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ORIGINAL RESEARCH

Benefits of a tuberculin skin testing refresher training programme for veterinary field technicians in the Bushbuckridge Municipality, South Africa

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Bovine tuberculosis (bTB) is an economically important global zoonotic disease affecting all mammalian species, caused by *Mycobacterium bovis*. The diagnostic test prescribed by the South African National Bovine Tuberculosis Control Scheme and required for international trade in live cattle is the intradermal tuberculin test. Theoretical and practical learning of tuberculin skin testing should be done simultaneously during student training. The study aimed to assess the training programme of Veterinary Field Technicians (VFTs) on tuberculin skin testing in cattle and its impact on their performance. Twenty-five VFTs, between the ages of 22 and 61, were enrolled for bovine tuberculosis (bTB) testing refresher training, which covered both theoretical and practical aspects of the tuberculin skin test. Twenty-three VFTs participated in both the pre-training and the post-training written assessment, while two VFTs each missed one of the assessments. The mean (± SD) pre-training score was 39% (±14%), and only 4/23 VFTs (17%) achieved the pass score of 50%. The mean post-training score was 55% (± 15%), and 16 (70%) passed the post-training test. The mean difference (post-training – pre-training) was 16% (95% CI: 12, 19%; $p < 0.001$), with a large effect size (Hedges' g_{av} = 1.07; 95% CI: 0.90, 1.25). VFTs in the age group 51–61 years performed poorly in the assessments compared to those aged between 22 and 50 years old. Adjusting for pre-training score, there was an inverse association between age and post-training score (b = -0.46; 95% CI: -0.75, -0.17; $p = 0.004$). It was concluded from this study that VFTs employed by the State were not allocated sufficient time for theoretical and practical re-training on tuberculin skin testing of cattle in Bushbuckridge local municipality, Mpumalanga province. The refresher training course was a useful intervention to effectively improve the theoretical and practical TB testing skills of VFTs.

Keywords: assessment, bovine tuberculosis, training programme, tuberculin skin test, Veterinary Field Technician

Introduction

Bovine tuberculosis (bTB) is an economically important global zoonotic disease affecting all mammalian species, caused by *Mycobacterium bovis*. It is transmitted through various routes, with aerosol transmission being the most common. The diagnostic test prescribed by the South African National Bovine Tuberculosis Control Scheme and required for international trade in live cattle is the intradermal tuberculin test, also known as Tuberculin Skin Test (TST). The TST is based on the cell-mediated immune response that presents as a delayed hypersensitivity reaction to mycobacterial tuberculo-protein (Schiller et al., 2010, Chan et al., 2022). The test entails the intradermal injection of tuberculin in the form of purified protein derivative (PPD) derived from *M. bovis* and *Mycobacterium avium*. PPD was stored in the fridge at 4 °C in the office and carried to the field in cooler boxes with ice packs. The skinfold is measured on day 0. Thereafter, the skin reaction is observed, measured and interpreted 72 hours later using the World Organization for Animal Health (WOAH) standards with a slight modification in the cut-off values (Tschopp et al., 2010, Holder et al., 2024)).

According to the WOAH guidelines, the test interpretation depends on whether a single or comparative test was used. A negative reaction for a single intradermal tuberculin test is when a skinfold thickness on the injection site is less than 2 mm and there are no clinical signs such as necrosis, oedema, pain or enlarged regional lymph nodes. A swelling more than 2 mm but less than 4 mm and no clinical signs is considered inconclusive. Any skin-fold thickness that is more than 4 mm and coupled with the above clinical signs is regarded as positive. Cut-off values for a comparative test are positive if the increase in skin-fold thickness on bovine injection site is 4 mm or greater than that of the avian site. It is inconclusive if the difference in skin-fold thickness between bovine and avian injection sites is less than 4 mm. A negative result is when the skin-fold thickness on bovine site is less or equal to the one on the avian site (Vera-Salmoral et al., 2024). This study used a comparative intradermal tuberculin test with the cut-off value for positive reactions being 5 mm. Reactions where the skinfold thickness of the bovine injection site was 5 mm or more than that of the avian site were considered positive. Those reactions with skin thickening of 1–2 mm were negative, and those with 3–4 mm were suspect. This was based on the guidelines as outlined in the national Bovine tuberculosis manual 2016. The PPD was kept in the fridge at 4 °C in the office and carried in cooler boxes with ice bricks to the field on the day of testing. Pre-calibrated McLintock syringes and calipers were used.

