

Learning outcomes for the education and training of laboratory animal caretakers in South Africa

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Education and training is essential for laboratory animal caretakers (LACs), but there are no courses available in South Africa. A national workshop was thus held to collaboratively establish the learning outcomes (LOs) for the education and training (E&T) of LACs. Eighty-five stakeholders from 30 institutions took part in small group discussions interspersed with plenary sessions to draw up the consensus LOs.

One-hundred-and-twenty LOs were identified, grouped into the following three main themes and 15 topics: 1) *Focus on animals* (animal care and husbandry, animal ethics, animal welfare, basic biology, environment); 2) *Focus on humans* (administration, health and safety, lifelong learning, professionalism, psychological wellbeing); and 3) *Focus on systems* (biosecurity, equipment, jurisprudence, logistics, and quality management).

This E&T framework provides a foundation for a career path in the laboratory animal science field. The psychological (i.e. mental and emotional) wellbeing of LACs forms a noteworthy component of the *focus on humans*, since working with research animals is stressful and coping mechanisms are needed in order to promote compassion satisfaction and prevent compassion fatigue and burnout.

Approximately 75% of the LOs are knowledge-based, while 25% are competencies in practical skills. It is recommended that competencies should be assessed by direct observation of practical/procedural skills, where competence in a procedure or practical task is assessed against predetermined criteria.

These LOs are published with the intent that they will promote animal and human wellbeing, support ethical science, maintain public confidence, and in so doing, contribute to a just and civilised society.

Keywords: learning outcomes, animal caretaker, laboratory animal science, education, training

Introduction

Laboratory animal caretakers (LACs) are the personnel employed in laboratory animal facilities with responsibility for the routine husbandry and general care of animals, maintenance of the animals' environment, and associated operational tasks. Appropriate education and training (E&T) of LACs is essential to ensure they are competent in their practical tasks; as moral imperative to protect the welfare of the sentient animals in their care; as a quality-control mechanism to reduce confounding variables and thus promote high-quality science; to maintain public confidence in the standards of animal care; and as a foundation for a career path.

There are currently no formal E&T courses available in South Africa that are specifically tailored to the needs of LACs, with variable on-the-job training being provided by employers. More broadly, a national need has been identified for the E&T of animal caretakers across veterinary sectors (i.e. companion, production, exotic, wild, and laboratory animals), with workshops being held by the South African Veterinary Council (SAVC) in 2017 and 2019 to discuss this need.

The updated South African National Standard for the Care and Use of Animals for Scientific Purposes (SANS 10386:2021)

requires that E&T should facilitate and assure the competence of all persons involved in the care, use and breeding of all animals used for scientific purposes (South African Bureau of Standards, 2021). A dedicated national workshop was thus held to collaboratively establish the learning outcomes (LOs) for the E&T of LACs in South Africa, as part of the main programme of the 2022 Congress of the South African Association for Laboratory Animal Science (SAALAS), held in Potchefstroom, North West province, from 15–18 March 2022.

Materials and methods

Over 400 stakeholders in the laboratory animal sciences sector in South Africa were invited by email to attend the conference and participate in the E&T workshop. This included invitations for LACs to apply for fully sponsored attendance to both the conference and the E&T workshop.

The E&T workshop was opened in a plenary session, followed by small group discussions between persons seated in proximity of each other (i.e. around 10 groups of 5–10 persons each). These breakout groups were tasked with drawing up the LOs for the E&T of LACs, with group discussions lasting around two hours. Outcomes were summarised on paper within each group. Group members were requested to record any additional LOs

which they felt were important, but for which there was not time to discuss in group format, on separate notes. The authors facilitated the discussions by addressing any questions and encouraging the process. Virtual attendees were requested to record their LOs in the relevant session in the conference app. The breakout groups reported their results in a plenary session, with LOs being recorded in a spreadsheet while displayed on screen. Participants were requested to ensure the correct recording of the LOs in wording and meaning. During an overnight break, the spreadsheet was supplemented with the additional LOs that were recorded by individual group members and by virtual attendees. On the second day, the spreadsheet was displayed on screen in a plenary session, with point-by-point editing of the wording of each of the LOs, to agree on phrasing, content and meaning. The workshop concluded with consensus agreement by the attendees (in-person and virtual) on the detail of the recorded LOs.

