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A measure of knowledge and confidence in relation to HIV and AIDS: reliability and validity

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Abstract *Knowledge of HIV and AIDS is widely seen as an important determinant of anxiety about such infection in health care workers. However, existing measures of this knowledge suffer from a number of methodological problems and few demonstrate adequate reliability and validity. This paper documents the development of a new measure detailing its reliability and validity. Knowledge, and also confidence in knowledge, were assessed across seven domains of relevant information (e.g. epidemiology, personal risk, symptomatology) in one non-expert group (non-medical undergraduate psychologists) and in three groups with greater expertise (nursing students and third year and final year medical students). The measure was shown to be reliable and to discriminate between the four groups in a manner consistent with the level of education received by each group and in terms of both the scale scores for the seven domains and the individual items. In general, final year medical students were shown to be more knowledgeable, and more confident in their knowledge, than the other groups. The non-medical undergraduates showed the lowest level of knowledge. In general, the groups appeared under-confident in their knowledge about HIV/AIDS. This was interpreted in terms of members of these groups exhibiting caution and the perceived fluctuating nature of the HIV knowledge base. Implications for the training of health care workers in relation to HIV/AIDS are discussed.*

Introduction

Since 1982 the prevalence of the human immunodeficiency virus (HIV) and of the acquired immunodeficiency syndrome (AIDS) has increased significantly world-wide. This increase may represent one of the greatest threats to public health in recent times. Health care workers (HCWs) are being required to treat growing numbers of both diagnosed and unrecognized HIV positive patients (see Kelen, 1990). Not surprisingly, there are many reports which have indicated increased feelings of anxiety and stress among HCWs with regard to the risks posed

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by this scenario (Imperato *et al.*, 1988; Kelly *et al.*, 1987; Link *et al.*, 1988; Lusby, 1985; Royse & Birge, 1987). When asked to comment on their anxiety, HCWs have reported that a lack of knowledge was one contributing factor (Armstrong-Esther & Hewitt, 1989; Bond *et al.*, 1988; Mannetti & Pierro, 1991).

HCWs report at least two ways in which lack of knowledge may increase their anxiety: (1) by not having enough information adequately to advise patients and patients' relatives about the disease process associated with HIV infection; and (2) through uncertainties about appropriate safe working practices (Armstrong-Esther & Hewitt, 1989; Bond *et al.*, 1988). However, although HCWs report that a lack of knowledge contributes to anxiety, most studies that have directly correlated HIV/AIDS-related knowledge and anxiety have failed to show a significant relationship between the two (Austin *et al.*, 1989; Brattebo *et al.*, 1990; Crawford, 1990). Logically, there are three possible reasons for this. First, despite the comments made by HCWs, no real relationship exists between knowledge and anxiety. Second, the measures of anxiety used may be inappropriate. In particular, these measures of anxiety may be too general, given the observation that HIV/AIDS-related anxiety appears to be context dependent (see Ferguson, Cox, Farnsworth, Leiter & Irving, 1994). Third, the lack of association between knowledge and anxiety may also reflect problems with existing measures of knowledge of HIV/AIDS.

This paper addresses this particular problem and describes the development of a psychometrically sound measure of HIV/AIDS knowledge, and presents initial reliability and validity data.

Problems with existing measures of knowledge about HIV/AIDS

A plethora of research has used measures of knowledge of HIV/AIDS in studies of both *expert* HCWs (Adamchak *et al.*, 1990; Armstrong-Esther & Hewitt, 1989; Brattebo *et al.*, 1990; Campbell & Waters, 1987; Mills *et al.*, 1986; Searle, 1987; Storosum *et al.*, 1991; Wertz *et al.*, 1987) and *novice* populations, notably the general public (Joseph *et al.*, 1987; Sherr, 1987; Strunin & Hingson, 1987; Temoshok *et al.*, 1987). Only a few studies have made comparisons between expert and novice groups (see Mannetti & Pierro, 1991).