These tests are performed by government VFTs under the supervision of the state veterinarian or by state veterinarians themselves. A VFT is an official with a minimum qualification

of a Diploma in Animal Health. In South Africa and many other African countries, training VFTs in TST for cattle is the backbone of bTB surveillance and control.

Government VFTs are para-veterinarians with the mandate to promote animal health through disease control and testing activities. In South Africa, the VFTs' profession is regulated by the South African Veterinary Council (SAVC), which outlines the scope of their practice and curriculum of training. VFTs registered with the SAVC are permitted to render basic primary animal healthcare services during a course of employment by the state under the supervision of the state veterinarian. The prescribed minimum standards of VFT training include Degrees, Diplomas and Certificates in Animal Health. Local accredited institutions offer the stipulated minimum standards of VFT training over a minimum period of three years. The core emphasis of the training is on disease control, prevention, surveillance, and primary animal health care.

Historically, veterinary education in African nations has concentrated on producing veterinary professionals to service the needs of both individual livestock owners and the livestock industry at large (Katajavuori et al., 2006, Alafiatayo et al., 2022). Since the mid-twentieth century, educational research has been interested in examining the relationship between inputs to the teaching process and the outcome, without necessarily adopting modern didactics and participatory teaching approaches (Ballantine et al., 2021, Vajoczki, 2008, Iles, 2002). According to White and Frederiksen (2005), for improved practical outputs, student training ideals should include a synergistic approach comprising theoretical, practical and meta-cognitive learning elements (White and Frederiksen, 2005). Theoretical and practical knowledge should be integrated during tertiary training; hence the curriculum should pay attention to practical knowledge in the theoretical part of the curriculum (Mordhorst and Jenert, 2023, Katajavuori et al., 2006, Hoidn and Olbert-Bock, 2016).

VFTs may enter the workforce thinking that they have gathered enough knowledge for their entire career. However, continuous theoretical and practical revision is necessary, and relevant opportunities should be made available. Many countries in sub-Saharan Africa, including their veterinary training institutions, suffer from shortages of suitably qualified veterinary staff and budgets to sustain a full TST practical training programme (Stephens, 2021, Nuwagaba, 2012, Thwala, 2017). These shortages result in a lack of continuous TST practice for VFTs and negatively impact the delivery of veterinary services such as bTB surveillance to agricultural communities. At the provincial level, VFTs are often not performing the TST activities required by the animal disease control mandate due to resource limitations, including financial constraints, poor handling facilities and equipment availability.

In South Africa, three institutions are authorised to train VFTs, namely the North-West University (NWU), which is located in North West province, the University of South Africa (UNISA) in Gauteng province and the Tsolo Agriculture and Rural Development Institute (TARDI) in the province of the Eastern Cape. The Tuberculosis/Brucellosis refresher course modules presented by these institutions prior to 2015 were not standardised. This trend was also practiced in other veterinary schools around the world (Hailat, 2005). In the past, these institutions did not allocate adequate time to practical TB testing in their curricula. Instead, it was the responsibility of the various provincial veterinary services to train their employed VFTs on practical aspects of TST using training materials developed by the national office of veterinary services.

The above-mentioned three institutions were, in 2015, given the responsibility by the national veterinary office to set up a standardised course and examinations through the South African Qualification Authority (SAQA), guided by the core competencies document developed by provincial veterinary services and the National Director of Animal Health (DAH). These institutions are currently offering the new standardised training course of the VFTs; however, only two weeks are allocated for TB and brucellosis training, one week to address the theoretical components and the other for practical training.

Nuwagaba (2012) showed that the training of VFTs in general has improved under the revised curriculum, though it still lacks key components, such as adequate interaction with communities. In addition, new graduates lacked practical skills and professional exposure, creating dissatisfaction and conflicts with employers, farmers and the SAVC. Revised curricula should therefore include a "practice and community attachment" to enhance practical skills that will make the graduates more employable. It is suggested that trainee VFTs should be taken to the communities for practical experience, which differs fundamentally from the controlled environment at the training institutions. Community-based TST training will enhance the skill set of the new graduate, both technically and professionally (Nuwagaba, 2012).