Following the workshop, the authors edited the phrasing of the LOs for grammar and punctuation, removed duplicate LOs, merged analogous LOs, and ensured the use of assessable verbs (i.e. verbs that enable the LOs to be assessed objectively) in accordance with Bloom's taxonomy of educational objectives (Bloom et al. 1956). Each LO was classified as representing either knowledge or competence in practical skills. The LOs were finally grouped into overarching themes based on their main emphasis,

and further sub-categorised into specific topics based on their subject matter.

Results

There were 97 registrations for the conference, representing 30 institutions, with 85 registrations for the E&T workshop (i.e. 67 in-person and 18 virtual), consisting of animal caretakers (including 23 sponsored delegates), trainee laboratory animal technologists, para-veterinary professionals (i.e. laboratory animal technologists, veterinary nurses, and veterinary technologists), veterinary professionals (i.e. veterinarians and veterinary specialists), laboratory animal facility managers and directors, quality-assurance managers, laboratory technicians, animal ethics committee members, animal researchers and related professionals.

In total, 120 LOs were identified, of which 89 were knowledge-based and 31 competencies in practical skills (Table I). The LOs were grouped into three overarching themes, i.e. representing a focus predominantly on animals (48 LOs), humans (37), or systems (35); and further categorised into the following 15 topics: 1) *Focus on animals* (Animal care and husbandry [21], Animal ethics [10], Animal welfare [7], Basic biology [6], Environment [4]); 2) *Focus on humans* (Administration [3], Health and safety [14], Lifelong learning [4], Professionalism [10], Psychological wellbeing

Table I: Learning outcomes for the education and training of laboratory animal caretakers in South Africa.

Learning outcomes	*
Focus on animals	
Animal care and husbandry	
Recognise that animal caretakers should be willing to work hands-on with animals	K
State the environmental requirements for relevant species, including minimum enclosure sizes, stocking densities	K
Explain the importance of water quality (and water level for aquatic species)	K
Define the appropriate food to feed to relevant species (and life-stages)	K
Describe what environmental enrichment is, why it is needed, and effective examples for relevant species	K
Explain the need for breeding management systems and problems with in-breeding	K
Explain the effects of social hierarchy, aggression, stocking densities, and animal gender, when combining animals from different cages or during cage changing	K
Discuss the impact of cage-changing on animal wellbeing and how to limit its negative impacts, e.g. in breeding colonies, pre-weaning litters, single-sex groups	K
Conduct the provision, supplementation or replacement of food, water, bedding, nesting materials, enrichment; and cage changing, for relevant species	C
Demonstrate how to approach animals gently, without excessive or sudden movements or noise	C
Demonstrate the correct handling and restraint of relevant species (including non-aversive handling methods)	C
Perform basic grooming as part of routine animal care in relevant species	C
Conduct gender identification (sexing) of animals of relevant ages and species	C
Perform the accurate weighing of animals	C
Perform the weaning of relevant animal species	C
Perform appropriate identification methods for relevant species	C
Conduct the appropriate transport of animals within and between facilities	C
Describe when clipping of nails or teeth may be required in relevant species and who should perform this	K
Explain why the animal caretaker is often the first step in raising alarm when there are animal welfare concerns	K
Explain approaches to overcome the fears and phobias that animal handlers may have, to remain calm and confident when working with animals	K