Two major problems concern many of the measures designed to examine *expert* knowledge of HIV/AIDS. First, such measures often fail to discriminate between experts and lay people. Mannetti and Pierro (1991) state: "a large majority of these studies conclude that health care workers are often as uninformed as lay people" (p. 133). (For an exception to this see McKinnon *et al.*, 1990.) Second, they fail to distinguish between experts at different stages of their training. Both may be because such measures contain *too many* extreme questions both 'easy' and 'difficult'. Any adequate measure of knowledge should include questions that reflect all levels of difficulty and thus provide a structure for discriminating between expert and novice groups.

Existing measures of knowledge of HIV/AIDS, for both *lay groups* and *expert groups* such as HCWs, suffer from four additional theoretical and methodological shortcomings. First, most existing measures have treated knowledge of HIV/AIDS as a unidimensional construct, summing individual items/questions to produce a single unitary score. However there is evidence (Armstrong-Esther & Hewitt, 1989; Goodwin & Roscoe, 1988) to suggest that the architecture of such knowledge is more complex and that there are many different and distinguishable domains of knowledge relating to HIV/AIDS (e.g. virology, epidemiology). While each of these domains may derive from a general underlying latent construct of HIV/AIDS-related knowledge, they may also represent distinct facets of such knowledge. The second shortcoming of existing measures relates to the issue of item/question selection.

Typically, studies have not stated from where or how the knowledge questions used were selected. Third, few researchers have produced data on the reliability and validity of their measures (McCown & Johnson, 1991; Temoshok *et al.*, 1987). It is, therefore, difficult to judge the psychometric adequacy of those measures. The final problem relates to the types of response scales used and the effects of guessing. Many studies to date have used a dichotomous response scale (either yes-no or right-wrong). Use of dichotomous scaling means that for each question there is a fifty-fifty chance of guessing the correct answer. The extent to which guessing accounts for the results reported and any differences between populations is usually unknown. There could be a number of solutions to this problem; (1) the effects of chance can be reduced by increasing the number of response options, (2) the effects of guessing can be statistically controlled, for aggregate scores, using Kline's (1986) correction formula and (3) for the analysis of single questions, comparison to chance can be made using the recurrence formula for the binomial distribution or the approximation to the normal curve.

In developing the measure of HIV/AIDS-related knowledge reported here all these issues were addressed.

Calibration or confidence in knowledge: believing in what you know

Another important aspect of knowledge measurement is what people believe they know, or their confidence in the knowledge they have. The relationship between knowledge and confidence is usually described as *calibration* and can be used to assess whether people are under-confident (know more than they believe they know), over-confident (believe they know more than they actually do) or perfectly calibrated (accurate in their beliefs about the knowledge they have) (see Keren, 1991). A review of the literature indicates that an over-confidence effect is typically found across a wide variety of knowledge domains. The inclusion of a measure of confidence in an HIV/AIDS-related knowledge measure adds to its potential power as a research tool.

Development of the measure of HIV/AIDS-related knowledge

The development of a measure of knowledge of HIV/AIDS for HCWs, which does not fall short with respect to any of the above problems, is described in this paper. Knowledge was assessed across seven domains: symptomatology, virology, immunology, epidemiology, treatments, personal risk and nursing procedures for HIV/AIDS. Some, but not all, of these domains have been examined before (Mannetti & Pierro, 1991). The present measure was designed to offer a more extensive coverage of knowledge than any existing measures. A full list of the questions used to tap the seven domains can be found in Appendix 1.

The questions generated to assess the seven domains of knowledge were either derived from existing questionnaire items or originated from a review of the current literature and subsequent consultation with nursing staff tutors, microbiologists and consultant venereologists. For each question, four plausible answers were provided in a multiple choice format. This reduced the effects of guessing to 25%. In addition to assessing the respondents' absolute knowledge, the measure required respondents to indicate their degree of confidence in the answer they gave using a visual analogue scale (see later).