The objectives of this study were to determine the competency of VFTs in Bushbuckridge to perform the bTB skin test according to national guidelines and standards, and to identify training needs of VFTs related to the TST. VFTs were assessed, re-trained and then re-assessed on their theoretical and practical knowledge, whereby assessments were conducted by means of written pre- and post-training quizzes and practical sessions were performed in the field.

Materials and methods

Study participants

The study was conducted in 2021 in the Bushbuckridge municipality of the Ehlanzeni North district of Mpumalanga province, South Africa. The target group consisted of VFTs employed by the provincial Department of Agriculture, Rural Development Land and Environmental Affairs (DARDLEA) on a permanent basis. The participants ranged in age from 22 to 61.

Study approach

VFTs were assessed, re-trained and re-assessed on the theoretical and practical aspects of the intradermal tuberculin skin test during a 4-day refresher course. A paper-based quiz based on the 2016 Bovine Tuberculosis manual of the Department of Agriculture, Land Reform and Rural Development (DALRRD 2016) was used to assess the VFTs' knowledge before and after the refresher course. The theoretical training was conducted on

the first and third days of the course by a subject expert from the Faculty of Veterinary Science, University of Pretoria. On Day 1, the principles of the test, all test parameters and their influence on the test were explained, followed by a working demonstration of the TB testing equipment, i.e. McLintock syringe, suitable disposable syringes and needles, and different types of callipers, including instructions for their correct use and reading. On Day 4, the underlying principles and a practical approach to test interpretation were conveyed to the participants by means of a PowerPoint presentation followed by hands-on skills training. Bovine skin models specifically designed for veterinary skills training were used. These skin models were manufactured in-house and peer reviewed by veterinary specialists. They were made of silicon practice skin sheets, measuring 20 x 30 cm and covered with artificial hair except for the area demonstrating the skin reaction (80 x 80 mm) (Michel et al., 2017). Each of the models represented a different skin test outcome, including oedema, diffuse or circumscribed swellings, hard and soft swellings, and central necrosis. The models were used to demonstrate how to correctly evaluate and describe the various skin reactions visually, through palpation and quantitatively by accurately measuring the skin thickness compared to a skin model with no reaction.

The theoretical training was conducted on Monday (Day 1). On Tuesday (Day 2), a herd visit to perform Part 1 of the skin test was made. Wednesday (Day 3) was reserved for self-study. Test interpretation (theory and practical using skills models) was conducted on Thursday (Day 4). Friday (Day 5) was dedicated to Part 2 of the test, interpretation of the skin test (evaluating clinical signs, taking skinfold thickness measurements and integrating both in the overall test interpretation).

On Day 2, this process included the farm or animal health inspection facility approach, consisting of: 1) history taking; 2) choice of injection site preparation; 3) shaving the injection sites on the neck; 4) filling in the McLintock syringe; and 5) injecting the bovine and avian tuberculin. Every step was monitored by the researcher (an experienced state veterinarian) and the subject expert to ensure the correctness of all procedures, including proper handling of the tuberculin. Day 5 was dedicated to reading and interpreting the TST reactions and was scheduled 72 hours after administering the tuberculin injections on Day 2. It was done at the local dip tank, a concrete basin that can be filled with an acaricide solution to treat cattle against ticks by dipping/coating animals by total or partial immersion. Each VFT was prompted to perform the different steps of the TST in the correct order. VFTs were required to show competency to the researcher or subject expert in all described procedures before being allowed to complete the practical. On Day 5 of the course, 72 hours after tuberculin injection, each VFT was given an opportunity to visually evaluate, palpate and measure the skin thickness before interpreting the findings for each tested animal.

The TST steps involved choosing an injection site on the animal. The neck was the preferred site for injecting PPD because of its high sensitivity to the intradermal injection of tuberculin. The site was shaved and disinfected followed by measuring the skin fold with a calliper. The needle was then inserted obliquely with the bevel facing outward. The tuberculin was injected into the deeper layers of the skin. A pear-shaped swelling should be felt upon palpation of the injection site to confirm the correct injection. Reading was done 72 hours later where the TB10 forms were completed to gather the necessary data that assisted with the interpretation of the test. Literature advises that it should be the same person who measures the skin fold before and after the injection (Good et al., 2018)).

