E-Journal of Humanities, Arts and Social Sciences (EHASS)
ISSN – Online 2720-7722 | Print 2821-8949
Volume 6 Issue 13 Special Issue 2025 pp 81-98
Available online at: https://noyam.org/journals/ehass/
DOI: https://doi.org/10.38159/ehass.20256136

Training Approaches for HIV-Associated Neurocognitive Impairment Screening in Primary Healthcare during the Fourth Industrial Revolution

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ABSTRACT

The Fourth Industrial Revolution (4IR) is transforming healthcare, human capital, and economic development by driving innovations that enhance service delivery, workforce capacity, and health outcomes. Despite these advancements, co-morbidities associated with HIV remain a public health challenge in South Africa, highlighting the need for innovative and culturally responsive approaches to care and training. HIV-associated neurocognitive impairment (H-NCI) knowledge and screening practices remain limited at the primary healthcare level in low- and middle-income countries. Existing training programmes for frontline primary healthcare workers rarely shift from traditional methods which limits the accessibility of such knowledge and reduces the effectiveness of timely screening in resource-constrained settings. Drawing from an in-field H-NCI training programme piloted among a cohort of South African primary healthcare workers, this paper outlines the theoretical underpinnings, teaching methodologies, evaluation strategies, and feedback mechanisms, offering lessons and recommendations for scaling similar interventions in other low- and middle-income countries. Increasing evidence indicates that H-NCI can negatively affect people living with HIV. To address gaps in screening practices and build on existing healthcare worker knowledge, the curriculum was designed to be contextually relevant and practical. The training programme combined YouTube-based materials, interactive case learning, scenario simulations, and discussions to support the identification and management of H-NCI. Following the training, healthcare workers reported increased knowledge of H-NCI and successfully administered a screening tool two months post-intervention. Overall, the programme strengthened their contextual understanding of H-NCI and developed practical screening skills among primary healthcare workers delivering frontline HIV services.

Keywords: Africa, continued medical education, HIV-associated dementia, training

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Publication History
Received: 18th May, 2025
Accepted: 5th November, 2025
Published online: 30th December, 2025

To Cite this Article:
Munsami, Adele Delysia. "Training Approaches for HIV-Associated Neurocognitive Impairment Screening in Primary Healthcare during the Fourth Industrial Revolution," *E-Journal of Humanities, Arts and Social Sciences* 6, no. 13 (2025): 68 - 80, https://doi.org/10.38159/ehass.20256136.

INTRODUCTION

In South Africa, approximately 8.0 million people are living with HIV (PLWH).[1] Seventy-eight percent of PLWH in South Africa are currently receiving antiretroviral therapy (ART).[2] Although HIV is recognised as a manageable, chronic illness following widespread availability of ART, there remain

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[2] StatsSA., "Mid-Year Population Report."

concerns for co-morbidities.[3] PLWH remain at risk of comorbidities, including HIV-associated neurocognitive impairment (H-NCI), even though the fourth industrial revolution (4IR) has seen the emergence of widespread availability of effective ART.[4]

HIV is able to invade the central nervous system, causing inflammation, which may then cause a range of neurocognitive and functional challenges among PLWH.[5] H-NCI varies in signs, symptoms, and clinical course, ranging from mild neurocognitive impairment to dementia, its most severe form.[6] PLWH with H-NCI typically experience difficulties with attention, memory, learning, problem solving, decision making, as well as with activities required for everyday functioning, including ART adherence.[7] Although the incidence of HIV dementia has fallen dramatically, the risk of developing milder H-NCI remains a concern.[8]

The diagnosis of H-NCI requires healthcare workers to have knowledge of the signs and symptoms, as well as the appropriate skills to identify H-NCI.[9] Appropriately trained personnel are limited in low-and middle-income countries like South Africa, especially at a primary healthcare level, where HIV services are predominantly provided, even in the era of 4IR.[10] These facilities experience high patient volumes, interruptions, and shortages in healthcare workers.[11] Medical, surgical, and neurosurgical specialities have adopted task-sharing to address these shortages in this setting.[12] Task-sharing involves reassigning services traditionally performed by specialists to less specialised cadres, supported by supervision and increasingly enabled through digital tools and decision-support technologies emerging in the 4IR.[13] In the context of the 4IR, such approaches are increasingly supported by digital innovations, including clinical decision-support tools and mobile health technologies that can guide and enhance

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[4] R. K., Heaton et al., "HIV-Associated Neurocognitive Disorders Persist in the Era of Potent Antiretroviral Therapy: Charter Study," *Neurology* 75, no. 23 (2010): 2087–96; Htein Linn Aung et al., "Cognitive Health in Persons with Human Immunodeficiency Virus: The Impact of Early Treatment, Comorbidities, and Aging," *The Journal of Infectious Diseases* 227, no. Supplement_1 (2023): S38–47; Ruaridh Cameron Smail and Bruce James Brew, "HIV-Associated Neurocognitive Disorder," *Handbook of Clinical Neurology* 152 (2018): 75–97.

[5] Sherri L Carter et al., "Cognitive Complaints, Depression, Medical Symptoms, and Their Association with Neuropsychological Functioning in HIV Infection: A Structural Equation Model Analysis.," *Neuropsychology* 17, no. 3 (2003): 410; Sarah B Joseph et al., "Biotypes of Central Nervous System Complications in People with Human Immunodeficiency Virus: Virology, Immunology, and Neuropathology," *The Journal of Infectious Diseases* 227, no. Supplement_1 (2023): S3–15.

[6] Joseph et al., "Biotypes of Central Nervous System Complications in People with Human Immunodeficiency Virus: Virology, Immunology, and Neuropathology"; Gulnaz Mohamoud et al., "Perceptions Regarding the Scope of Practice of Family Doctors amongst Patients in Primary Care Settings in Nairobi," *African Journal of Primary Health Care and Family Medicine* 10, no. 1 (2018): 1–7; Crystal C. Watkins and Glenn J. Treisman, "Cognitive Impairment in Patients with AIDS–Prevalence and Severity," *HIV/AIDS-Research and Palliative Care*, 2015, 35–47.