All questions and answers were cross checked for accuracy by the experts consulted, and finally checked by a senior consultant venereologist. This ensured that the information was factually correct and, in turn, that only one of the answers provided was correct. In total, 37 questions, assessing all levels of difficulty, were produced. Question difficulty was assessed

from informal comments collected from tutoring staff and a small pilot sample of nursing staff.

To complete the HIV/AIDS knowledge measure, respondents were required to choose, from a list of four alternatives, the one answer they believed to be correct. Following this, respondents were required to place a cross on a 10 cm visual analogue scale, which was anchored at its extremes with 'a complete guess' and 'completely accurate', to indicate their degree of confidence in the answer they chose. Scores were derived by measuring (cm) from 'a complete guess' to the mark made. Higher scores, distance in cm, indicated greater confidence.

The measure allows for three types of knowledge to be assessed. The first two are absolute assessments and the third a relative assessment. The first assessment provides a raw *knowledge* score (i.e. accuracy after correction for guessing) for each domain. The second assessment provides a raw confidence in knowledge score which reflects the respondent's self-reported level of confidence for each domain. This is referred to as *confidence* and this is expressed in terms of being more or less confident. Finally, there is the degree of knowledge *calibration*. Calibration reflects the relationship between what people actually know (raw knowledge scores) and what they believe they know (raw confidence in that knowledge). Calibration is expressed in terms of the degree of under- and over-confidence in each domain of knowledge. These aspects of knowledge (knowledge, confidence and calibration) were calculated for the seven domains of knowledge and for a *total* knowledge score (the sum of all the knowledge questions).

Discriminant validity

For a knowledge measure to be valid it must be able to distinguish between expert and novice groups and also between experts at different stages of their training. To assess the discriminant validity of the knowledge measure reported here, the measure was administered to four groups of students who were believed to vary in their degree of expertise. There was one truly novice group (non-medical undergraduate psychology students) and three more expert groups (student nurses, third year medical students and final year medical students). Given the seven domains examined (symptomatology, virology, immunology, epidemiology, treatments, personal risk and procedures) the following differences between groups were to be expected:

- student nurses should, by the nature of their training, know more about symptomatology, treatments, personal risk and procedures than non-medical undergraduates,
- medical students should know more about all domains of knowledge than non-medical undergraduates,
- medical students and student nurses *should converge on areas of shared knowledge*, such as procedures and personal risk, and
- final year medical students, due to clinical training, should be more knowledgeable than third year medical students.

These kinds of differences should also be reflected in the confidence judgements. While these examples show the *types* of trends expected, they are not intended to constitute a comprehensive set of hypotheses. With regard to calibration, on the basis of previous literature, a tendency to over-confidence in knowledge of HIV/AIDS was predicted (see Keren, 1991).

Method

Subjects

All subjects were studying in institutions in the East Midlands (UK). Four study populations were sampled on a *volunteer* basis.

The first sample was of 94 non-medical undergraduate psychology students. Any students who had been involved in the actual provision of health care were not included. Ninety-six subjects were approached in February 1992: 2 failed to complete the measure. This sample had a mean age of 22 years 11 months (SD = 5 years 7 months): 73 were female and 21 male. The second sample was of 96 final year nursing students. They had a mean age of 23 years and 5 months (SD = 4 years 4 months): 92 were female and 4 male. All 96 students approached (in February 1992) completed the questionnaire. The third sample was of 28 third year (pre-clinical) medical students. Again all subjects approached (in May 1993) completed the measure. This sample had a mean age of 20 years 10 months (SD = 7 months): 14 were female and 14 male. The fourth sample was of 39 final year (pre-final examination, post clinical training) medical students. Again all subjects approached (in May 1993) completed the measure. This sample had a mean age of 24 years 1 month (SD = 2 years 2 months): 24 were female and 15 male.

These samples were judged to be comparable both in terms of age and level of education, but not nature of education and level of knowledge, with the sex ratios reflecting those of the institutions from which the samples were drawn. The three more expert groups were being taught on a rotational basis such that some may have just received HIV/AIDS training, some would have received the training some time previously and some would not yet have received any such training. The non-expert group of undergraduate psychology students had received no formal training in relation to HIV/AIDS.