Study outcomes were reported to the provincial and national veterinary services, together with recommendations for improvements in the relevant aspects of VFT training.

Knowledge assessments

The training was preceded by assessing the baseline theoretical and practical knowledge of the VFTs by means of a written paper-based quiz, given on Day 1. An identical quiz was used for assessment after the refresher re-training course had been completed. The quiz consisted of six open-ended questions, totalling 50 points, which assessed the subjects' knowledge of TST equipment and its use, client history taking, skin test reading and interpretation of reactions. The minimum score required to pass both the pre- and post-training quizzes was 50%.

Self-evaluation of TST skills per training aspect

A short questionnaire was administered at the end of the course as a once-off, anonymous and confidential Google form in which participants evaluated their own level of knowledge and skills about the TST before and after the training. The questionnaire also requested participating VFTs to evaluate the TST refresher course.

TB10 forms

Under South Africa's animal health legislation, prescribed herd-level tuberculosis testing using the TST requires farm and herd information and testing results to be recorded on a designated TB10 form by the accredited veterinary official conducting the testing. Data recorded includes the official performing the TST, identification of the cattle tested, skin reactions at the injection sites, recording the readings, interpreting the findings and the final diagnosis. Completed forms were reviewed, interpreted and signed off by the responsible state veterinarian. The signed TB10 form is legally considered a valid diagnostic test result record. During the re-training, each participating VFT was required to correctly complete the TB10 form so as to assess their level of understanding of the TST procedure.

Statistical analysis

Statistical analysis was done on the knowledge assessment only. Cronbach's α was calculated for the standardised (mean 0, variance 1) question scores for both the pre- and post-training assessments to assess the internal consistency of the test questions in measuring knowledge. Data were assessed for normality using the Shapiro-Wilk test. Listwise deletion was applied for paired analysis, so only subjects completing both pre- and post-training assessments were included. Paired-sample *t*-tests were conducted to compare the pre- and post-training scores, testing the null hypothesis that the difference between

the two scores was zero. For robustness, a Wilcoxon signed-rank test was also performed. A variation of Cohen's effect size, Hedges' g_{av}, was calculated to quantify the magnitude of the effect of the training, accounting for the correlation between the scores by using (SD pre-training score + SD post-training score)/2 as the standardiser (Lakens, 2013). Values of 0.2, 0.5, and 0.8 were interpreted as small, medium, and large effect sizes, respectively. Scores were compared between genders using Welch's *t*-test. Associations amongst pre-training scores, post-training scores, score differences and age were assessed using Spearman's rank correlation. To control for potential confounding, a simple linear model was used to estimate the independent associations of pre-training score, age and gender with the post-training score. Significance was assessed at $p < 0.05$. Statistical analyses were done using Stata 18 (StataCorp, College Station, TX, U.S.A.).

Ethical approval

Research and animals' ethics clearance was received from UP's Faculty of Veterinary Sciences (REC 152-20). Ethics approval for administering questionnaires from the Faculty of Humanities at UP (HUM038/0821). All VFTs that participated had signed a consent form at the beginning of the study. Twenty-three out of 342 communal cattle attending their regular foot and mouth disease inspection at a local dip tank were randomly selected for the study. The TST and associated training was done very early in the morning to allow enough grazing time for the cattle after the exercise. All cattle present were accustomed to being herded to the inspection point every week and handling by the VFTs for routine disease surveillance and hence were not exposed to any undue stress.

Results

Age groups and gender

Ten (40%) of the 25 enrolled VFTs were between 50–65 years old, 5 (20%) were 40–49 years old, 5 (20%) were within the 30–39-year range and 5 (20%) were 20–29 years old. Seventeen out of the twenty-five (68%) VFTs were males, and 8 (32%) were females. Twelve out of the 25 VFTs qualified from the NWU, 7 from Technikon South Africa, 2 from TARDI, 3 from UNISA and 1 from Technikon Vaaldriehoek. The VFTs' working experience ranged from 5–34 years.

