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Diagnostic and treatment decision making in community nurses faced with a patient with possible venous leg ulceration: a signal detection analysis

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Keywords

Clinical decision making, clinical judgement, signal detection, tissue viability, venous leg ulcers, wound care.

What is already known about the topic?

- Caring for patients with leg ulcers is a significant part of many community nurses' workloads. Despite being faced with uncertainty, nurses must still make the judgements and decisions that determine the care and treatment received. Some nurses are employed as experts in the area and undertake the role of "Tissue Viability Specialist" - or one of its synonyms/variants.
- The care and management of this group of patients varies and some of this variation may be due to nurses' clinical judgements and decisions.
- Evidence based guidance on treatment and management for patients with venous leg ulcers exists. Nurses' clinical judgements and decisions are one of the mechanisms by which this guidance is enacted in clinical practice.

What this paper adds?

- This is the first signal detection analysis of the judgements and decisions of community nurses caring for people with venous leg ulcers.
- Whilst specialist tissue viability nurses were more likely to correctly identify and treat a patient with venous leg ulceration, their abilities varied as much as a generalist group of nurses.
- The study reveals that variation in clinical practice may be partly due to differences in nurses' receptiveness to clinical information and their propensity to diagnose and treat venous leg ulceration in patients.

Abstract

Background

Judgements and decisions about venous leg ulcer management are characterised by uncertainty. Good judgements and reduced variations in practice require nurses to identify relevant "signals" in clinical encounters. Nurses, even experienced ones, vary in their ability to separate these signals from surrounding noise.

Objectives

Examine specialist and generalist nurses' discrimination of clinical signals and noise when i) diagnosing venous versus other causes leg ulceration, and ii) starting multilayer compression therapy.

Design

A signal detection analysis within a cross sectional survey.

Settings

Four English NHS districts.

Participants

Tissue viability specialist (n=18) and generalist (district and practice nurses, n=18) sampled from networks of nurses caring for people with leg ulcers. Mean age was 46 years, 78% had more than 10 years nursing experience. They worked on average 32.5 hours per week, of which 10 hours were spent caring for people with leg ulcers.

Methods

110 clinical scenarios based on anonymous patient data from a large clinical trial of compression therapy for leg ulceration. The scenarios were classed as either signal (venous leg ulcer present and/or compression therapy warranted, n=57) or no signal cases (other kind of ulcer and/or compression therapy contraindicated, n=53) by four experts. Nurses made diagnostic and treatment judgements for each scenario. A signal detection analysis was undertaken for each

nurse. Measures of signal detection (d prime or d′) and judgement tendency or bias (C) were computed. Differences between specialist and generalist nurses were tested for using the Mann Whitney U test and graphically explored using Receiver Operating Curves (ROC).

Results

Specialists identified more true positive cases than the generalist nurses: 75% vs. 59% for the diagnostic judgement ($p<0.01$) and 70% vs. 60% for the treatment judgement. They were significantly more sensitive to the signals present (d′ 1.68 vs 1.08 for the diagnostic judgement and 1.62 vs. 1.11 for the treatment judgement). Specialists exhibited a significantly higher bias towards initiating treatment (C = .81 vs. .56, $p<0.01$) but this did not extend to their diagnostic judgements. Specialists also varied slightly less in their signal detection abilities.

Conclusions

Nurse specialism was associated with better, but still variable, clinical diagnostic and treatment signal detection in simulated venous leg ulcer management.