Procedure

Each sample completed the knowledge measure in small groups. All respondents were informed that participation in the study was voluntary and assurance of anonymity was given. Two researchers were always involved in the distribution of the questionnaires. Respondents completed the knowledge measure in quiet conditions; discussion was not permitted and reference books were not available. Following completion of the measure, all respondents were fully debriefed. The correct answers were given and time was allowed for discussion of the subject area.

Statistical treatment

Reliability. Internal reliability for the knowledge and confidence measures was assessed in two ways. For each domain of knowledge, an index of internal reliability was calculated (KR-20s for the knowledge scales and alpha coefficients for the confidence scales). Despite the common expectation that both should exceed 0.7 (Nunnally, 1978), internal reliability for a knowledge measure will be low. This is because knowledge may be viewed as a criterion based measure (Anastasi, 1988) and, as such, restriction in response range is likely to occur. This restriction may mean that even highly reliable measures will show low inter-item correlations (see Anastasi, 1988). In such a case, one way to demonstrate good reliability is to show that each domain of knowledge correlates with some form of criterion measure (Anastasi, 1988; Kline, 1986). In this paper, the total knowledge score (minus the domain of interest) was treated as the criterion and scores for each domain were correlated with this

criterion score. This reflects the suggestion that there is a general underlying latent construct of knowledge of HIV/AIDS to which the specific domains are related (see Introduction). This strategy for reliability was applied to both the knowledge and confidence measures. These knowledge domain-total correlations are analogous to item-total correlations and should, therefore, be significant with a value of 0.2 or greater (Kline, 1986).

External reliability (test-retest) was not assessed, for two reasons. First, for ethical reasons, all respondents had to be debriefed immediately after completing the knowledge measure and were given the correct answers to the questions. Second, a great many respondents indicated, in positive answers to a free-response question—"Did you find completing the questionnaire beneficial in anyway?"—that they would go and look up more information on HIV/AIDS. It is highly likely, therefore, that taking a second measurement would lead to low test-retest reliabilities because knowledge would have increased.

Discriminant validity. To assess the discriminant validity of the measure, multivariate analysis of variance (MANOVA) was used. This was necessary as multiple dependent variables were to be analysed simultaneously (Bray & Maxwell, 1985). For each domain, total scores were calculated prior to analysis and corrected for chance using Kline's (1986) correction formula. These chance corrected scores were then standardized to percentages of their maxima. *Post hoc* comparisons were used to test for significant differences between groups.

Calibration: under-, over-confidence and accuracy. Calibration coefficients, as defined by Arkes *et al.* (1987), were calculated. These are non-standardized coefficients and indicate the degree of under-confidence, over-confidence or perfect calibration. If a group is on average perfectly calibrated (i.e. know what they know), this coefficient is zero. Over-confidence is indicated by a + ve sign and under-confidence by a − ve sign.

Results

The results are presented in four sections. The first presents data on the internal psychometric properties and reliability of the knowledge measure, while the second provides an examination of the validity of the measure. The third section examines the data for the individual knowledge questions and the final section examines the calibration data.

Section 1: Reliability: psychometrics of the HIV/AIDS knowledge measure

Table 1 presents the internal psychometric properties of the knowledge measure. This analysis was based on the data from the combined samples ($n = 257$). All the alpha coefficients and the knowledge domain-total correlations for the confidence measures were acceptable. As predicted, the KR-20s were low, but each domain correlated significantly with the total knowledge score minus that domain. It is concluded, therefore, that the knowledge measure is internally reliable.

Section 2: Validity

The initial inter-group comparisons for knowledge and confidence were based on the total scores. This type of analysis is consistent with that carried out by previous researchers. The analyses were performed using two one-way between groups MANOVAs at four levels.