Pre- and post-training quiz assessment

A total of 23 VFTs completed both assessments, resulting in 23 paired observations that were included in the analysis. Four out of 23 VFTs (17%) passed the pre-training quiz with a score ≥ 50%. The pre-training scores ranged from 17–70% with a

Table I: VFTs demographics and assessment scores

VFT ID	Training institution	Year of qualification	Gender	Age	Pre-quiz Total	Pre-quiz %	Post-quiz Total	Post-quiz %	Difference between post-and pre-quiz scores %
1	TARDI	2020	M	24	20.5	41	34	68	27
2	North West University	1986	M	37	19.5	39	31.5	63	24
3	TARDI	2019	M	24	26.5	53	36.5	73	20
4	North West University	1999	M	56	32	64	38	76	12
5	North West University	2016	M	31	21	42	27	54	12
6	North West University	2017	F	40	16.5	33	25	50	17
7	North West University	2001	F	42	22	44	26	52	8
8	North West University	1995	M	54	18.5	37	25	50	13
9	North West University	2013	M	29	23	46	37.5	75	29
10	University of South Africa	2008	F	37	35	70	39.5	79	9
11	University of South Africa	2008	M	37	28	56	30	60	4
12	Technikon South Africa	1996	M	58	19	38	18	36	-2
13	Technikon South Africa	1997	M	57	10.5	21	14.5	29	8
14	North West University	2013	M	29	24.5	49	36.5	73	24
15	Technikon South Africa	1996	M	57	11.5	23	24.5	49	26
16	North West University	2004	F	40	17.5	35	27.5	55	20
17	University of South Africa	2013	F	29	14.5	29	25	50	21
18	Technikon South Africa	1994	M	57	11.5	23	20	40	17
19	Technikon South Africa	1999	M	59	8.5	17	11.5	23	6
20	Technikon South Africa	1986	M	61	14	28	19	38	10
21	North West University	2017	F	26	17.5	35	30	60	25
22	North West University	1994	M	58	13.5	27	21.5	43	16
23	North West University	2006	F	37	22	44	31	62	18
24	Technikon South Africa	1995	M	48			31	62	
25	Vaaldriehoek Technikon	1996	F		32.5	65			

Table II: Pre- and post-training assessment scores by gender

Variable	*n*	Pre-training score [mean (SD)]	Post-training score [mean (SD)]	Difference [mean (SD)]	*p*-value*
Gender					
Female	7	41 (14) [a]	58 (10) [a]	17 (6) [a]	< 0.001
Male	16	38 (14) [a]	53 (17) [a]	15 (9) [a]	< 0.001
All participants	23	39 (14)	55 (15)	16 (8)	< 0.001

* Paired *t*-test comparing pre- and post-training scores
[a] Within columns, values with different superscripts differ ($p < 0.05$, Welch's *t*-test)

mean (± SD) of 39% (± 14%) whereas the post-training scores ranged from 23–79% with a mean (± SD) of 55% (± 15%). Sixteen VFTs out of 24 (70%) passed the post-training quiz. A paired sample *t*-test showed a mean increase in post-training scores compared to the pre-training scores of 16 (95% CI: 12, 19; $p < 0.001$). The Wilcoxon signed-rank test was also significant ($p < 0.001$). A large effect size (Hedges' $g_{av} = 1.07$; 95% CI: 0.90, 1.25) was observed. No significant relationship was found ($p > 0.05$) between gender and scores for either the pre- or post-quizzes. A strong positive correlation between pre- and post-training scores was seen (Spearman's rho = 0.866; 95% CI: 0.666, 0.950; $p < 0.001$). The scores for the participants aged ≥ 55 years were 17–64% whereas the post-training quiz had a 23–76% range. Those younger than 55 years old scored 27–70% in the pre-quiz and 43–79% in the post-quiz. Older participants scored lower in the pre-quiz (rho = -0.549; 95% CI: -0.796, -0.145; $p = 0.008$) but also showed significantly lower improvement (rho = -0.565; 95% CI: -0.805, -0.166; $p = 0.006$) and scored significantly lower in the post-quiz (rho = -0.679; 95% CI: -0.865, -0.329; $p < 0.001$). In the linear model, pre-training score was positively associated (b = 0.79, $p < 0.001$), age was inversely associated (b = -0.46, $p = 0.004$) and gender was not associated ($p = 0.835$) with post-training score.