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[8] Joseph et al., "Biotypes of Central Nervous System Complications in People with Human Immunodeficiency Virus: Virology, Immunology, and Neuropathology"; Heaton et al., "HIV-Associated Neurocognitive Disorders Persist in the Era of Potent Antiretroviral Therapy: Charter Study."

[9] J. A. Joska et al., "A Comparison of Five Brief Screening Tools for HIV-Associated Neurocognitive Disorders in the USA and South Africa," *AIDS and Behavior* 20, no. 8 (2016): 1621–31.

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[13] F. C. Robertson, L. Lippa, and M. L. Broekman, " Task Shifting and Task Sharing for Neurosurgeons amidst the COVID-19 Pandemic," *Journal of Neurosurgery* 133, no. 1 (2020): 5–7; Tasneem Kathree et al., "Management of Depression in Chronic Care Patients Using a Task-Sharing Approach in a Real-World Primary Health Care Setting in South Africa: Outcomes of a Cohort Study," *Community Mental Health Journal* 59, no. 7 (2023): 1261–74.

frontline practice. However, it remains unclear whether task-sharing of H-NCI services to primary healthcare PHC workers can effectively close the existing service gaps in South Africa.[14]

This uncertainty is underscored by limited knowledge and experience related to H-NCI at the primary healthcare level. Two cross-sectional surveys of healthcare workers in South Africa found that knowledge of H-NCI and H-NCI screening was scarce.[15] The paucity in available literature describing H-NCI training highlights a potential skills development gap among healthcare workers in low- and middle-income countries. A recent scoping review identified only one single-day training programme across the continent that briefly addressed H-NCI, suggesting that both the content and format of existing training are insufficient for real-world application in resource-constrained and digitally evolving environments.[16]

To the researcher's knowledge, at the time of writing, there are no existing H-NCI training programmes designed to equip primary healthcare workers in South Africa with the skills required for effective screening. The primary aim of this paper was to describe the process of designing and developing a contextually relevant H-NCI training programme for implementation at the primary healthcare level in South Africa.[17] This article outlines the development of a digitally supported, work-integrated training intervention tailored for primary healthcare workers providing frontline HIV services. It also presents the theoretical framework underpinning the curriculum development, which integrates principles of culturally responsive pedagogy and leverages educational innovations emerging from the 4IR.

METHODOLOGY

Research Design

The in-field training adopted an exploratory, quasi-experimental, pre- and post-cohort training intervention. The details of the methodology and findings can be found in Munsami et al.[17] With a view toward task-shifting in a 4IR context and a push toward building capacity in the digital age, a contextualised work-integrated training programme for healthcare workers providing HIV services at primary healthcare facilities in South Africa was developed. A range of strategies was considered in the design and development of the training intervention, with the Exploration, Preparation, Implementation, and Sustainability (EPIS) framework serving as the overarching guide. Originally developed to support the integration of public health interventions in the United States, the EPIS framework has since been applied successfully in diverse global contexts, including South Africa.[18] Within this training, EPIS was used to conceptualise implementation as a dynamic, stage-based process, enabling the structured development of a responsive and scalable training programme. Table 1 outlines the EPIS stages and corresponding activities followed in the design of the Primary Healthcare H-NCI training intervention, summarising how relevant theoretical frameworks, such as Kern's model, experiential learning, and training evaluation strategies, were applied across each phase of the EPIS process to guide the intervention's development.

[14] Munsami et al., "HIV-Associated Neurocognitive Impairment Knowledge and Current Practices: A Survey of Frontline Healthcare Workers in South Africa."

[15] Munsami et al., "HIV-Associated Neurocognitive Impairment Knowledge and Current Practices: A Survey of Frontline Healthcare Workers in South Africa"; Hetta Gouse et al., "Assessing HIV Provider Knowledge, Screening Practices, and Training Needs for HIV-Associated Neurocognitive Disorders. A Short Report," *AIDS Care* 33, no. 4 (2021): 468–72.

[16] Adele Munsami et al., "Mental and Cognitive Healthcare Training Targeting Primary Healthcare Workers Providing HIV Services in Africa: A Scoping Review," *AIDS Care* 35, no. 2 (2023): 280–88.

[17] Adele Munsami et al., "Integrating HIV-Associated Neurocognitive Impairment Screening within Primary Healthcare Facilities: A Pilot Training Intervention," *Nursing Research and Practice* 2022, no. 1 (2022): 4495586.

[18] Nasreen S Jessani et al., "Integrated Knowledge Translation to Advance Noncommunicable Disease Policy and Practice in South Africa: Application of the Exploration, Preparation, Implementation, and Sustainment (EPIS) Framework," *Health Research Policy and Systems* 19, no. 1 (2021): 82.

Table 1: Training development process guided by EPIS framework

EPIS Stage		Intervention aim	Activity	Outcome
Exploration	Identify potential knowledge or gaps in existing health systems	Explore existing H-NCI knowledge, previous training and current practices among healthcare workers providing HIV services in South Africa.	Scoping review of H-NCI training literature Cross-sectional survey of healthcare workers providing HIV services in South Africa	We identified a paucity in the literature describing existing H-NCI training among healthcare workers providing HIV services in Africa. We found limited knowledge of H-NCI, and screening practices were uncommon among primary healthcare workers.
		Examine healthcare workers' views on H-NCI prevalence and screening at the primary healthcare level. Identify potential barriers to H-NCI screening at the primary healthcare level and healthcare workers' views on training.	Focus-group discussions with primary healthcare workers. In-depth interviews with primary healthcare workers	We identified gaps in H-NCI knowledge among healthcare workers. Healthcare workers desired training to identify H-NCI.
Preparation	Planning for the integration of the selected evidence-based practice into the existing system, including identifying potential challenges	Examine existing system components that could be strengthened to improve the integration of the proposed intervention at the primary healthcare level.	Consultation with key stakeholders, continued education managers and trainers from the Department of Health in South Africa	We gained insight into the existing systems at a primary healthcare level for potential implementation of an evidence-based practice and training preferences.
		Design and develop an H-NCI curriculum and training programme appropriate for providers at a primary healthcare level.	Consultation with the University's Higher Education Department.	Introduced to Kern’s six-step approach, outcomes-based education model and Kirkpatrick’s training evaluation strategy.