Table 1. *Coefficient alphas and KR-20s for the seven domains of knowledge and an overall knowledge score*

	Absolute Knowledge		Confidence in Knowledge	
Scale	KR-20	Domain-total correlation	Alpha	Domain-total correlation
Unidimensional Scale	0.75		0.95	
Symptomatology	0.41	0.53*	0.85	0.88*
Virology	0.46	0.52*	0.75	0.80*
Immunology	0.18	0.41*	0.73	0.88*
Epidemiology	0.08	0.26*	0.78	0.79*
Treatments	0.33	0.53*	0.79	0.86*
Personal risk	0.18	0.40*	0.76	0.87*
Procedures	0.37	0.50*	0.80	0.72*

* $p < 0.001$.

Results indicated significant differences between groups on their total knowledge scores ($F(3,246) = 154.15$, $p < 0.001$, $MS_{error} = 9.65$; $eta^2 = 0.65$) and their total confidence scores ($F(3,246) = 99.43$, $p < 0.001$, $MS_{error} = 118577.63$; $eta^2 = 0.55$). *Post hoc* comparison with Tukey HSDs indicated a trend such that final year medical students scored significantly higher on both measures (knowledge and confidence) than the third year medical students who in turn scored significantly higher than the student nurses, who in turn scored significantly higher than the non-medical undergraduates. To assess which of the seven domains accounted for these effects, a mixed design MANOVA was used. Separate analyses for the knowledge and confidence data were performed.

The results of the two analyses are presented graphically in Figures 1 and 2. Considering the knowledge data first, there was a significant effect for subject group ($F(3,253) = 151.99$, $p < 0.001$, $MS_{error} = 938.37$, $eta^2 = 0.65$), a significant effect for the domain of knowledge ($F(6,1518) = 8.89$, $p < 0.001$, $MS_{error} = 625.09$, $eta^2 = 0.034$), qualified by a significant interaction between subject group and domain of knowledge ($F(18,1518) = 11.42$, $p < 0.001$, $MS_{error} = 625.09$, $eta^2 = 0.12$). Similarly, analysis of the confidence data indicated a significant main effect for subject group ($F(3,246) = 97.94$, $p < 0.001$, $MS_{error} = 634.54$, $eta^2 = 0.54$), a significant main effect for the domain of knowledge ($F6,1476) = 113.4$, $p < 0.001$, $MS_{error} = 60.67$, $eta^2 = 0.32$), qualified by a significant interaction between subject group and domain of knowledge ($F(18,1476) = 18.09$, $p < 0.001$, $MS_{error} = 60.67$, $eta^2 = 0.18$).

To aid interpretation of both the knowledge and confidence graphs (Figures 1 and 2), any means that differ in value by 4.31 or more between the four groups indicate a significant difference between the groups. So, for example, if knowledge of symptomatology is considered, the following picture emerges (see Figure 1). Final year medical students were significantly more knowledgeable than the other three groups about symptomatology. Third year medical students were more knowledgeable about symptomatology than student nurses who in turn were more knowledgeable than non-medical undergraduates. For knowledge about treatments, all groups were significantly different from each other with the final year medical students scoring the highest score, followed by the third year medical students, the student nurses and finally the non-medical undergraduates. In terms of confidence in their knowledge about symptomatology, all groups were significantly different from each other, with final year medical students showing the highest confidence, followed by third year medical students, student nurses and finally non-medical undergraduates.

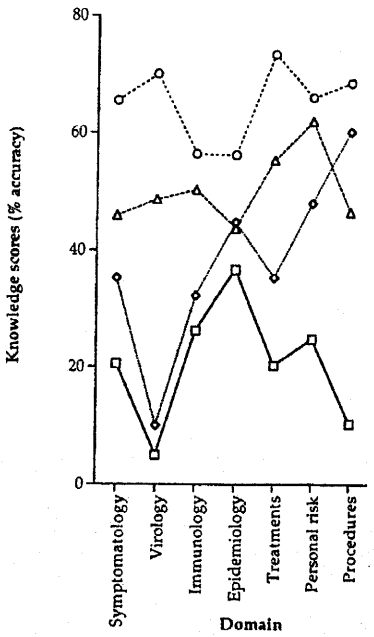

FIG. 1. *Percentage accuracy scores for the seven domains of HIV/AIDS knowledge as a function of study group (○ final year medical students; △ 3rd year medical students; ◇ student nurses; □ non-medical undergraduates).*