Recognise the impacts that people (including caretakers) can have on animals, that can negatively affect animal wellbeing or scientific quality (including smells from perfume)	K
Animal ethics	
Summarise the key principles of moral philosophy, animal research ethics, and personal values, with regard to the care and use of animals for scientific purposes	K
Discuss the intrinsic value of animals as sentient beings and the importance of compassion for animals	K
Explain the 5 freedoms, 5 domains, 4Rs (3Rs), and the application thereof in the animal research context	K
Discuss the use of animals in research, in the context of animals as living sentient beings vs scientific tools	K
Name some non-animal alternatives (replacements) to animal research	K
Discuss the perceptions of society re. different animal species, and how this is affected by context (e.g. research animals vs wild populations; or caring for "vermin" species)	K
Explain the institutional ethical review and approval process by the Animal Ethics Committee (AEC) by use of the harms-benefit assessment	K
Discuss the importance of the animal caretaker's role, in terms of the harms-benefit assessment and AEC approval for a project	K
Explain the importance of good animal welfare and care, and the impact of inappropriate care on animal wellbeing and scientific quality	K
Identify what a good culture of care looks like, and how this can be achieved (prioritising animal welfare, human welfare, scientific quality, openness)	K
Animal welfare	
Demonstrate the assessment of basic animal health and welfare (including the mental domain, i.e. wellbeing)	C
Demonstrate how to record animal welfare abnormalities and what to do when abnormalities are recorded (e.g. suffering, sick, in pain, emergency, found dead)	C
Explain how to report animal welfare problems and incidents	K
Discuss humane endpoints in animal studies, when they are determined and by whom	K
Explain when emergency euthanasia may be required and who to contact when needed	K
Demonstrate the importance of attention to detail during welfare monitoring, e.g. how small changes in animal behaviour or enclosures can signal important abnormalities	C
Explain the importance of using correct animal welfare terminology	K
Basic biology	
Describe the basic biology of relevant species (reproduction, development, anatomy, physiology, nutrition, behaviour)	K
List the needs of relevant species, including environment, enrichment, social, exercise, nutrition	K
Describe normal and abnormal behaviour of relevant species (breeds or strains)	K
Discuss inter-species effects: predator-prey (rat smell for mouse), infection transmission, effect of pets at home on animals at work	K
Define the terms: virus, bacteria, fungi, parasite	K
Describe basic clinical signs of disease and pain (how to distinguish from normal)	K
Environment	
Explain the importance of the environment (macro and micro) to animal wellbeing and scientific quality	K
Perform observations of the macro-environment (facility, room, temperature, humidity, smells, air-flow and pressures (HVAC), light intensity and cycles, noise, vibration)	C
Perform observations of the micro-environment (cage, food, water, bedding, nesting material, enrichment, water quality and level for aquatics)	C
State the mechanism for reporting of environmental abnormalities	K
Focus on humans	
Administration	
Demonstrate basic computer skills (use of keyboard and mouse, word processor, spreadsheet, email, internet search)	C
Explain the importance of good record-keeping (e.g. animal records, environmental records, population records, stock taking)	K
Apply basic numerical skills, including calculations (addition, subtraction, multiplication, division), dilutions, and units (gram vs. kg, ml vs. litre)	C
Health and safety	
State the location of emergency exits, refuges, assembly points, emergency contact list	K
Explain the emergency procedure for the facility, and how to raise the alarm (the first responder's response)	K
Recognise signage (hazards, biosafety levels, radiation, chemicals, eye wash stations, first aid kits, emergency exits, assembly points, PPE required, fire alarms, fire extinguishers, gases, flammable substances, noise, no cell phones, no smoking)	K
Identify hazards and how to control risk (bite/scratch/kick/butt/crush/sting/other animal-induced, ergonomics, heavy lifting, slip, trip, fall, ladders, stairs, noise, heat/steam/pressure from autoclaves, inhalation of dust/chemicals/gases/anaesthetics, sharps, electrical shock, burns, flammable substances, chemicals, spills, medicines, experimental substances, infectious agents, chemotherapeutics, radiation)	K
Identify sources of animal allergens (hairs, urine, dander), how to avoid or control exposure, signs of human allergies	K