Background

With between 0.6% and 3.6% of adults developing a leg ulcer in their lifetime, caring for patients with leg ulcers is a significant component of community nurses' workloads. (1, 2) Leg ulceration is also expensive: the UK NHS spends between £168-£600 million (at least) on care and treatment in this group of patients.(2, 3) These societal burdens are mirrored in the individual burden experienced by patients. Pain, diminished mobility and self-image, smell and fatigue are all experienced by patients with leg ulcers. Venous insufficiency is the most common cause of chronic leg ulceration.(4)

Good quality evidence exists to guide clinical practice in some aspects of caring for people with venous leg ulcers. To aid diagnosis, the use of Doppler technology to measure the ankle brachial pressure index (ABPI) and identify arterial insufficiency is well established.(5) For promoting healing, the use of multi-layer high compression and pentoxifylline as an adjuvant therapy to compression are also evidence-based strategies. (6, 7) Many aspects of caring for patients with leg ulcers do not have systematic reviews and randomised controlled trials available to inform practice. Even where these exist, the evidence is often of too poor quality to be relied upon; an example being choosing which dressing to put onto a venous leg ulcer. (8-10) The care of patients with leg ulcers varies widely from high quality and evidence based to suboptimal.(11-14)

Nurses are the healthcare professionals often charged with diagnosing, treating, and managing a person with a venous leg ulcer.(15) Meeting this responsibility requires nurses to use their judgement to weigh up the information within the clinical environments and make choices that maximise the chances of healing and improved quality of life. This is not straightforward. Nurses must collect, synthesise and make sense of multiple sources of information: a patient's medical history, biography, social circumstances, clinical signs and symptoms, whilst being mindful of the patient's preferences. Nurses use their clinical, experiential, and academic knowledge and their previous experience to make sense of the information they are confronted with. They use a variety of modes of reasoning and cognitive shortcuts (heuristics) to process this information. (16) The information available to nurses will be of variable quality and so will contribute varying amounts to the accuracy of judgements and the success of decisions.(17) As a decision maker in

this complex clinical environment the nurse's key function is to separate valuable information (the signal) from the less valuable (noise). Some nurses will be better than others at separating signals from noise. This variation in the ability to handle uncertainty, or the ratio of signal to noise in wound care, is an important determinant of unwarranted variations in practice.(18)

Perhaps because of the challenges involved in the care of patients with leg ulceration, nursing has developed the specialism of tissue viability and roles such as tissue viability specialist as part of the multidisciplinary team (MDT). Given the title, their role in the MDT, and specialist status, it is not unreasonable to assume that these nurses are better at discriminating signals from noise when caring for patients. Research suggests that this assumption may be misguided. When claims in favour of specialism are adjusted for the quality of the research underpinning such claims the universally positive impacts assumed to accompany specialism becomes less sustainable.(19, 20) Specialism comes at a cost in healthcare systems, but the costs associated with the tissue viability specialist workforce are not available so exploring TVN value is unknown. (21-23) However, if the judgements and decisions of specialist nurses are no better than cheaper generalists then scarce financial and human resources may be better spent elsewhere in the system.

Research questions

In this paper we aim to examine wound care nurses' diagnostic and treatment judgements by examining their abilities to separate a clinical signal from clinical noise. To achieve this aim we ask, "What is the variation in the ability within and between specialist and generalist nurses to discriminate between a signal and noise when i) diagnosing venous versus other cause leg ulceration, and ii) determining whether starting multilayer compression therapy is warranted?"

Theoretical framework

Signal Detection Theory (SDT) provides the framework for our analysis. (24) SDT has been applied to many areas of judgement and decision making since its initial application to communication and psychology.(25, 26) In nursing, SDT has been used to examine critical event risk assessment and the impact of enhanced realism in clinical simulation education.(27, 28)

To understand signal detection theory, consider a healthcare professional judging the likelihood of a venous leg ulcer in a patient. Each patient either has a venous leg ulcer or they do not. This true (but unknown) state can only be estimated (judged) by the nurse. Thus, there are four possible outcomes associated with the judgement (see table 1):

[Place table 1 here]