Section 3: Analysis of individual questions

To test for systematic group differences for each question, analyses of the data for each knowledge question were conducted. Appendix 1 presents these results. It can be seen that for most questions there is a significant effect of group. In general this trend indicated that percentage accuracy again increases from non-medical undergraduates, through student nurses to third year medical students and then to final year medical students.

Section 4: Calibration: confidence in knowledge

The results examining the degree of calibration are presented in Table 2.

Of the 32 mean calibration coefficients reported in Table 2, 81.25% were in the direction of under-confidence. All of the coefficients, however, were close to zero (perfect calibration). Over-confidence occurred six times, for the following domains and groups: (a) knowledge about procedures for both final year medical students and non-medical undergraduates, (b) knowledge about epidemiology for both third and final year medical students, and (c) knowledge about virology for both non-medical undergraduates and student nurses.

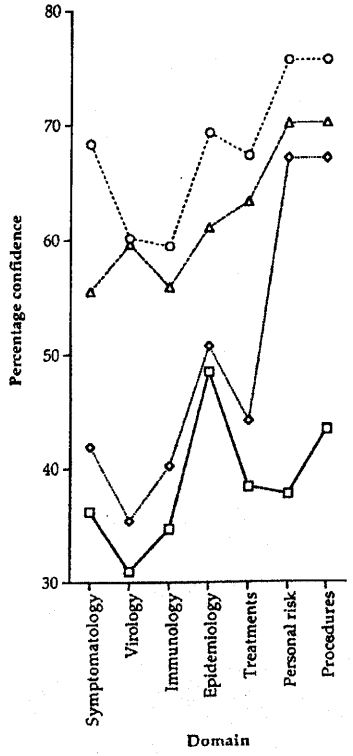

FIG. 2. *Percentage confidence scores for the seven domains of HIV/AIDS knowledge as a function of study group (○ final year medical students; △ 3rd year medical students; ◇ student nurses; □ non-medical undergraduates).*

To identify significant effects between the four study groups, a series of one way between groups analyses of variance (ANOVA) were applied to the mean calibration coefficients for each domain. This indicated that for four of the knowledge domains (virology, epidemiology, treatments and procedures), and for the total knowledge score, there were significant differences in the degree of calibration between groups. Tukey HSDs were applied to these data to examine exactly where the differences lay. For knowledge about virology, the analysis showed that third year medical students were more under-confident than the other three groups. The remaining three groups did not differ significantly from each other. Both student nurses and non-medical undergraduates appeared over-confident and final year medical students appeared under-confident. For knowledge about epidemiology, the results showed that both non-medical undergraduates and student nurses were more under-confident than third and final year medical students who tended towards over-confidence. In terms of treatments, non-medical undergraduates were less under-confident than the other three

Table 2. *The mean calibration coefficients for the four study groups (UG = non-medical undergraduate psychologists, Nurses = nursing students, 3rd yr Medics = third year medical students and Final yr Medics = final year medical students) by the seven domains of knowledge about HIV/AIDS (plus an overall total knowledge score)*

Scale	UG	Nurses	3rd year Medics	Final year Medics	F
Symptomatology	−0.0453	−0.0993	−0.0576	−0.0503	1.9
Virology	+0.0200	+0.0242	−0.1732	−0.0339	11.1**
Immunology	−0.1053	−0.0936	−0.0794	−0.0764	0.18
Epidemiology	−0.0444	−0.0869	+0.0194	+0.0230	3.8**
Treatments	−0.0233	−0.0776	−0.1254	−0.0441	2.5*
Personal risk	−0.0610	−0.1535	−0.0686	−0.1036	2.3
Procedures	+0.1053	−0.0311	−0.0076	+0.0954	6.2**
Total scale	−0.0215	−0.0667	−0.0718	−0.0227	3.4*