List the common zoonoses and their control measures for relevant species	K
Explain the correct use of eyewash stations, first aid kits, fire extinguishers, fire alarms	K
Explain the protection that different types of PPE provide	K
Discuss when and how to wear PPE to protect humans and animals	K
Demonstrate how to correctly don (put on), doff (remove), and dispose of PPE	C
Demonstrate the safe use, storage and disposal of hazardous substances	C
Summarise lone worker policies and health and safety policies of employer	K
Explain the correct reporting mechanism for health and safety incidents and concerns	K
Discuss the need for occupational health programmes for staff (medical examinations or tests, required vaccinations, working when immunosuppressed or pregnant)	K
Lifelong learning	
Identify how to remain motivated, interested and up to date with the broader LAS field	K
Recognise the career progression opportunities in the LAS field, and how to pursue them	K
Recall that obtaining a grade 12 qualification or equivalent, may be required for some career progression opportunities	K
Recognise the need for continuing professional development (CPD), including knowledge and skills (competencies)	K
Professionalism	
Explain the importance of integrity and ethical behaviour (virtue ethics)	K
Recognise that animal caretakers have an important and valued voice, and should use their voice	K
Discuss the importance of taking personal responsibility for one's own professional and career development	K
Describe one's responsibility for handing over professional duties to other personnel, when unable to meet these duties (e.g. if sick or on leave)	K
Discuss the importance of good communication skills and breaching language barriers, including communicating clearly when one does not understand, and where to go for assistance	K
Discuss appropriate personal and professional conduct (dress code, attitude, language, posture, time management, cell phone management, use of alcohol/other substances, unauthorised absence from work)	K
Explain the importance of adhering to protocols and rules (e.g. SOPs, professional codes, institutional policies, standards and regulations)	K
Summarise the importance of confidentiality in research protocols and animal facilities (e.g. not disseminating photographs, social media)	K
Discuss how the way one performs one's job, can have significant (positive or negative) impacts on animal wellbeing or scientific quality	K
Discuss institutional systems for performance appraisals	K
Psychological wellbeing	
Describe the importance of personal wellbeing (mental, emotional, physical, spiritual) in enabling one to care optimally for others (including for animals)	K
Discuss how to develop and maintain emotional resilience, to be able to deal with difficult situations (animal suffering, euthanasia, value conflicts)	K
Discuss the emotional cost of caring for animals, in an environment of animal suffering and euthanasia	K
Describe compassion fatigue, how to identify, how to deal with, and how to prevent	K
Explain the importance of social support and mindfulness in preventing compassion fatigue and promoting compassion satisfaction	K
Recognise the types of professional support that is available when having a tough mental/emotional time (counselling, psychologists)	K
Focus on systems	
Biosecurity	
Discuss the importance of pest control	K
Explain the importance of access control	K
Explain how to perform cleaning, disinfection and sterilisation	K
Perform chemical dilutions (disinfectants)	C
Demonstrate cleaning, disinfection and sterilisation	C
Demonstrate appropriate cleaning/disinfection of different sections of a facility	C
Perform autoclaving (food, water, bedding, enrichment, nesting material, cage parts, waste)	C
Demonstrate waste handling and disposal (biological waste, carcasses, PPE, sharps, bedding, food, water)	C
Describe personal hygiene principles (handwashing, showering before/during/after work) and work practices (not touching face, eating or drinking, use of jewellery/cell phones)	K
Describe principles of preventing contamination and cross-contamination (cleaning/disinfection/sterilisation between animals, species, cages, procedures, work areas, facilities, people, fomites)	K
Explain the concepts of barrier systems (personnel, equipment, consumables, animals, PPE) and different biosafety levels (BSL)	K

Discuss the function of engineering controls in biosecurity (HVAC, air pressure cascades, cabinets/hoods, interlocking doors, caging systems)	K
Explain how to correctly enter and exit facilities (BSL 1-3 labs, experimental, theatre, SPF, barrier, breeding)	K
Demonstrate how to correctly enter and exit facilities (BSL 1-3 labs, experimental, theatre, SPF, barrier, breeding)	C
Recognise whether a biosafety lab (BSL-2 and higher) is safe to enter (based on air pressure readings)	K
Identify whether a biosafety cabinet or laminar flow hood is safe to use	C
Equipment	
Identify the various components of the animal housing system (cages/tanks)	K
Demonstrate how the various components of the animal housing system (cages/tanks) fit together	C
Demonstrate how to identify cage parts, water bottles, enrichment, etc., that should not be used (cracks, sharp edges, damaged)	C
Perform appropriate washing of cage/tank parts and water bottles, using manual and automated methods	C
Demonstrate the correct use of relevant equipment, e.g., cleaning equipment, biosafety cabinet, laminar flow hood, bedding disposal station, automated cage washer, autoclave, high-pressure sprayer, disinfectant fogger, environmental monitoring system (temperature, humidity, lux, humidity), individually ventilated cages (IVC) air-supply units (blowers), fridge, freezer, cold room, scale, thermometer, instrument washer, RO water dispenser, incubator, water bath, bedding sifting machine, HVAC, magnehelic gauge, etc.	C
State the mechanism for reporting of abnormal equipment	K
Jurisprudence	
List relevant national laws of relevance to the care and use of animals for scientific purposes (e.g. Animals Protection Act, Veterinary and Paraveterinary Professions Act, Medicines and Related Substances Control Act, SPCA Act, permits)	K
Summarise the basic principles of relevant national standards (SANS 10386) and the responsibilities of animal caretakers defined therein	K
Describe the relevant health and safety legislation, including worker protection and compensation (Occupational Health and Safety Act)	K
Logistics	
Describe animal facility logistics, including planning and timing of performing various animal caretaker tasks, ensuring adequate cage cleaning for daily needs, stock control and rotation, etc.	K
Explain the requirement for the early reporting of low stocking levels of consumables (food/water/bedding/nesting/disinfectants), cages/ water bottles, etc. before these are depleted	K
Summarise the roles of the various animal facility staff, and how the animal caretaker contributes to the functioning of the facility	K
Explain how the animal facility links to the rest of the research infrastructure (e.g. labs of scientific teams)	K
Quality management	
Summarise the core principles of quality management systems (controlled documents, SOPs, data collection sheets), their importance, and the QA manager's role	K
Explain the importance of formal practical competence assessments after training in SOPs, and the periodic reassessment of competence in practical skills	K
Demonstrate the ability to fill in forms or records correctly (complete all fields, black pen, correction of errors with initial, signature and date)	C
Demonstrate how to record and report deviations from the correct procedure (SOP)	C
Review how bad habits develop (e.g. informal training by peers) and how to change to good routines (e.g. following SOPs)	K
Discuss the importance of providing feedback on SOPs and the QA system, and recommending improvements to processes	K