Evaluation and internal consistency

All but one of the participants' scores improved following refresher training (Figure 1).

Cronbach's α for the standardised question scores was 0.784 for the pre-training quiz and 0.853 for the post-training assessment. In both assessments, Question 4 ("how to disinfect the syringe and needle") had the lowest correlation with the test score ($r = 0.489$ and 0.625 for the pre- and post-assessments, respectively), and Question 6 ("how to select the injection site, shave and inject") had the highest correlation with the test score ($r = 0.804$ and 0.907 for the pre- and post-assessments, respectively).

Confidence levels in comparison pre- and post-training

Participants individually evaluated their own practical and theoretical knowledge on bTB after the training. Thirteen out of the twenty-three participating VFT's confidence on TST performance improved after the training.

In combination with evaluating the overall knowledge level during the self-evaluation, each VFT scored their confidence levels pertaining to each section of the training (Fig. 2). The various results of the self-evaluation depicted an increased level of VFT confidence in test-site selection and preparation, TB10-form completion, ability to correctly fill and clean the McLintock syringe, and accurately interpret TST results. Despite the majority of VFTs expressing an improvement of their TST knowledge level, several VFTs requested additional training on test result interpretations (5); the use of calipers (6); and filling and cleaning of the McLintock syringe (6). Feedback forms indicated that the majority (96%) of the group would recommend the course to other VFTs.

Discussion

The TST forms an integral part of bovine tuberculosis surveillance and control in many countries worldwide. This study investigated the level of competence among 23 VFTs on TST training. Competence is the ability to carry out tasks in an effective, correct and appropriate manner. It involves the habitual use of professional training, technical skills, knowledge and reflections in daily practice so that the community being served benefits (Johnson et al., 2008). Incompetence, on the other hand, could