			Conducted extensive literature searches of training methods and evaluation strategies.	Identified academic detailing and Miller's pyramid for assessing clinical competence.
Implementation	Coaching and active facilitation of evidence-based practices are implemented.	Conduct training, demonstrations, and active facilitation of evidence-based practices in a real-world clinic setting.	Didactic lectures, case studies and group discussions.	Trained primary healthcare workers to identify signs and symptoms of H-NCI and to administer an H-NCI screening tool.
		Examine the feasibility, appropriateness, and acceptability of H-NCI screening at a primary healthcare level.	Pre- and post-questionnaires Simulation and direct observation of skills Provided feedback to participants	Evaluated the impact of training on knowledge and skills. Determine whether H-NCI training methods were feasible and appropriate. Determine which cadres were suitable to administer an H-NCI screening tool.
Sustainability	Address the use of the newly installed practices over time	Evaluate the use of the newly installed practices over 8 weeks	Pre- and post-questionnaires Simulation and direct observation of skills Provided feedback to participants	Evaluated retention of knowledge and skills.

Population and Sample

The empirical study underpinning this commentary has been published and focused on South African primary healthcare workers. The population included frontline healthcare workers delivering HIV services across South Africa. The pilot study was conducted in two primary healthcare facilities in KwaZulu-Natal (KZN), with a total of 32 participants, including professional nurses, enrolled nurses, and lay health workers. Participants were selected to reflect typical primary healthcare staffing structures and roles, providing insight into knowledge levels, screening practices, and training needs related to H-NCI.

Data Collection

A four-hour H-NCI training programme was implemented over two weekly, two-hour sessions at selected primary healthcare facilities.[19] The curriculum combined lectures to convey knowledge with practical exercises to build H-NCI skills, designed to be cost-effective, easily replicable, and minimally disruptive to routine patient care. Sessions were delivered on-site, ensuring staff remained available for clinical duties. Training was guided by academic detailing, a peer-to-peer approach in which trained professionals visit participants' work settings to demonstrate, discuss, and reinforce new skills, promoting adoption of interventions such as standardised assessment tools.[20] Iterative cycles of demonstration, discussion, and feedback supported contextualised learning and competency development in H-NCI screening. Full details of the pilot programme's development and data collection procedures are available in the previously published study.[21]

Data Analysis

Data was analysed using IBM SPSS Statistics version 27. (IBM Corp., 2017). H-NCI knowledge was compared across professional groups, including general medical doctors, nurses, and adherence counsellors, at three time points: pre-training, immediately post-training, and eight weeks post-training. Analyses included frequency distributions and Fisher's exact test, with results reported as means and standard deviations to summarise group performance and assess changes over time, which have been previously published.[22]

Ethical Considerations

Ethical approval for the study within which the training intervention was developed, was granted by the University of Cape Town Faculty of Health Sciences Human Research Ethics Committee (H/REC 624/2018), as well as the City of Cape Town Department of Health and the KwaZulu-Natal Department of Health in the Ugu District. The training programme received additional approval from the HIV and Sexually Transmitted Infections (HAST) district manager, the district mental health manager, the operational manager, and the chief executive officer at each participating facility. All participants provided written informed consent prior to participating in the training.

DISCUSSION

Developing the Training Curriculum

The Primary Healthcare H-NCI training curriculum was guided by Kern's 6-step approach to curriculum development, which aligns with the principles of the EPIS framework. Kern's 6-step approach has been successfully applied within medical education across multiple specialities and training and has been described as a practical and theoretically sound approach to developing, implementing, evaluating and

[19] Munsami et al., "Integrating HIV-Associated Neurocognitive Impairment Screening within Primary Healthcare Facilities: A Pilot Training Intervention."

[20] Aaron R Lyon et al., "Developing the Mental Health Workforce: Review and Application of Training Approaches from Multiple Disciplines," *Administration and Policy in Mental Health and Mental Health Services Research* 38, no. 4 (2011): 238–53; Ann F Garland, Marc Kruse, and Gregory A Aarons, "Clinicians and Outcome Measurement: What's the Use?," *The Journal of Behavioral Health Services & Research* 30, no. 4 (2003): 393–405.

[21] Munsami et al., "Integrating HIV-Associated Neurocognitive Impairment Screening within Primary Healthcare Facilities: A Pilot Training Intervention."

[22] Munsami et al., "Integrating HIV-Associated Neurocognitive Impairment Screening within Primary Healthcare Facilities: A Pilot Training Intervention."

continually improving health education.[23] The curriculum was informed by the following six steps 1) problem identification and general needs assessment among healthcare workers, (2) targeted needs assessment of healthcare workers educational needs, (3) goals and objectives of the educational intervention, (4) appropriate educational strategies for work-integrated learning among primary healthcare workers, (5) implementation of training intervention and (5) feedback and evaluation of training intervention (Figure 2).

i. Problem identification and general needs assessment of healthcare workers' educational needs

A scoping review of available published literature showed that there were limited data on H-NCI training provided to primary healthcare workers in Africa.[24] Due to the paucity in this data, mental health trainings targeting primary healthcare workers providing HIV services were assessed. Mapping what is known on mental health training, which may include H-NCI or similar concepts, is a useful base to examine brain and/or behaviour training approaches targeting frontline HIV healthcare workers. This also allowed the researcher to examine the curriculum, training approach and common methods of implementation that were rigorously tested and peer reviewed, ensuring that the training intervention design was appropriate for healthcare workers providing HIV services.

ii. Targeted needs assessment

Focus group discussions and in-depth interviews were conducted due to the paucity of available published studies detailing the training of primary healthcare workers to administer cognitive impairment screening tools to PLWH.[25] These discussions and interviews explored H-NCI knowledge in more detail to identify specific knowledge gaps, healthcare workers' previous training and their perceptions of the best training methods in this context. These interviews highlighted that frontline healthcare workers were aware of symptoms of H-NCI but often associated these symptoms with treatment side effects or depression, and showed a need to provide information which distinguished H-NCI from other illnesses or conditions. The interviews also highlighted primary healthcare workers' preference for face-to-face training, as well as their willingness and desire to learn more about H-NCI through further training.

