

Mapping the Evolution of Competency-Based Veterinary Education: A Decadal Bibliometric Review

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Abstract | Competency-Based Veterinary Education (CBVE) has emerged as a dominant framework for aligning veterinary training with professional practice demands. However, a systematic understanding of both the evolution of CBVE research and its alignment with diverse global veterinary systems remains limited. This study provides a bibliometric and visual analysis of CBVE literature indexed in the Web of Science Core Collection from 2016 to 2025. Using VOS viewer, we analyzed publication trends, citation patterns, co-authorship networks, co-citation structures, and keyword co-occurrence. A total of 729 publications were identified, demonstrating a marked increase in research output and citation impact over time. Results reveal a strong concentration of CBVE scholarship within a small number of core journals and high-income countries, particularly the United States, the United Kingdom, and Canada. Such structural concentration may create topic and feasibility biases (e.g., privileging resource-intensive assessment architectures), which can threaten external validity for resource-constrained training systems. Thematic evolution indicates an expansion from early emphases on skills assessment and simulation toward broader programmatic integration (e.g., Entrustable Professional Activities and longitudinal feedback systems) and system-facing priorities (e.g., One Health and learner/professional well-being). Synthesizing these patterns, we propose a three-stage developmental model (measurement → programmatic integration → social accountability/competence-in-context) to organize how CBVE scholarship is responding to workforce and public health demands. The most formidable barrier to aligning CBVE with diverse contexts appears to be a self-reinforcing publication/indexing ecosystem coupled with resource gradients, which amplifies “core” frameworks while underrepresenting locally adapted innovations. Aligning CBVE frameworks with diverse veterinary service contexts is essential for strengthening animal health systems and One Health capacity worldwide.

Keywords | Competency-based veterinary education, Bibliometric analysis, VOS viewer, Curriculum development, One health

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INTRODUCTION

The late 20th century marked a broad shift in global higher education toward outcomes-oriented training, emphasizing measurable competencies rather than time-based credit accumulation (Banse *et al.*, 2024). This shift

is particularly consequential in veterinary medicine because veterinary graduates are increasingly expected to deliver care that is safe, ethical, and accountable to society while responding to evolving demands in animal welfare, food systems, and zoonotic risk at the human animal environment interface (Mwatondo *et al.*, 2023;

Smith *et al.*, 2022). Against this backdrop, competency-based education (CBE) organizes curricula, instruction, and assessment around explicitly defined competencies, with learner progression contingent on demonstrated performance rather than fixed instructional duration (Read and Gonya, 2024). From an animal and veterinary sciences perspective, such reforms are not only pedagogical: they influence the readiness and capacity of the veterinary workforce to support animal health services and One Health preparedness in diverse practice contexts (Baines *et al.*, 2024).

In veterinary education, major competency frameworks including North American and European “Day One” expectations have accelerated the adoption of competency-based approaches (Matthew *et al.*, 2020). In parallel, CBVE scholarship has expanded across curriculum design, assessment architecture, clinical training innovations, and faculty development. However, implementation remains challenging. Recent work highlights persistent issues such as inconsistent definitions of competence, the resource intensity of assessment infrastructures, and cultural and logistical constraints that can limit sustainability and cross-context transferability (Decloedt *et al.*, 2021; Gordon *et al.*, 2023). Implementation-focused syntheses further emphasize the need to preserve fidelity to core CBVE principles while allowing adaptation to local conditions an issue that is especially salient for institutions operating under constrained resources or differing service delivery realities (Chaney and Hodgson, 2021).

To understand how a scholarly field is structured identifying its core contributors, influential outlets, and the evolution of research themes over time bibliometric analysis paired with visualization tools (e.g., VOSviewer) offers a powerful, quantitative approach. It maps growth patterns, collaboration networks, co-citation structures, and thematic frontiers in ways that complement traditional qualitative reviews (Donthu *et al.*, 2021; Moral-Muñoz *et al.*, 2020). Applying this macro-level lens to Competency-Based Veterinary Education (CBVE) is particularly consequential. It can reveal the intellectual architecture of the field, showing where research efforts and collaborations are concentrated, and how the discourse aligns with pressing societal needs such as workforce capacity and One Health. However, such a comprehensive, data-driven portrait of CBVE scholarship is currently absent. This study therefore employs a bibliometric and visual analysis to provide this missing perspective, not to critique pedagogical approaches, but to inform future research and resource allocation by making the field’s dynamics and gaps empirically visible.