As Table 1 illustrates, judgments in which a nurse correctly indicates an ulcer is of the venous type and in truth the ulcer really is a venous leg ulcer can be termed a hit or true positive. Judging that a patient's ulcer is a venous leg ulcer, when in truth it is not, represents a false alarm or false positive. Thus, for this yes/no (VLU present/not) task, judgement performance is a function of hit rates and false alarm rates. Hit rates represent the probability of correctly recognising a venous leg ulcer and the need for evidence based treatment. False alarm rates represent the probability of incorrectly classifying an ulcer as venous when in truth it is not and incorrectly judging the need for evidence based treatment. A good clinical judge uses cognitive and other strategies to maximise hit rates and minimise false alarm rates. (25)

In SDT, where a nurse makes judgements on patients who have a VLU, then these are termed signal cases/trials. Conversely, judgements on patients who do not have a venous leg ulcer represent noise or no signal trials. The problem is that the true state of each patient is unknown by the nurse. The nurse can only use the imperfect information they have at their disposal to reach a judgement. When making such judgements individuals draw on internalised rules or heuristics.(25) Each person has their own unique rules, but common examples include, "don't act when something doesn't look quite right" or, "err on the side of caution when uncertain".(29) Multiple judgments, comprising both signal and noise trials, will contain varying amounts of useful and less useful information. Nurses with good clinical judgement are able to employ their internalised rules to effectively separate noise from a signal. Thus, over multiple signal trials there will be a distribution of hit and false alarm rates and an equivalent distribution for noise

trials. Figure 1 shows how signal and noise distributions arise in multiple cases of the same kind of judgment.

[Place Figure 1 about here]

Two important concepts are also illustrated in figure 1. Firstly, each nurse will have a tendency towards classifying patients as having a VLU or another type of ulcer. For the treatment judgement, this tendency will be towards whether compression therapy is warranted or not. C is the distance between the decision criterion and the neutral point at which neither a signal or noise response is favoured (C= zero at this point). The degree of deviation from this neutral point is measured in standard deviation units. Accordingly, a positive C indicates a tendency towards "venous leg ulcer" or "start compression" and negative values of C indicate a tendency toward classifying ulcers as "other than venous" and towards "reduced/no compression".

Each nurse's judgements will have their own unique signal and noise distributions, and these will overlap. A greater overlap represents less ability to separate signals from noise. This overlap is termed d prime or d′. A d′ prime of zero indicates that a nurse cannot distinguish signals from noise; the greater the value of d′ the better the nurse's ability to distinguish signals from noise.

Design

A yes/no signal detection design comparing generalist community nurse judgements with tissue viability specialists' judgements. (24, 25)

Methods

Nurses working in community settings in one primary care trust (PCT) in the north of England and tissue viability specialist nurses in four PCTs in northern and southern England were invited to take part via e mail and letter during 2011-12. A non-random sample of 18 generalist community nurses and 18 tissue viability specialist nurses (n=36) were shown 110 clinical scenarios (see appendix A) in which they were asked to judge whether the clinical information contained in the scenario was suggestive of i) either a venous leg ulcer or some other kind of ulcer? And ii) the type of compression therapy (if any) they would recommend. The sample of

36 nurses had at least 90% power to detect a clinically significant 20% difference between experts' and generalists' abilities to correctly diagnose a venous leg ulcer with an alpha of 0.05. (30)

The number of scenarios (n=110) was based on the formula provide by Stewart for producing stable standard errors. (31) An online survey package (www.surveymonkey.com) was used to present the scenarios and to collect the data. Each scenario consisted of a written vignette and a photographic image of a wound (see Appendix A).