− ve = under-confident and + ve = over-confident.
** $p < 0.01$, * $p < 0.05$.

groups. With regard to knowledge about procedures for dealing with HIV/AIDS in the health care setting, the pattern of differences was almost identical to that for treatments. However, student nurses and third year medical students tended to under-confidence while the final year medical students tended to over-confidence. When total HIV/AIDS knowledge was considered, the pattern of differences seen for treatments, personal risk and procedures was again repeated: student nurses, third and final year medical students were significantly more under-confident in their total knowledge of HIV/AIDS than the non-medical undergraduates. It seems therefore that with aspects of knowledge which relate directly to health care work (treatments and procedures) expert groups (student nurses, third and final year medical students) are, on the whole, significantly more under-confident than non-medical undergraduates.

Discussion

This paper has provided data on the development of a measure of knowledge of HIV/AIDS which covers seven domains of relevant information. The reliability of the measure has been demonstrated. The validity of the measure has also been demonstrated to the extent that the seven domains of knowledge discriminate between groups believed to vary in their level of knowledge of HIV/AIDS.

The measure reported here does not suffer any of the criticisms levelled at previous measures. In particular, it measures knowledge across several domains, has acceptable reliability and validity, controls for guessing and covers a breadth of item difficulty in its questions. In addition, unlike other measures currently used in this area, it assesses respondents' confidence in the knowledge that they have. This extends the range of uses to which such an instrument may be applied. For example, in terms of outcome variables such as anxiety about nursing HIV/AIDS patients, attitudes to HIV/AIDS patients and quality of care of HIV/AIDS patients, this instrument makes it possible to ask whether it is actual knowledge in any particular domain, confidence in that knowledge or the relationship between what people know and what they think they know (calibration) that relates to these outcomes.

Examination of the results in more detail indicates that, for the seven domains of knowledge, there is a trend such that final year medical students are more knowledgeable and more confident than third year medical students who, in turn, are more knowledgeable and confident than student nurses who are more knowledgeable and confident than non-medical

undergraduates. However, for specific domains of knowledge this was not always the case. For example, when knowledge about immunology is considered, both third year and final year medical students appeared to know more than student nurses and non-medical undergraduates. This pattern was almost identical for confidence in knowledge about immunology except that student nurses were more confident than non-medical undergraduates. Thus in a domain of HIV/AIDS related knowledge—immunology—for which student nurses and non-medical undergraduates receive little or no training, but for which medical students receive a significant amount of training, the knowledge scores differ between the groups in the manner expected. For knowledge about procedures, an area in which all expert groups receive training but non-medical undergraduates do not, there is convergence of the scores of the expert groups and divergence between the scores of the expert groups and the non-medical undergraduate (non-expert) group. Considering individual knowledge questions, the general trend was the same with final year medical students being most knowledgeable.

At one level, these findings may be seen as trivial (those that should be more knowledgeable are). However, given that other studies have failed to show the knowledge measures differentiate between expert and non-expert groups, these findings are an important argument for the validity of this measure (see Mannetti & Pierro, 1991). In addition, this measure distinguishes, in a meaningful way, between experts working in different areas of health care and between those at different stages in their training.