Therefore, this study conducts a bibliometric and visual analysis of CBVE-related research indexed in the Web of Science Core Collection (2016–2025) to: (1) characterize

publication and citation trends and identify core outlets and influential contributions; (2) map collaboration and concentration patterns across authors, institutions, and countries/regions; and (3) reveal major thematic clusters and their temporal evolution to inform future research and educational practice primarily by identifying where evidence is concentrated or missing (rather than implying pedagogical superiority) especially where veterinary education intersects with workforce capacity, One Health priorities, and the delivery of accessible animal healthcare.

MATERIALS AND METHODS

DATA SOURCE AND SEARCH STRATEGY

The bibliometric data used in this study were retrieved from the Web of Science Core Collection (WoSCC), which was selected for its rigorous indexing standards and widespread use in bibliometric research (Wider *et al.*, 2025). The search was conducted on January 19, 2026, covering publications from January 2016 to December 2025.

To capture literature related to CBVE, a topic-based search was performed using the following query:

TS=((“veterinary educat*” OR “veterinary curriculum” OR “veterinary school*” OR “veterinary student*”) AND (“competenc*” OR “skill*” OR “clinical skill*” OR “professional skill*” OR “day-one skill*” OR “outcome-based educat*” OR “CBVE”))

Only peer-reviewed “Article” and “Early Access” written in English were included. Conference proceedings, editorials, letters, and non-research items were excluded to ensure data consistency and analytical rigor. After screening and deduplication, a total of 729 records were retained for subsequent analysis (Figure 1).

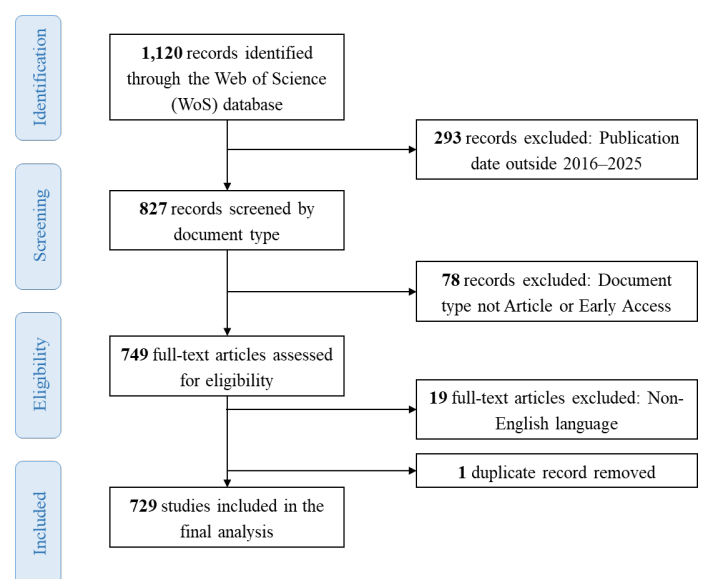


Figure 1: PRISMA flowchart.

BIBLIOMETRIC ANALYSIS AND VISUALIZATION

Bibliometric analysis and visualization were conducted using VOSviewer (version 1.6.20). Co-authorship, co-citation, and keyword co-occurrence networks were constructed to examine collaboration patterns, intellectual structure, and thematic evolution within CBVE research.

Full counting was applied for authorship, country, and institutional analyses. Association strength normalization was used to generate network maps. For keyword co-occurrence analysis, author keywords and Keywords Plus were merged, and minor lexical variations (e.g., singular/plural forms and spelling differences) were manually harmonized to improve interpretability.