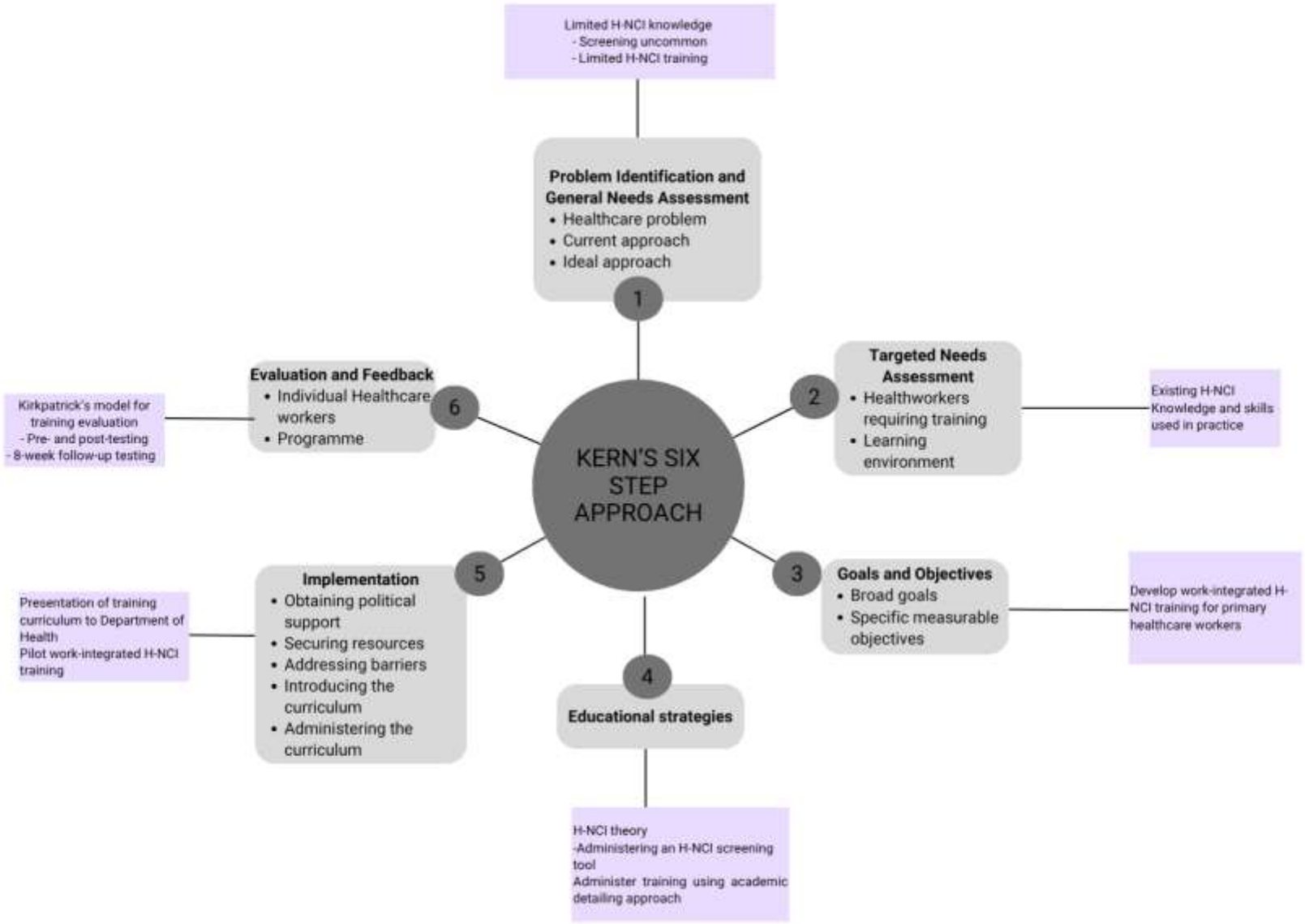
iii. Goals and objectives of the educational intervention

The Primary Healthcare H-NCI training curriculum was designed to address key learning areas, goals and objectives informed by the needs assessments. The first objective of the intervention was to develop an appropriate training programme to equip primary healthcare workers with knowledge on H-NCI, to be able to identify signs and symptoms among patients accessing care. The second objective was to train primary healthcare workers to administer an H-NCI screening tool, and the final objective was to explore retention of the knowledge and skills over time among these cadres of healthcare workers.

[23] Amy C Robertson et al., "Application of Kern's 6-Step Approach in the Development of a Novel Anesthesiology Curriculum for Perioperative Code Status and Goals of Care Discussions," *The Journal of Education in Perioperative Medicine: JEPM* 21, no. 1 (2019): E634; Leigh R Sweet and Debra L Palazzi, "Application of Kern's Six-Step Approach to Curriculum Development by Global Health Residents," *Education for Health* 28, no. 2 (2015): 138–41.

[24] Munsami et al., "Mental and Cognitive Healthcare Training Targeting Primary Healthcare Workers Providing HIV Services in Africa: A Scoping Review."

[25] Adele Munsami et al., "Exploring HIV-Associated Neurocognitive Impairment in the Era of Effective Antiretroviral Therapy: A Primary Healthcare Perspective," *Qualitative Health Research* 32, no. 10 (2022): 1487–97.