Calibration

The pattern of results relating to the calibration data showed that 81.25% of the assessments were in the direction of *under-confidence*. This is surprising, given that the predominant effect reported in the literature is towards over-confidence (Keren, 1991). However, previous studies of calibration have tended to make their examinations in relation to general knowledge (e.g. What is the capital of Norway?). The type of knowledge assessed in this study differs from such general knowledge and the findings of this study easily fit within a simple framework for explaining under-confidence. The knowledge assessed is technical and personally relevant and relates to an anxiety provoking subject. This combination leads to caution. Those involved do not want to be over-confident in an area which has such high potential for personal risk (see Ferguson, Farnsworth, Cox, Twardzicki & Leiter, 1993; Ferguson, Farnsworth, Cox & Cox, 1993). This argument is reflected in the detail of the findings. That is, for aspects of knowledge which relate directly to health care practice (treatments, procedures and total HIV/AIDS knowledge), the more expert groups were, on the whole, more under-confident than the non-expert group. Given the anxiety engendered by HIV/AIDS, the more expert groups adopt a more cautious approach. An alternative explanation for the over-confidence effect in the literature relates to the stability of general knowledge compared to knowledge about HIV/AIDS. Most general knowledge questions assess fairly stable aspects of knowledge which are not likely to change in the near future (e.g. What is the capital of Norway?). Knowledge associated with HIV/AIDS, however, is not so stable. It may be seen as being in a state of flux, because of new discoveries and because of different experts expressing slightly contradictory positions. Simple awareness of this instability may lead to under-confidence by subjects being cautious about knowledge which is not in a state of surety (see Ferguson, Onwumere, Leonard & Bremner, 1994).

Implications for teaching health care workers

The findings presented in this paper have a number of implications for the training that

HCWs receive. None of the groups in this study demonstrated complete accuracy in knowledge for any of the domains, although for certain individual questions, all members of a given group answered correctly. This suggests that improvements in knowledge can be made. As already mentioned, HCWs indicate that they are anxious because they feel they do not have an adequate level of knowledge to explain to patients and patients' relatives what is happening during the disease processes associated with HIV infection (Bond *et al.*, 1988). Consistent with this, the results indicate that, compared to medical students' knowledge, student nurses' knowledge of both immunology and virology was low. Other research suggests that a number of these domains of knowledge are in fact related to both general anxiety about HIV/AIDS and nursing specific HIV/AIDS anxiety (Ferguson, Farnsworth, Cox, Twardzicki & Leiter, 1993). Both of these domains of knowledge are central to explanations of the HIV disease process and are therefore relevant to interactions with patients and relatives. Nurse training in these areas should, therefore, be reviewed and this may well reduce some of the anxiety that nurses express about HIV/AIDS.

Reductions in HCWs' anxiety may be important, not only because anxiety is itself an undesirable occupational health outcome, but also because inflated levels of anxiety may have negative consequences for safe working practice (Eysenck, 1986). Successful training programmes will be those which recognize the complex nature of the relationships between knowledge, anxiety, safe working practices and the quality of patient care. However, it must be emphasized that the exact relationship between anxiety and performance is far from clear and caution must be exercised in this respect in recommending programmes to eradicate anxiety. It may be that an inverted U-shape relationship exists between anxiety and performance, indicating that both too little and too much anxiety are likely to lead to more error prone performance. With too little anxiety, vigilance may be reduced and errors of omission may occur. With too much anxiety, panic may ensue resulting in errors of commission. The problem for research here is to know what exactly constitutes a 'healthy' and useful level of anxiety. However, this should not directly detract from the provision of more detailed knowledge on all aspect of HIV/AIDS for all categories of health care workers.

Measurement of HIV/AIDS knowledge: a final note

The results of this study show that knowledge about HIV/AIDS can, and should, be assessed in a multi-dimensional way but with the assumption of a single underpinning dimension of knowledge. The measure developed here is one which is specifically designed for HCWs; however, similar types of device may be developed for use with other populations.

Additionally, it must be noted that knowledge in the area of HIV/AIDS, as with any area, is constantly in a state of flux. The questions used in this measure were designed in such a way as to ground them with a particular term of reference (e.g. a specific year) and, to this extent, they should always be accurate. However, updated information will inevitably become available and so alterations may need to be made. This will be the case especially in areas such as treatments and epidemiology. Finally, it must be noted that the psychometric approach adopted here is only one approach to assessing knowledge. Free recall interviews, protocol analysis, laddering, cognitive mapping and other knowledge elicitation procedures are equally valid and useful approaches (Ferguson, Dodds, Craig, Flannigan & Yates, 1994).

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