Thresholds were applied to reduce network complexity and enhance visualization clarity. Specifically, keywords with a minimum occurrence of 10 were included in network construction. Temporal overlay visualization was employed to identify emerging research themes and shifts in scholarly focus over time.

ANALYTICAL FRAMEWORK

The analytical framework comprised four components: (1) descriptive analysis of annual publication and citation trends; (2) identification of core journals, authors, institutions, and countries based on productivity and citation impact; (3) co-citation analysis to reveal the intellectual foundations of CBVE research; and (4) keyword co-occurrence and temporal overlay analysis to explore thematic clusters and their evolution.

Together, these complementary analyses provide a comprehensive overview of the structural characteristics, knowledge base, and research frontiers of CBVE scholarship.

RESULTS

GROWTH OF THE FIELD

CBVE-related research showed sustained growth between 2016 and 2025 (Figure 2). Annual publications increased from 35 in 2016 to 140 in 2025, with notable peaks in 2021 (115) and 2025 (140). Citation impact increased even more sharply, rising from 4 citations in 2016 to 1,089 in 2025, indicating both expanding volume and increasing recognition of the field's outputs.

CONCENTRATION OF OUTLETS AND CONTRIBUTORS

The literature is highly concentrated in a small number of core outlets. Across 111 sources, the top five journals produced 505 of 729 publications (>69.3%) (Table 1). The Journal of Veterinary Medical Education was the dominant platform (373 publications, 51.2%) and the most

connected outlet (total link strength=20,561), where total link strength represents the summed strength of an item's links with other items in the network (i.e., connectedness rather than study quality). suggesting a strong disciplinary core for knowledge dissemination. At the same time, highly cited work also appeared in interdisciplinary venues, reflecting cross-fertilization with broader health professions education and public health.

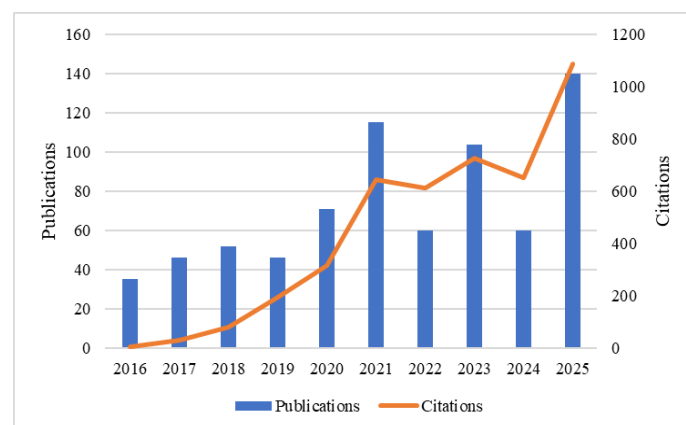


Figure 2: Quantity of publications and citations between 2016 and 2025.

Table 1: The top 5 journals in the field.

Rank	Journals	Docu- ments	Cita- tions	Total link strength
1	Journal of Veterinary Medical Education	373	2148	20561
2	Frontiers in Veterinary Science	45	166	3751
3	Veterinary Record	36	219	5550
4	JAVMA: Journal of the American Veterinary Medical Association	26	215	3574
5	Animals	25	135	2668

Table 2: The top 5 authors in the field.

Rank	Author	Docu- ments	Cita- tions	Total link strength
1	Hunt, J. A.	24	170	3081
2	Baillie, S.	18	125	1557
3	Tipold, A.	18	81	2507
4	Anderson, S. L.	14	120	2309
5	Matthew, S. M.	12	215	2949

Authorship and institutional contributions similarly displayed a core-periphery structure. Among 2,472 authors, the top five contributed 86 publications (Table 2); productivity and citation impact were unevenly distributed, with a small set of researchers acting as central connectors in the coupling network. Among 655 institutions, the top five produced 155 publications (21.3%), indicating organizational concentration (Table 3).

Table 3: The top 5 organizations in the field.