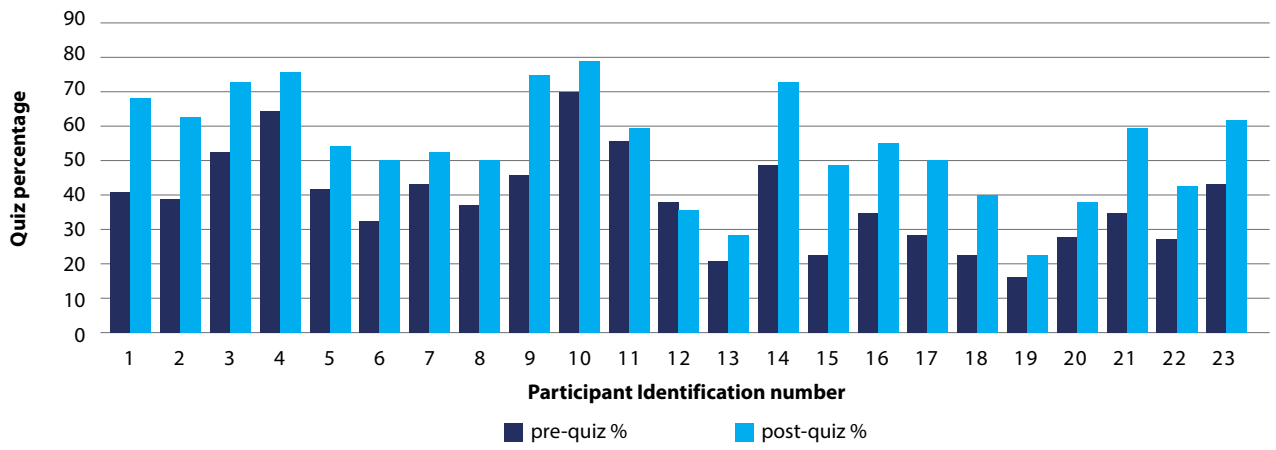

Figure 1: Pre-training and post-training quiz results per VFT

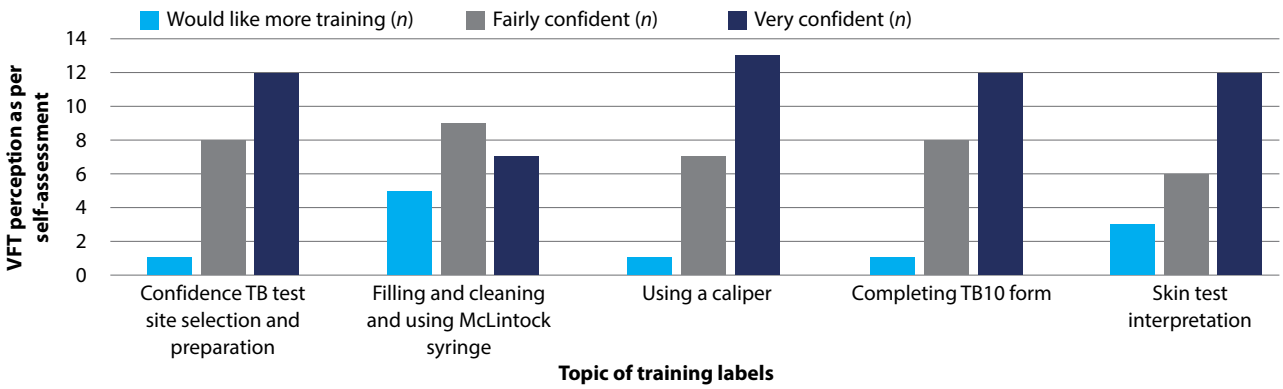

Figure 2: VFT confidence scores for performing various elements of the TST post-training

be due to insufficient training, lack of professional exposure and supervision or to difficulties with moral character or psychological fitness (Kaslow et al., 2007, Cohen and Baruch, 2022).

The results of our study revealed a significant difference in the mean scores of the pre-training and post-training quizzes. Several conclusions can be deduced from these findings. Firstly, results indicate a lack of competence in performing the TST at the time of the pre-training assessment. Secondly, re-training of VFTs on both the theoretical and practical components of the TST resulted in a significant improvement in overall administration of the TST.

Theoretical knowledge regarding the performance of TST is multi-faceted, including knowledge of a variety of topics. This is likely the reason for the modest measure of internal consistency (test reliability) in the pre-training ($\alpha = 0.784$) and post-training ($\alpha = 0.853$) assessments, since the presence of multiple underlying factors being tested results in an underestimate of test reliability (Tavakol and Dennick, 2011). Nevertheless, these measures can be used to critically assess the utility of each question in the assessment and to make improvements where necessary.

It is essential to ensure VFTs acquire and retain the practical and theoretical competency to perform the TST. Since it is unknown for how long the acquired skills will be retained, periodic and graded refresher training courses should be considered as part of the skills development for all VFTs. The study findings indicated that the competence of 75% of the VFTs was not up to the required standards with regard to the retention of skills. Therefore, the need for the programme on TB training to be revisited regularly by conducting refresher courses on TST is essential (Swan and Kriek, 2009). A previous study found that a veterinary training programme and curriculum require constant review and adaptation to keep abreast of national and international advances and requirements (Swan and Kriek, 2009). A revision of the curriculum every five or six years is required to allow a new programme to be fully implemented every decade, with minor adaptations introduced in the interim. It is emphasised that curricular changes are not necessarily linear extensions of existing programme but that they must take cognisance of future scenarios affecting the profession over time spans of 10–20 years (Walker and Soltis, 2004). For a curriculum to be successful, it should be based on a defined set of competencies in knowledge, understanding, skills and professional attributes that all veterinary and para-veterinary students should have attained and demonstrated by the time they graduate.

Seven of the twenty-three participating VFTs were female, and 16 were male. The imbalance in gender could be due to the fact that the veterinary profession was historically dominated by males (Lawrence, 1997, Treanor and Marlow, 2021). The profession has undergone a global shift, from a male-dominated one to attracting predominantly females, in the past two decades (Tokbaeva and Achtenhagen, 2023, Bidaisee, 2018). Cultural beliefs played a role in the past in that females were not even allowed to enter a cattle kraal (enclosure where cattle are kept at night).