*Each LO represents either Knowledge (K) or a Competence (C) in a practical skill. 3Rs – The Three Rs (i.e., to Replace, Reduce and Refine the use of animals), 4Rs – the Four Rs (i.e., the 3Rs plus Responsibility), AEC – Animal Ethics Committee, BSL – BioSafety Level, HVAC – Heating, Ventilation, and Air Conditioning, LAS – Laboratory Animal Science, PPE – Personal Protective Equipment, QA – Quality Assurance, SANS – South African National Standard, SOP – Standard Operating Procedure, SPF – Specified Pathogen-Free

[6]); and 3) *Focus on systems* (Biosecurity [16], Equipment [6], Jurisprudence [3], Logistics [4], and Quality management [6]).

Discussion

The workshop achieved its aim to collaboratively co-create a framework for the E&T of LACs in South Africa. The small group format was successful in stimulating collegial discussion, whilst the plenary sessions allowed for further discussion and debate while enabling consensus to be reached, thus producing a balanced set of LOs.

The inclusion of the relatively large number of animal caretakers in the workshop, with varying levels of experience and training, was key to advise on the actual developmental needs of LACs in practice. The diversity of veterinary and para-veterinary professionals who engaged in the workshop is characteristic of

the laboratory animal science field, where a diverse veterinary team is often involved due to the complexity of activities and the consequent heterogeneity of skillsets required. These professionals often work closely with LACs, as do animal facility managers/directors, quality-assurance managers, scientists and animal ethics committee members, such that the inclusion of these stakeholders in the workshop was important to ensure the holistic nature, relevance and comprehensiveness of the LOs produced to the LAC career as a whole.

The grouping of the 120 LOs into the three overarching themes – i.e. representing a focus mainly on animals, humans, or systems – is intended as a useful conceptual structure for both educators and learners. Within each of the themes, the LOs have been categorised into five distinct topics with related content per topic, thus producing a final framework of fifteen topics.

Focus on animals includes animal care and husbandry, animal ethics, animal welfare, basic biology, and the animals' environment. A significant complexity in the laboratory animal science field stems from the fact that many facilities house multiple animal species, which may include invertebrates and vertebrates (i.e. fish, amphibia, reptiles, birds and mammals). It is thus important for the LOs to be extended to all relevant species per facility (Table I), in order to ensure appropriate knowledge, understanding and competence on a per-species basis.

Focus on humans includes administration, health and safety, lifelong learning, professionalism, and psychological wellbeing. The E&T framework of LACs presents a foundation for a career path, rather than an isolated set of LOs, as witnessed by the inclusion of professionalism and lifelong learning. For the first time since 1997, it is now again possible to study towards becoming a Laboratory Animal Technologist in South Africa, i.e. a para-veterinary professional who is registered with the SAVC (Fourie, 2022). The E&T framework could thus assist LACs in preparing (both professionally and personally) for career progression opportunities which they may elect to pursue in future. Obtaining a matriculation certificate (Grade 12 in South Africa) or equivalent will be important for learners who wish to pursue a career path in the sector, including those intending to become Laboratory Animal Technologists.