Limited H-NCI knowledge
- Screening uncommon
- Limited H-NCI training
Problem Identification and General Needs Assessment
• Healthcare problem
• Current approach
• Ideal approach
1
Targeted Needs Assessment
• Healthworkers requiring training
• Learning environment
2
Existing H-NCI Knowledge and skills used in practice
Goals and Objectives
• Broad goals
• Specific measurable objectives
3
Develop work-integrated H-NCI training for primary healthcare workers
4
Educational strategies
H-NCI theory
-Administering an H-NCI screening tool
Administer training using academic detailing approach
Implementation
• Obtaining political support
• Securing resources
• Addressing barriers
• Introducing the curriculum
• Administering the curriculum
5
Presentation of training curriculum to Department of Health
Pilot work-integrated H-NCI training
Evaluation and Feedback
• Individual Healthcare workers
• Programme
6
Kirkpatrick's model for training evaluation
- Pre- and post-testing
- 8-week follow-up testing
KERN'S SIX STEP APPROACH

i. Educational strategies

The curriculum was designed as a blended learning programme, comprising both theoretical and practical components to support knowledge acquisition and clinical skill development. The theoretical component included didactic lectures, case studies, and group discussions, while the practical component incorporated video demonstrations, interactive role-playing, and scenario-based learning. To facilitate structured delivery and promote scalability, two core training resources were developed: a participant workbook and a trainer manual. The workbook outlined the key learning objectives, theoretical content, applied exercises, and embedded assessments. The trainer manual adopted a rubric-based lesson plan format, providing facilitators with step-by-step guidance, time allocations, suggested dialogue, and multimedia requirements to ensure fidelity and reproducibility across sites. This approach closely mirrored that of Sibeko et. al. who implemented a mental health training programme for community health workers in South Africa.[26] The inclusion of multimedia aids and structured instructional support aligns with 4IR principles of accessible, technology-enabled, and standardised training delivery in resource-constrained settings.

Curriculum Appraisal

A participatory curriculum design approach to evaluate the training curriculum was used.[27] This approach relied on the involvement of stakeholders and end users in the design and evaluation process, as well as facilitating buy-in from key personnel to support the roll-out of the proposed intervention.[28] The H-NCI training curriculum was evaluated by the HAST Ugu district manager in KwaZulu-Natal, who is involved in continued education. The Ugu district mental health manager and trainers from other districts in KwaZulu-Natal also evaluated the training curriculum. Feedback was provided using the criteria for high-quality interventions outlined by Jacobs et.al.[29]

Training delivery

The training was delivered using a learner-centred, competency-based approach grounded in principles of active and experiential learning.[30] This approach prioritises engagement, critical thinking, and real-world problem-solving by integrating collaborative activities, case studies, and hands-on practice.[31] The design incorporated blended learning methods that combine synchronous and asynchronous digital platforms to enhance accessibility and flexibility. Leveraging emerging technologies such as interactive demonstrations and mobile learning, participants are empowered to personalise their learning journey and apply their skills dynamically in diverse contexts. Repeat follow-up assessment and reflective practice are embedded to support mastery and lifelong learning beyond the training environment. The delivery of the training intervention is described in greater detail by Munsami et al., (2022).[33]

ii. Implementation

The Primary Healthcare H-NCI training adopted an academic detailing approach, which has received considerable research attention and empirical support.[32] Academic detailing has been used in psychiatric

[26] Sibeko et al., "Piloting a Mental Health Training Programme for Community Health Workers in South Africa: An Exploration of Changes in Knowledge, Confidence and Attitudes."

[27] Melissa-Sue John et al., "An Iterative Participatory Approach to Developing an Early Childhood Problem-Based STEM Curriculum.," *Grantee Submission* 3, no. 3 (2018).

[28] John et al., "An Iterative Participatory Approach to Developing an Early Childhood Problem-Based STEM Curriculum."; Mary Sidebotham et al., "Midwifery Participatory Curriculum Development: Transformation through Active Partnership," *Nurse Education in Practice* 25 (2017): 5–13.

[29] Ary D et al., "Introduction to Research in Education: Cengage Learning," 2018.

[30] Felix Chad, "Designing Competency-Based and Experiential Learning Materials for Future-Proof Education," 2025; Claudine Muraraneza and Gloria Ntombifikile Mtshali, "Conceptualization of Competency Based Curricula in Pre-Service Nursing and Midwifery Education: A Grounded Theory Approach," *Nurse Education in Practice* 28 (2018): 175–81.

[31] Richard A Voorhees and Alice Bedard-Voorhees, "Principles for Competency-Based Education," in *Instructional-Design Theories and Models, Volume IV* (Routledge, 2016), 33–64.

[33] Munsami et al., "Integrating HIV-Associated Neurocognitive Impairment Screening within Primary Healthcare Facilities: A Pilot Training Interventio

[32] Lyon et al., "Developing the Mental Health Workforce: Review and Application of Training Approaches from Multiple Disciplines."

healthcare interventions.[33] The approach involves in-person visits to the work setting of the target audience from a trained professional. During the visit, the trained professional demonstrates the new practices and discusses the intervention.[34] Garland et.al. suggest that academic detailing could be used to increase the use of standardised assessment tools, which are often not routine in community practice, highlighting the appropriateness of this approach for the training intervention that was developed. [35]

The most common techniques involved in academic detailing include targeted pre-training assessment and feedback about the knowledge and current practices of individuals and groups.[36] This is commonly done through survey evaluations of providers' understanding of concepts or tracking specific practices, for example, screening practices or referrals.[37] The pre-assessments were followed by didactic information sessions informed by the training curriculum. This was followed by active and open-ended questioning sessions, which allowed participants to engage with the facilitator on the content, clarify concepts or request further information to aid learning.[38] Academic detailing involves the distribution of reference materials that contain the content of the training, for example, a participant workbook, as well as a specific plan to promote the implementation of learned skills in practice following the training, which was utilised in this training. Return visits from the trained professional or training facilitator enforced key messages and conducted post-training assessments, are typically between one to two visits.[39]

The training intervention was implemented among healthcare workers providing HIV services at primary healthcare facilities in KwaZulu-Natal. Participants included medical doctors, professional nurses, and adherence counsellors, cadres typically involved in task-sharing practices within low- and middle-income countries. Given the high patient volumes and staffing constraints common in these settings, the Primary Healthcare H-NCI training was designed to be minimally disruptive and contextually feasible. Two structured sessions, each lasting approximately two hours, were delivered on-site during allocated meeting times to accommodate clinical responsibilities. An additional session featured ten-minute simulations and direct observation of procedural skills, where participants were assessed on their ability to administer the H-NCI screening tool. This work-integrated approach enabled real-time application of knowledge and skills within the clinical environment.[40]

iii. Feedback and evaluation

The evaluation of the Primary Healthcare H-NCI training was guided by Kirkpatrick's model of training evaluation.[41] This model consists of four levels of evaluation, which include 1) reaction, 2) learning, 3) behaviour and 4) results (Figure 3).[42] Kirkpatrick's model has been used to evaluate training interventions targeting healthcare workers in several countries.[43]