The information in each scenario was based on cues relevant for diagnosing and treating venous leg ulcers.(32-44):

- Patient age
- Patient gender
- Medical History
- Position of the ulcer
- Appearance of the lower limb
- Level of pain (indicated by a pain score)
- ABPI reading
- Diagnosis (this cue generated by the nurse participant as their first judgement)
- Signs of infection
- Exudate levels
- Patient preferences about compression therapy

The signal

Records of patients with venous or mixed leg ulceration were randomly sampled from a clinical trial of compression therapy for leg ulceration (VENUS 2). Non-random sampling was used to select arterial and unusual aetiology ulcers from the clinical records of consenting patients. The aetiological proportions of the samples mirrored the prevalence of venous, arterial or mixed aetiology leg ulcers in the UK population. (13, 14)

To establish whether each scenario warranted a diagnosis of venous leg ulceration or some other aetiology, and the need for compression therapy, four experts who each had a minimum of two years' experience in tissue viability specialist nursing and venous leg ulcer research were each shown the scenarios using the same online method as the participants. A consensus panel meeting was then convened and the panel were presented with each scenario in turn and informed of the range of their individual answers. The panel then discussed each scenario and agreed a group answer for each question. The group was able to reach agreement for each question. Of the 110 scenarios, the specialist panel deemed 57 indicated a venous leg ulcer and 54 warranted compression therapy – these were the "signal" trials. Accordingly, there were 53 "no signal" trials for the diagnostic judgement and 56 for the treatment judgment.

Analysis

Data were analysed as a yes/no signal detection task.(25) Hits and false alarms were calculated for the diagnostic and treatment judgement for each nurse for each scenario. Hit (H) and false alarm (F) rates for each judgement were calculated for each nurse. H was found by dividing the hits for each novice by the number of signal trials. F was calculated by dividing the number of false alarms by the total number of noise trials. Z scores for H and F and signal detection measures (d′ and C) were computed using appropriate formulae.(25) Assumptions of normality were checked using the Shapiro-Wilk test. The Mann-Whitney U test of significance was used for testing the hypothesis that TVNs and generalists differed in their signal detection abilities. All analysis was undertaken in SPSS version 21.

In order to graphically represent signal detection ability in the two groups receiver operating curves (ROC curves) were calculated for each group and the area under the curve (AUC) for each group computed using the ROC procedure in SPSS version 21 and SDT visualizer software (available from http://code.google.com/p/sdt-metrics/downloads/list). The state variable was signal or noise status of each scenario for each judgement and the test variable was the judgement of the nurses in the two groups. As well as its intuitive graphical interpretation, AUC is interpreted as the probability that a randomly selected patient with a venous leg ulcer has a judgement indicating greater likelihood than a that for a randomly chosen patient from the non-VLU group.(45)

Ethical approval was provided by the University of York's Health Research Ethics and Governance Committee and Local Research Ethics and Research Governance Committees in Yorkshire and Sussex, UK.

Results

36 community nurses completed the judgement task, of whom nine worked in district nursing teams, nine in general practice nursing teams and 18 were community tissue viability specialist nurses. The nurses had a mean age of 46 years (sd = 8), all were female and 78% had more than 10 years nursing experience. On average they worked 32.5 hours per week (sd=7), spending 10 hours per week (sd = 8) on leg ulcer care. Thirty three percent of the nurses had a degree or post graduate qualification, in 19% of nurses this qualification related to leg ulceration specifically. A third of nurses were nurse prescribers and 95% described themselves as specialist or senior nurses.

Table 2 presents the hit and false alarm rates, d′, C and the AUC for Tissue Viability and generalist nurses in the study.

[table 2 here]

Figures 2 and 3 show the ROC curves for the two groups of nurses. For both the diagnostic and intervention judgements the Tissue Viability Nurses had a higher AUC. The 95% confidence intervals for the diagnostic AUC were 65.7 to 70.5 (generalists) and 75.9 to 80.1 (specialists) and for the intervention AUC 66.8 to 71.5 (generalists) and 74.4 to 78.7 (specialists). Thus, the differences were statistically significant.