Rank	Organization	Docu- ments	Cita- tions	Total link strength
1	North Carolina State University	32	140	6098
2	Lincoln Memorial University	31	245	8308
3	Massey University	31	192	9354
4	University of Bristol	31	192	6857
5	The Ohio State University	30	220	7770

At the country level, 76 countries were represented, but the top five (United States, United Kingdom, Canada, Germany, Australia) contributed 614 publications (84.2%). The United States alone produced 328 publications (45.0%) and had the highest network connectivity (total link strength=37,124), underscoring its central role in shaping the global CBVE research agenda. This hub structure is consistent with (i) early and coordinated CBVE framework development and dissemination in North America (Matthew *et al.*, 2020; Banse *et al.*, 2024), (ii) higher research capacity and larger institutional networks in the United States and other high-income settings, and (iii) visibility effects driven by indexing and citation practices in major databases (Donthu *et al.*, 2021). Accordingly, the concentration observed here should be interpreted as the structure of WoS-indexed CBVE scholarship rather than a definitive measure of global

educational innovation.

When normalized, several countries show higher connectivity intensity (total link strength per document) than the United States, suggesting that the U.S. dominance in raw total link strength largely reflects volume, whereas network embeddedness per output is more distributed (Table 4).

INTELLECTUAL BASE (CO-CITATION)

The co-citation network (18,418 references) revealed a coherent intellectual base spanning expertise development, curriculum and instructional approaches, and competency-based assessment. Highly cited foundational references included Ericsson (2004), which positioned deliberate practice and feedback as central to expert performance; Read *et al.* (2016), which mapped trends and variability in clinical pathology instruction across North American veterinary schools; Scalese *et al.* (2005), which supported simulation and video-based feedback for teaching and assessing clinical skills; Smeak (2007), which documented structured approaches to teaching and evaluating veterinary surgical skills; and Bok *et al.* (2011), which operationalized competency-based assessment for clinical reasoning (Table 5). Collectively, these references underscore structured practice, simulation-enabled skills training, and rigorous assessment as the conceptual backbone of CBVE scholarship.

Table 4: The top 5 countries in the field.

Rank	Country	Documents	Citations	Total link strength	Citations per document	Total link strength per document
1	United States	328	2041	37124	6.22	113.18
2	United Kingdom	117	765	21591	6.54	184.54
3	Canada	74	469	13494	6.34	182.35
4	Germany	48	231	8446	4.81	175.96
5	Australia	47	436	9119	9.28	194.02

Table 5: The top 5 references by citation frequency.

Rank	Authors	Title	Cita- tions	Total link strength	Why foundational
1	Ericsson <i>et al.</i> (2004)	Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains	42	167	work on deliberate practice
2	Read <i>et al.</i> (2016)	Curricular trends in instruction of clinical pathology in American and Canadian veterinary medical schools	42	171	curriculum trends in veterinary training
3	Scalese <i>et al.</i> (2005)	Teaching clinical skills to medical students: The use of simulated patients and videotaping in general practice	42	122	simulation-based clinical skills training
4	Smeak <i>et al.</i> (2007)	Teaching and evaluation of surgical skills in veterinary schools: Trends and techniques	40	174	surgical skills assessment
5	Bok <i>et al.</i> (2011)	The development of a competency-based assessment program for clinical reasoning in veterinary medicine	38	114	competency-based assessment of clinical reasoning

THEMATIC STRUCTURE AND EVOLUTION (KEYWORD ANALYSIS)

Keyword co-occurrence analysis of 2,696 terms indicated that the field's thematic structure is anchored by broad education- and competency-related concepts, alongside prominent clinical training and assessment terms. Using a minimum occurrence threshold of 10, 114 keywords formed four clusters (four colors) (Figure 3).