The psychological (i.e. mental and emotional) wellbeing of LACs forms a notable component of the *focus on humans*, being distinct from health and safety considerations. Laboratory animal personnel (including animal caretakers) may experience significant stress from working with research animals, such that their professional quality of life, which is comprised of compassion fatigue (i.e. burnout and secondary traumatic stress) and compassion satisfaction, is associated with multiple factors including social support and the level of animal welfare (LaFollette et al. 2020). There is thus an inter-relationship between human and animal wellbeing in laboratory animal facilities (LaFollette et al. 2020). It is thus noteworthy that there is a concomitant increasing emphasis being placed on the psychological wellbeing of animals, in the field of animal welfare science (Mellor et al. 2020).

Focus on systems includes biosecurity, equipment, jurisprudence, logistics, and quality management. The term biosecurity refers to measures aimed at preventing the introduction and/or spread of harmful organisms, to minimise the risk of transmission of infectious disease. Since both biosecurity and equipment may vary significantly between facilities, it is important that the LOs are extended to all relevant aspects, to ensure appropriate knowledge, understanding and competence in practical skills.

While the proportion of knowledge-based LOs (~75%) outnumbers the competency-based LOs (~25%), it is important to recognise that the knowledge-based LOs often form the foundation of understanding why a relevant competency-based practical skill should be performed in a particular way, or to understand one's role in the workplace more holistically. It also follows that the total amount of time spent by a learner in completing the full set of LOs, may consist of only a minority of time spent on acquiring the knowledge-based LOs, while the

majority of time may well be spent on acquiring the competency-based LOs and associated practical skills.

Both knowledge and competencies in practical skills may include aspects of understanding. It is recommended that competencies in practical skills should be assessed by direct observation of practical/procedural skills (DOPS), a well-defined mechanism to measure a person's competence in a procedure or practical task, where their performance is assessed against predetermined criteria using a checklist (Laboratory Animal Science Association [UK] 2022). Such DOPS assessment takes into account the integration of knowledge, skills and attitude that are required to carry out the task. Training in practical skills should be based on standard operating procedures (SOPs).

Appropriate assessment plans will also be needed for knowledge-based LOs, as agreed upon by the relevant institutions, facilities, the LAS community and regulators. Knowledge-based assessment plans will need to consider the literacy of the target community, will be resource-dependent given the investment in time required to create and deliver the plans and to quality-assure them, and could in principle include question types such as multiple choice, extended matching, drag and drop, label the diagram, and other similar approaches, with due consideration of Bloom's taxonomy for educational learning objectives.

The depth of content of each LO, i.e. the details provided by the educator during teaching/training and the criteria required by the assessor for successful completion of the LO, should be specified at a level where it does not overload the learner with unnecessary information, so as to ensure that it remains relevant to the LAC, i.e. to ensure appropriate knowledge, understanding and competence in a practical skill.

The LOs presented here should in principle enable any South African institution to develop an E&T course or training programme for LACs who are working in their facilities or institution. Individual institutions, facilities and education providers will need to decide how to deliver education and training for each LO, including which animal species are relevant per facility, to ensure competence in practical skills on a per-species basis in each facility. This framework is also suitable for adaptation to other low-and-middle income countries. There is thus the potential for professional associations (e.g. SAALAS) to also play a role in promoting awareness of the LOs and/or assisting in establishing education and training opportunities.

The LOs are published with the intent that they will promote animal and human wellbeing, support ethical science, maintain public confidence, and in so doing, contribute to a just and civilised society.

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Conflict of interest

Author AJM was vice-president and member of the Executive Committee of SAALAS; employed by the University of Cape Town;

and Director of the veterinary specialist consulting firm Scientific Veterinary Consulting at the time of the SAALAS conference. Author JSM was a member of the Executive Committee of SAALAS; and employed by the University of Cape Town at the time of the SAALAS conference. Author DIL declares they have no conflicts of interest that are directly or indirectly related to the research.

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Ethical approval

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

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