occur from selecting students principally for reduced accident-proneness is probably small, and that there would likely be other indirect effects on other criteria (such as academic ability) which could increase the rate of accidents. If selection is to have an influence upon accident rates then it must be an indirect one, through increasing the general competency of doctors. The potential effects of education and training upon accident rates are far greater than selection, and therefore the optimal form of selection should concentrate upon a small number of well-specified criteria which are likely directly to affect overall competency.

Three principal areas on which medical student selection might concentrate seem to be:

(1) academic achievement as expressed in conventional public examination results;
(2) study habits, and in particular a 'strategic' or 'deep' approach to learning;
(3) ability to communicate, perhaps assessed in part by interviews, but probably capable of more formal, systematic assessment.

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