(a) Red: Foundations and Modalities of Veterinary Education (e.g., education, veterinary education, students, teachers, blended learning, flipped classroom, case-based learning, knowledge, ethics, clinical reasoning, empathy)

(b) Green: Technical Skill Acquisition and Assessment (e.g., skills, clinical skills, surgical skills, simulation, models, deliberate practice, assessment, validation, objective structured clinical examination (OSCE))

(c) Blue: Curriculum Design and Professional Competency Development (e.g., curriculum, competency, outcomes, program, communication, entrustable professional activities (EPAs), spectrum of care)

(d) Yellow: Student Mental Health and Well-being (e.g., stress, anxiety, depression, burnout, mental-health, resilience)

These keywords were subjected to timeline and overlay analyses to visualize the temporal evolution of research fronts. The timeline highlights the 2020–2025 period using a color gradient, with keywords prominently framed for emphasis (Figure 4). Early work emphasized defining, teaching, and measuring technical competencies through simulation and structured assessments. Subsequent themes expanded toward curriculum redesign and active/digital pedagogies (e.g., flipped classroom, blended learning, gamification, 3D printing), alongside developmental assessment and feedback. More recent work increasingly incorporated learner well-being and professional identity, and broadened CBVE's scope toward societal responsibility through One Health, ethics, animal welfare, and public health. In 2025, “spectrum of care” emerged as a new frontier, reflecting growing attention to pragmatic decision-making and context-sensitive clinical practice.