The first level of the Kirkpatrick model evaluates trainees' reaction to the training. This involved the examination of the trainees' impressions and perceptions of the program following the intervention.[44] Healthcare workers participating in the Primary Healthcare H-NCI training provided feedback by completing a survey at the end of the training. The survey assessed key components of the training intervention, including the perceived value of the training, satisfaction with the training curriculum and the H-NCI screening tool, as well as whether healthcare workers would recommend the

[33] Lyon et al., "Developing the Mental Health Workforce: Review and Application of Training Approaches from Multiple Disciplines"; Laura Desveaux et al., "Improving the Appropriateness of Antipsychotic Prescribing in Nursing Homes: A Mixed-Methods Process Evaluation of an Academic Detailing Intervention," *Implementation Science* 12, no. 1 (2017): 71.
[34] Lyon et al., "Developing the Mental Health Workforce: Review and Application of Training Approaches from Multiple Disciplines."
[35] Garland, Kruse, and Aarons, "Clinicians and Outcome Measurement: What's the Use?"
[36] Lyon et al., "Developing the Mental Health Workforce: Review and Application of Training Approaches from Multiple Disciplines."
[37] Lyon et al., "Developing the Mental Health Workforce: Review and Application of Training Approaches from Multiple Disciplines."
[38] Lyon et al., "Developing the Mental Health Workforce: Review and Application of Training Approaches from Multiple Disciplines."
[39] Lyon et al., "Developing the Mental Health Workforce: Review and Application of Training Approaches from Multiple Disciplines."
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[41] Donald L Kirkpatrick and R L Craig, "Evaluation of Short-Term Training in Rehabilitation," *Evaluation of Training; Oregon University: Eugene, OR, USA*, 1970, 35–56.
[42] Andy Smidt et al., "The Kirkpatrick Model: A Useful Tool for Evaluating Training Outcomes," *Journal of Intellectual and Developmental Disability* 34, no. 3 (2009): 266–74.
[43] Mohammad Reza Heydari et al., "Using Kirkpatrick's Model to Measure the Effect of a New Teaching and Learning Methods Workshop for Health Care Staff," *BMC Research Notes* 12, no. 1 (2019): 388.
[44] Smidt et al., "The Kirkpatrick Model: A Useful Tool for Evaluating Training Outcomes."

training program to other primary healthcare workers. The researcher also provided participants with the opportunity to make suggestions to improve future H-NCI training.

The second level of this model, learning, allows participants to demonstrate their understanding of specific skills and/or knowledge gained from the training.[45] The Primary Healthcare H-NCI trainee assessments were designed using Miller's pyramid for assessing clinical competence as a framework (see Figure 4). This framework has been used to assess clinical competence among students in healthcare fields, including those training as medical doctors and nurses. This model emphasises the importance of acquiring knowledge to perform a task in practice and has been successfully used to assess diagnostic and management skills in medical education.[46] Figure four illustrates the following four levels: knowledge (knows), competence (knows how), performance (shows how), and action (does).[47] Pre- and post-multiple-choice questionnaires were used to evaluate knowledge, as well as participants' attitudes and comfort with H-NCI tools before and after the training. The questions were adapted from a validated tool developed by Johnston et. al, measuring knowledge, attitude and behaviour among students in healthcare fields.[48]

The third level is behaviour or performance, which involves the assessment of the trainees' ability to apply newly learned knowledge or skills in practice.[49] At the end of the Primary Healthcare H-NCI training, key feature cases were used to assess whether participants knew how to identify symptoms of H-NCI. The team also used direct observations of procedural skills to assess participants' ability to administer screening tools to a standardised patient, as part of a simulation.[50]

The final level of the Kirkpatrick model measures the overall impact of the training, such as increased knowledge of H-NCI or identification of H-NCI symptoms at a primary healthcare level. The researcher conducted follow-up assessments to determine whether participants' knowledge and skills were retained two months post-training. This, with a view toward improving the curriculum, teaching methods, evaluation strategies and the overall methodology of the Primary Healthcare H-NCI training for future interventions.

[45] Smidt et al., "The Kirkpatrick Model: A Useful Tool for Evaluating Training Outcomes."

[46] John J Norcini, "ABC of Learning and Teaching in Medicine," *Work Based Assessment. BMJ* 326, no. 7392 (2003): 753–55; Blazar E, Krishnan V, and Mody S, "ICE BLOG," *Https://Icenetblog.Royalcollege.ca/2020/03/03/Education-Theory-Made-Practical-Volume-4-Part-5/.*, 2020.

[47] Norcini, "ABC of Learning and Teaching in Medicine"; Blazar E, Krishnan V, and Mody S, "ICE BLOG."

[48] Janice M Johnston et al., "The Development and Validation of a Knowledge, Attitude and Behaviour Questionnaire to Assess Undergraduate Evidence-based Practice Teaching and Learning," *Medical Education* 37, no. 11 (2003): 992–1000.

[49] Smidt et al., "The Kirkpatrick Model: A Useful Tool for Evaluating Training Outcomes."

[50] Val Wass et al., "Assessment of Clinical Competence," *The Lancet* 357, no. 9260 (2001): 945–49.