The participants' age ranged from twenty-two to sixty-one years. The VFTs older than 55 performed poorly compared to the younger ones (22 to 36 years of age). The group represented a range of VFT experience levels, from individuals who had over twenty years of experience to those who had only recently qualified and been appointed. Twenty years' experience would normally be associated with an expectation of high proficiency (Bosse et al., 2015), however, it was not the case with the participating VFTs. This was attributed to the fact that VFTs have not been regularly performing TST due to a lack of resources such as TB testing equipment, lack of compliance by cattle farmers and poor cattle handling facilities. The very low prevalence of bTB in communal areas may have impacted the prioritisation of financial resources for bTB surveillance. VFTs aged above fifty years performed poorly as compared to those below fifty as indicated by the statistically significant difference of $p < 0.05$. Most of them lacked self-confidence as they did the practical part of the re-training. Some were confident in one aspect of performing the TST and lacking in another, for example, they would do well on injection site selection but poorly on tuberculin injection technique.

The refresher training was enhanced by conducting the practical training within a local cattle farming community, equivalent to those where the participating VFTs are working. This scenario supports the notion that VFTs must constantly improve their knowledge base by reading and practising the latest TST technical skills. VFTs can expand their TST competency by

constantly checking their testing practices and knowledge (Marsick, 1988).

VFTs reflected on and critiqued their TST routines. This allowed them the opportunity to learn and understand all aspects of the TST as they were re-trained (Marsick, 1988). VFTs usually do not reflect on their experiences during training at the college as there is not enough time during the short practical training period, hence their learning is not sufficiently integrated with practical experience. It is recommended that local state veterinarians working with the newly qualified VFTs should prompt the officials to self-reflect and assess their TST skills within their specific work settings. Lecturers at VFT training institutions are encouraged to do the same with their students (Marsick, 1988).

Most participating VFTs would recommend the course to others, an indication that the refresher training was beneficial to them and would propose that other VFTs take advantage of the same benefits. This study's results indicate that theoretical studies need to be supported by *in situ* practical training. The TST training approach should be structured in a way that would accommodate bTB surveillance and control in communal cattle (Mayen, 2006).

The study had a few limitations: the structure of the test may have been unfamiliar to some participants, even though it was clarified before use. A questionnaire in which participants evaluated their own level of knowledge and skill could have created an element of bias towards higher scores.

The refresher training has partially closed the gap in TST proficiency in the study area. The re-training would encourage the local veterinary services to test as many cattle as possible in the area since the re-trained VFTs are able to accurately perform and interpret the results of TST. A well-coordinated TST programme in this municipal area would contribute immensely in addressing the zoonotic threat posed by *M. bovis*. Well-trained and confident VFTs play a key role in bTB surveillance since there will be early detection of infected cattle hence reducing bTB transmission. Cattle productivity and health would improve.

A wildlife/livestock/human interface, where the study was done poses a huge zoonotic risk which requires a multidisciplinary approach. Human settlements have grown over the last three decades to within 30 meters of the Kruger National Park fence where African buffaloes are enclosed. Buffaloes have been reported to breakout into the neighbouring communities, increasing the risk of *M. bovis* transmission. Previous studies have indicated that *M. bovis* can spillover from buffaloes to cattle and eventually to humans (Musoke et al., 2015, Sichewo et al., 2020). Another recent study discovered that *M. bovis* is present in shared water sources in South Africa's province of Kwazulu-Natal, further increasing the risk of zoonotic TB (Matthews et al., 2025). A One Health framework is needed to effectively deal with the complicated relationships between wildlife, human and livestock.

Conclusions

Limitations in prior and ongoing training strategies can influence the competence of VFTs when performing the TST. This has impacted negatively on the performance of VFTs in the control of bTB in southern Bushbuckridge. Furthermore, a lack of competence by veterinary officials to perform the TST impedes the fulfilment of the legislative mandate of the Bovine Tuberculosis Scheme, as indicated in the Animal Diseases Act 35 of 1984 and the Bovine Tuberculosis Manual of 2016 (Arnot and Michel, 2020).

Therefore, it is strongly recommended that adequate TST training time be allocated in the curriculum of VFTs and in the form of 12 monthly periodic refresher courses throughout their working careers to avoid skills decay.

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Conflicts of interest

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