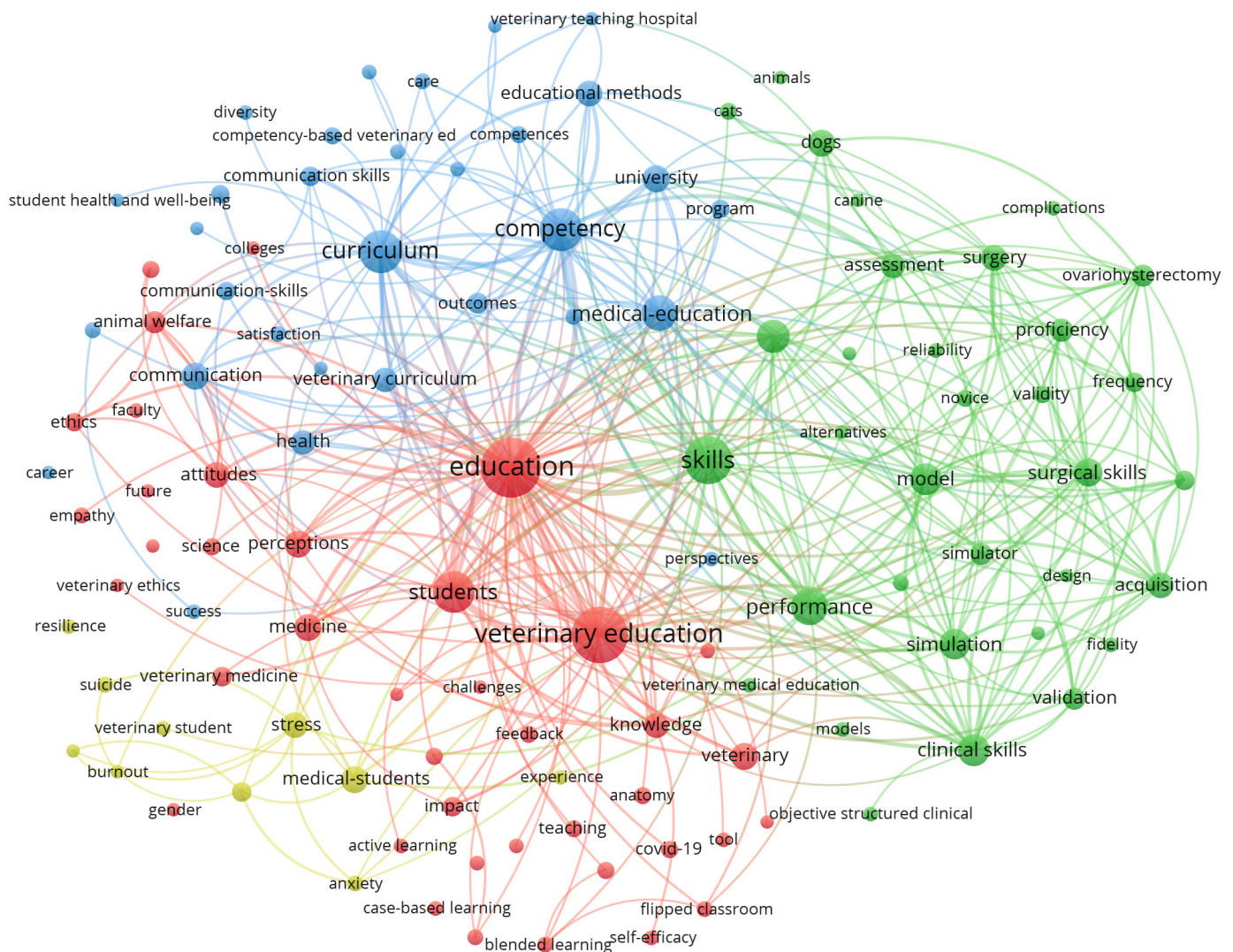


Figure 3: Cluster network visualization of keyword co-occurrence.