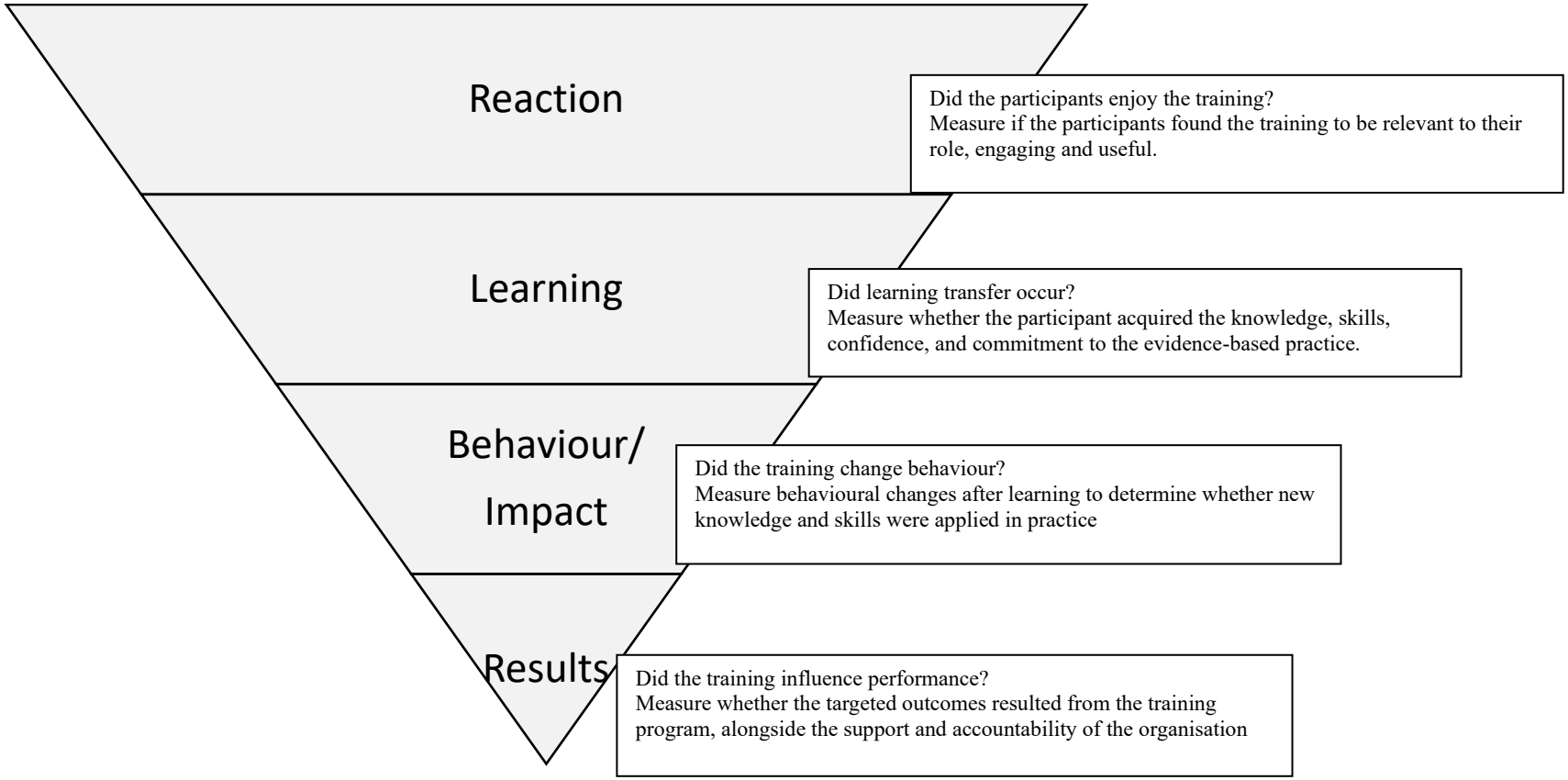

Figure 3: Kirkpatrick's four levels of training evaluation[51]

[51] Kirkpatrick and Craig, "Evaluation of Short-Term Training in Rehabilitation"; Smidt et al., "The Kirkpatrick Model: A Useful Tool for Evaluating Training Outcomes."