Discussion

The d′ values of the tissue viability nurses in the study show they had a greater ability than generalist community nurses to identify when a simulated patient had a venous leg ulcer and when the evidence-based treatment of compression therapy was warranted. The values of C show

that TVNs also had a bias toward favouring compression therapy. The net result of these differences in signal detection abilities was a 10% greater probability of correctly identifying a patient with a VLE and a 7% higher probability for correctly judging the need for compression therapy. It is important to recognise that what constitutes a "good" AUC is context specific. In this study, context includes the uncertainty associated with the judgement task and the costs of false positives/alarms and the benefits of true positives/hits. The curves for both groups suggest that both TVNs and generalists seem willing to set judgement criteria that risk false positives in order to maximise the chances of correctly identifying the ulcer and the need for compression.

The standard deviations for the two group's measures of signal detection ability (d′) show wide variation within the two groups. D prime is a function of the standardized hit and false alarm rates and table 2 shows that most of the variability in d′ can be attributed to variability in the groups' ability to identify true positives/hits in the scenarios. Despite the tissue viability nurses all having job titles implying specialist expertise, and all making judgements based on the same information and presented in the same ways, they varied almost as much as the non-specialists. Notably however the variability was lower, and the distribution of hits skewed towards higher performance amongst TVNs in the diagnostic judgement task. TVNs were closer in performance terms to the experts used to define the signal and noise trials in the study.

Tissue viability, as a specialism, is generally perceived as good for patients, the NHS, and the profession of nursing.(46) Bold claims have been made about the cost reductions and improvements in quality that can result from developing tissue viability services. For example, in relation to pressure ulcers it has been claimed that developing tissue viability services reduce hospital admissions by 50% whilst also saving £59,100 in a single six month period.(47) Such claims are rarely the result of comparative research with a contemporaneous control group.

At the core of why specialist services are better, and conversely why unwarranted variations in practice occur, is the issue of clinical judgement.(18, 46) Benbow, in a paper arguing for TVNs to develop their leadership and accountability skills, argues that nurses should not over-rely on protocols and guidelines at the expense of clinical judgement.(46) One of the main drivers for the flourishing of clinical guidelines in healthcare were the unacceptable variations in healthcare

practice associated with unaided clinical judgement.(18, 48) The analysis we present in this paper shows that there are indeed benefits associated with TVNs: they were better at diagnosing a condition that costs the NHS significant amounts of money and also at judging when evidence-based treatment is necessary. However, this average effect downplays the fact that nurses varied. The title "Tissue Viability Nurse" did not guarantee good signal detection ability. Table 2 suggests that there is still scope to improve the abilities of, and reduce the variability between, TVNs to correctly identify true positive cases.

Our analysis has a number of limitations. One of the most significant is our use of experts to determine which of the 110 simulated cases shown to the nurses carried a signal of VLU and/or the need for compression therapy. Our use of formal consensus methods to gather their opinion was only a partial defence against social group biases such as groupthink (49) or social polarisation (50). We considered using the actual diagnoses and treatments noted in medical records, on the basis that these labels represent reliable and internally valid measures of the strength of the underlying signal.(51) However, diagnoses and treatment decisions noted in medical records are themselves the function of clinical experts. Thus, they are prone to the same biases and flaws as raw expert opinion. Ermec, for example, has reported how unreliable recorded medical diagnosis can be, even at the point of death. (52) The signal detection analysis reported here was nested in a broader study of decision making and judgement undertaken using a social judgement analytic (53) framework. Social judgement studies require information presentation and relationships between cues and cues and outcomes to be representative of the environment they relate to.(53, 54) In the absence of a wholly reliable measure, we chose to represent the reality that in actual clinical practice the correct diagnosis and treatment is often the result of clinical team discussion and consensus.

Whilst we sampled enough nurses to identify clinically significant differences the generalist nurses were all from a single geographical region in the United Kingdom. North Yorkshire is a diverse health economy serving some 3 million people with a wide range of community health services but it is possible that nurses from a different service and geographical contexts would produce a different picture. We cannot be certain that our sample of nurses is representative of all tissue viability or community generalist nurses.