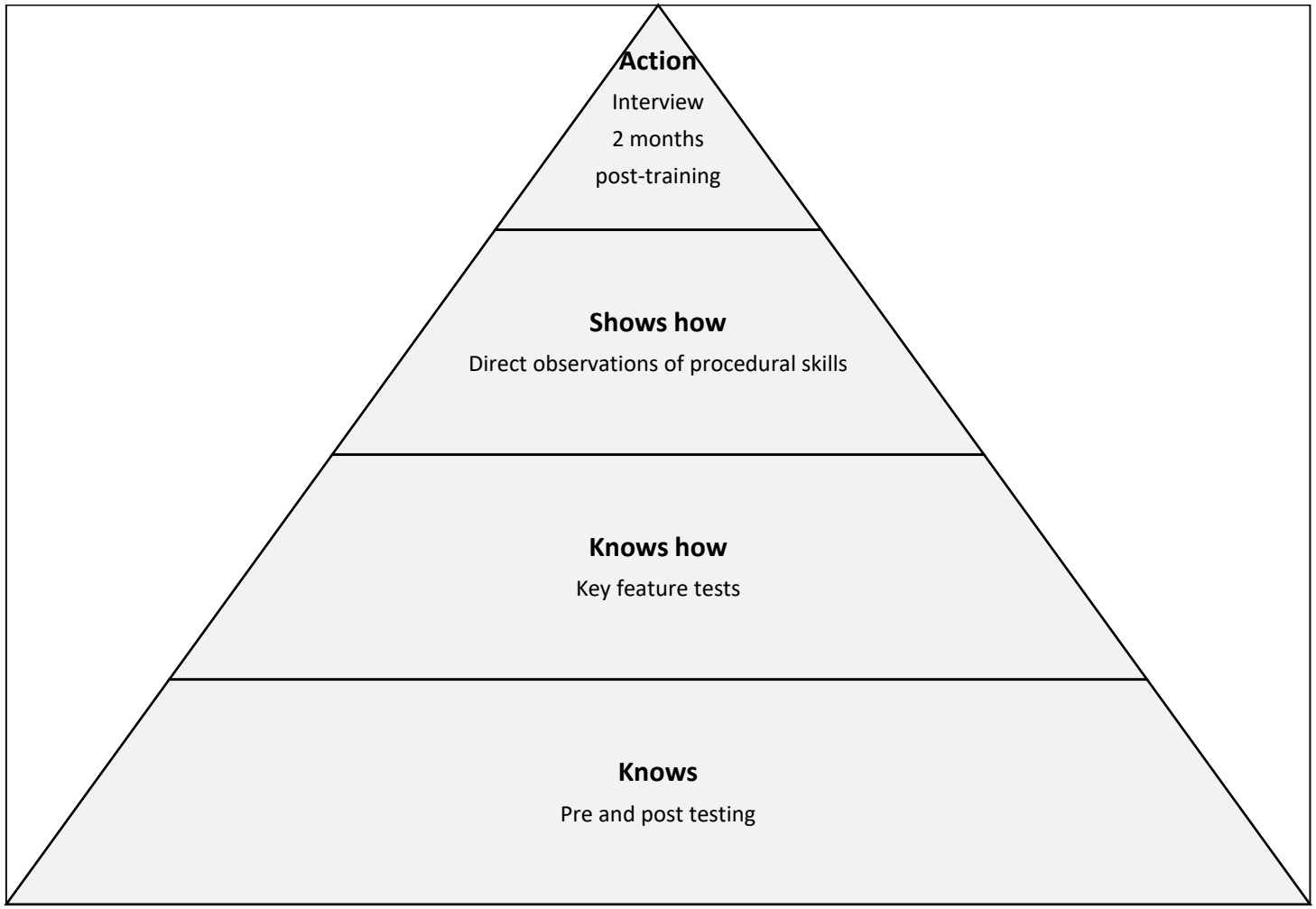

Figure 4: Evaluation strategy adapted from Millers Pyramid of clinical competency[52]

[52] Blazar E, Krishnan V, and Mody S, "ICE BLOG."

Lessons Learned

Symptomatic H-NCI remains a persistent risk, particularly among PLWH who are non-adherent to ART. Despite this, published literature describing H-NCI training interventions for healthcare workers in low- and middle-income countries remains limited.[53] To the author's knowledge, this is the first article to detail the design, development, and piloting of an H-NCI training programme tailored for primary healthcare workers delivering HIV services in South Africa.

A central question guiding this intervention was whether a standardised H-NCI screening tool could be reliably administered by healthcare workers at the primary care level, where the majority of PLWH access services. The programme targeted various cadres, including medical doctors, professional nurses, staff nurses, and adherence counsellors.[54] Findings from the pilot suggest that medical doctors and professional nurses, who are more frequently involved in clinical decision-making, were better positioned to administer the H-NCI screening tool after two structured training sessions and ongoing practice over an eight-week period. In contrast, adherence counsellors encountered difficulties with several components of the screening tool and required more intensive support to achieve proficiency. Within the typical clinic workflow, adherence counsellors may be more appropriately tasked with identifying symptoms of H-NCI, rather than conducting the full screening process.[55] This highlights the need for a differentiated training approach: one that focuses on symptom recognition for counsellors and full screening competency for clinicians.

The researcher also explored the feasibility and utility of a work-integrated learning model in the context of high-volume, resource-constrained primary healthcare settings. The on-site delivery model enabled higher participation by accommodating existing meeting schedules and minimising disruptions to clinical care. However, frequent interruptions, which are common at this level of care, due to patient care responsibilities and staff shortages, may have compromised the depth of learning for some participants.[56] These findings underscore the need for adaptable training formats that are both time-efficient and robust enough to support clinical skill development under real-world constraints in the 4IR.

Ongoing mentorship emerged as a critical component of effective skills transfer, particularly given the complexity of administering H-NCI screening tools. These tools demand the ability to multitask, assign accurate scores, and communicate results clearly, skills that benefit from iterative feedback. Follow-up visits allowed facilitators to identify persistent challenges, reinforce correct administration techniques, and troubleshoot contextual barriers. While this academic detailing approach proved effective, it requires sustained investment in time and personnel. Nonetheless, leveraging routine staff meetings as dedicated slots for mentorship and skills reinforcement presents a practical, low-cost strategy to sustain training gains and align with scalable 4IR-enabled capacity-building models.

CONCLUSION

The shortage of trained healthcare workers in low- and middle-income countries, particularly those equipped to recognise H-NCI, necessitates innovative strategies such as task-sharing from specialists to frontline providers. This training discussed in this manuscript explored whether primary healthcare workers in South Africa could effectively administer an H-NCI screening tool within the constraints of high-volume clinical settings. Using the EPIS framework as a guiding structure, the researcher designed and implemented a contextually relevant, work-integrated training programme that prioritised minimal disruption to service delivery.

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[53] Munsami et al., "Exploring HIV-Associated Neurocognitive Impairment in the Era of Effective Antiretroviral Therapy: A Primary Healthcare Perspective."
[54] Munsami et al., "Mental and Cognitive Healthcare Training Targeting Primary Healthcare Workers Providing HIV Services in Africa: A Scoping Review."
[55] Joska and Sorsdahl, "Integrating Mental Health into General Health Care: Lessons from HIV."
[56] Westbrook et al., "The Impact of Interruptions on Clinical Task Completion."

The training demonstrated that medical doctors and professional nurses could competently administer the H-NCI screening tool following structured instruction and practice. However, sustained mentorship remains essential for consolidating skills, particularly when introducing clinical tools not routinely used at this level of care. Adherence counsellors, while integral to the HIV care cascade, may be better positioned to identify early signs and symptoms of H-NCI and should receive training tailored to that specific role.

The integration of a work-based learning model proved feasible in overburdened clinical environments and aligns with scalable, digitally supported approaches characteristic of the 4IR. As such, further refinement of H-NCI training should explore blended delivery formats, mentorship models, and differentiated learning pathways to enhance adaptability and reach. Continued evaluation of training feasibility, acceptability, and clinical utility in low- and middle-income countries remains critical to strengthening frontline capacity to address neurocognitive health in HIV care.

Acknowledgments: The author wishes to thank the Department of Health for their assistance, all facilities and healthcare workers who participated in training. The author places on record her thanks to the South African Neurocognitive Association (SACNA), the National Institute for Human and Social Sciences (NIHSS), in collaboration with the South African Humanities Deans Association (SAHUDA) and the David and Elaine Potter Fellowship programme for their support. The researcher also thanks Professor John Joska, Professor Sam Nightingale, Professor Hetta Gouse and Professor Goodman Sibeko for their contributions.

Conflicts of interest/Competing interests: The author declares no conflict of interests.

Authors' contributions: AM developed, revised, and submitted the final manuscript for review.

Funding: This research received no specific grant from any funding agency in the public, commercial or non-profit sectors.

Data: There are no available data.

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