The study is novel. It is one of only a few studies that have looked explicitly at cognition, judgement and decision making in wound care and amongst wound care nurses. With some notable exceptions, most studies focus on styles of reasoning (40, 55, 56), few examine what happens at the cognitive level of information synthesis.(57)

Because being competent and offering value-for-money is a key goal for many healthcare professionals (46) our use of self-reported measures was subject to a social desirability bias. We mitigated this potential bias by explicitly requiring nurses to make a judgement in response to stimuli rather than report, "what they would have done" in an abstract sense. Ideally, we would have liked to present real patients to nurses and model signal detection based on actual clinical practice. However, this was not feasible on methodological grounds, as we could not control the consistency of signal presentation. It would also have been impractical.

Modelling judgement ability using signal detection approaches allows the researcher to predict the likelihood of a nurse identifying a signal: the area under the curve (AUC) for each nurse. In theory, it is possible to validate each nurse's judgement model by examining the judgements recorded in their patient's records for hits and false alarms. Such activity could be a useful clinical audit activity for nursing teams keen to foster improved judgement and better calibration between perceived and actual performance in team members.

We used real cases from a large clinical trial as the basis for developing scenarios. This meant that not only was the data of high quality but that value was added to the trial dataset by using it in another context. As with many clinical trials however, it is likely that people who were older than 65 and with multiple comorbidities were most likely under-represented.(58)

Some may question virtue of exploring judgement alone when a pragmatic clinical trial of specialist nurse led services versus alternatives would reveal whether they result in improved diagnostic accuracy and treatment outcomes. Such a trial would need to be sufficiently large and would be expensive to undertake. Moreover, a better understanding of judgement as the primary mechanism by which care is determined is more likely to reveal how, as well as why, specialist

nurse led care represents an improvement.

Claims of improved quality and reduced cost are at the core of efforts to secure tissue viability as a nurse-led specialism in a post-austerity NHS.(59) This study has shown that for two of the key judgements that might drive such improvements, such claims could be warranted and should be explored further. What our analysis has not shown is whether any apparent improvements in recognition of diagnostic and treatment signals are worth the costs of employing and developing tissue viability nurses. At its crudest, the TVNs in our sample were 10% more likely to correctly identify a venous leg ulcer in line with expert opinion. We did not undertake an economic analysis of how expensive a TVN is compared with a generalist community nurse. This is a question that other researchers may wish to pursue.

Conclusion

Correct diagnosis and treatment judgement are important for optimising patients' quality of life and minimising the costs of care to both patients and health care commissioners and providers. Misdiagnosis of venous leg ulceration is likely to lead to sub-optimal care such as failure to apply adequate compression, extended periods of open ulceration, increased pain and less chance of achieving healing. Trial data suggests that 70% of patients with uncomplicated venous leg ulceration who receive high compression therapy will heal within six months (60, 62). Patients who do not receive this treatment will be unlikely to heal but will still require similar (if not greater) levels of nursing time and dressings. Greater involvement of tissue viability nurses in diagnosing venous leg ulcers and guiding treatment choices may on average be associated with better clinical care but the extent to which this policy would be cost-effective remains untested.

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Table 1: the four possible outcomes from a "yes/no" diagnostic signal detection tasks

		True state of patient: VLU	True state of patient: No VLU
Nurses' judgement of whether VLU present or not	VLU	True positive **HIT** Correct judgement	False positive **FALSE ALARM** Incorrect judgement
	NO VLU	False negative **MISS** Incorrect judgement	True negative **CORRECT REJECTION** Correct judgement

Table 2: Signal Detection Measures for tissue viability and generalist community nurses for diagnostic and need for intervention judgement tasks.

	Hit Rate		False Alarm Rate		C		d'		AUC	
	Dx (*SD*)	Rx (*SD*)	Dx (*SD*)	Rx (*SD*)	Dx (*SD*)	Rx (*SD*)	Dx (*SD*)	Rx (*SD*)	Dx (95% CI)	Rx (95% CI)
TVN	.75 (.14)**	.70 (.03)	.19 (.10)	.17 (.02)	.09 (.35)	.81 (.21)**	1.68 (.45) **	1.62 (.41)**	.78 (.75 – .80)*	.76 (.74 - .78)*
Gen	.59 (.19)**	.60 (.16)	.23 (.11)	.22 (.04)	.28 (.45)	.56 (.25)**	1.08 (.47) **	1.11 (.41)**	.68 (.65 - .70)*	.69 (.66 - .71)*

**=between group (TVNvs. generalist community nurses) significance p<0.01.

*= between group (TVNvs. generalist community nurses) significance p<0.05.

Figure 1: Distribution of the decision variable, across noise and signal cases/trials, showing the judgement tendency/bias (C) and detection ability (d prime or d).

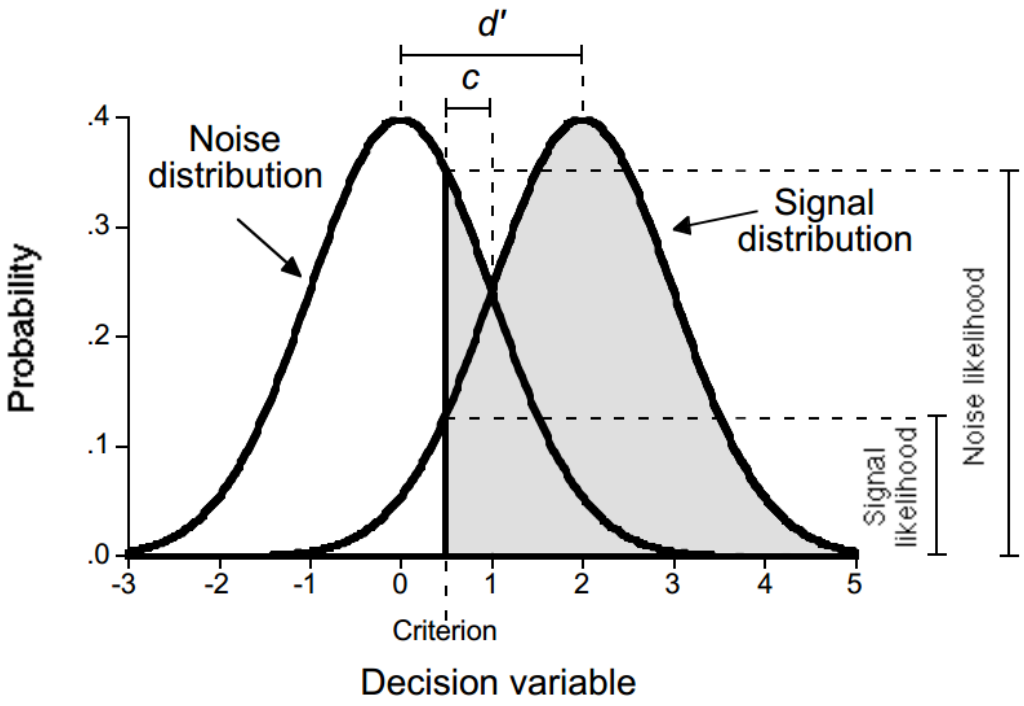
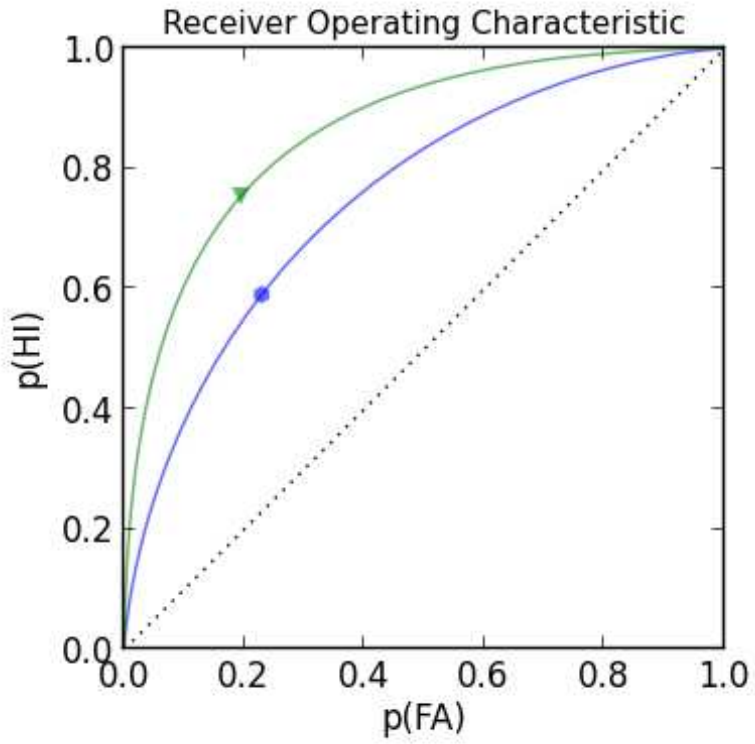


Figure 2: ROC curves for diagnostic judgement task: generalist nurses and tissue viability specialists



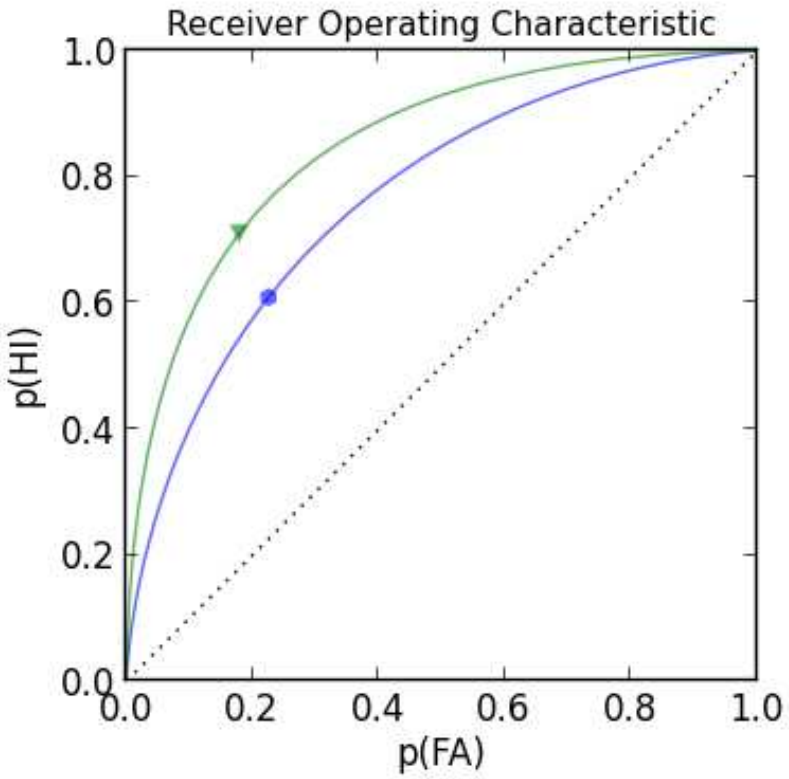
Generalist nurses AUC = .68

Tissue Viability Nurses AUC = .78

p(HI) = probability of a hit/true positive

p(FA) = probability of a false alarm/false positive

Figure 3: ROC curves for intervention judgement task: generalist nurses and tissue viability specialists



Generalist nurses AUC = .69

Tissue Viability Nurses AUC = .76

P(HI) = probability of a hit/true positive

P(FA) = probability of a false alarm/false positive

Appendix A –screen capture of clinical scenario