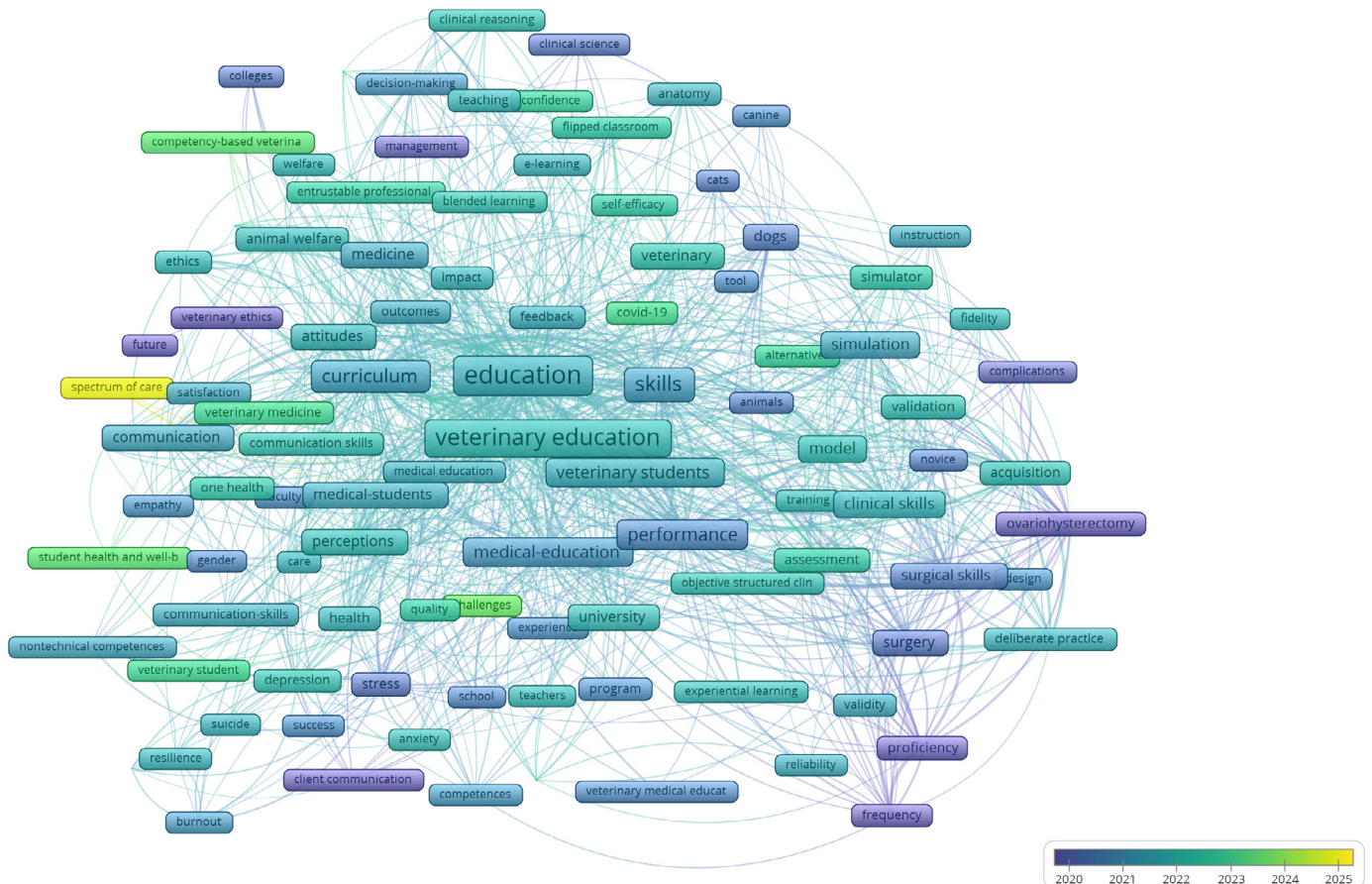


Figure 4: Timeline visualization of co-occurring keywords.

DISCUSSION

SUMMARY OF KEY FINDINGS

This bibliometric analysis mapped the development of CBVE research over the past decade and identified three consistent patterns. First, both publication volume and citation impact increased steadily, indicating that CBVE has moved from an emerging reform idea to a consolidated framework for curriculum design and assessment. Second, CBVE scholarship remains structurally concentrated in a small number of core outlets and high-income countries, forming a pronounced core-periphery pattern. Third, thematic evolution suggests an expansion from early emphases on skills and assessment toward system-facing priorities, including One Health, learner/professional well-being, and increasing attention to contextually appropriate veterinary care along a “spectrum of care.”

EXPLAINING THE CORE-PERIPHERY STRUCTURE: MECHANISMS, CONSEQUENCES, AND TESTABLE PROPOSITIONS

MECHANISMS (WHY MIGHT CONCENTRATION EMERGE?)

The observed concentration is likely driven by a self-reinforcing interaction among professional standards, institutional research capacity, and the publication-citation ecosystem. Competency frameworks and accreditation

expectations shape reform agendas and encourage the production of scholarship aligned with the methodological conventions of high-visibility venues. Over time, “what counts” as rigorous evidence (e.g., certain assessment architectures or simulation-intensive designs) can become standardized through these same venues, amplifying citation accumulation and reinforcing the agenda-setting role of core contributors (Foreman *et al.*, 2024).

CONSEQUENCES (SO WHAT?)

This concentration pattern carries significant implications, extending beyond questions of academic inclusivity.

1. External validity and feasibility risks: CBVE designs grounded in resource-intensive infrastructures may not translate to institutions with limited faculty capacity, constrained clinical exposure, or fewer opportunities for high-fidelity simulation. This may widen implementation inequities and restrict the global applicability of dominant models (Chernikova *et al.*, 2025).
2. Topic and intervention bias toward high-resource solutions: Publication ecosystems can privilege interventions that are feasible in well-resourced settings while underrepresenting system constraints that directly influence animal health outcomes, such as affordability of care, service accessibility, and workforce

distribution. Recent veterinary literature increasingly frames “access to veterinary care” as a welfare-relevant issue, because barriers to access can affect animal welfare through delayed/foregone care and downstream health impacts (Pasteur *et al.*, 2024), and has motivated spectrum-of-care-aligned educational responses in clinical training (Read *et al.*, 2025).

3. Visibility/indexing bias: A critical implication is that database coverage may partly produce the observed core-periphery pattern. Because WoS selectively indexes journals and English-language outputs, regional scholarship, local-language publications, and practice-facing educational innovations may be undercounted.

TESTABLE PROPOSITIONS (HOW CAN FUTURE STUDIES VERIFY THESE MECHANISMS?)

To move beyond description toward theory-building, future research can test the following propositions:

- P1 (Visibility correction hypothesis): Including Scopus/ERIC and regional databases will reduce the apparent magnitude of core dominance and reveal additional thematic clusters particularly those focused on context-specific implementation and service delivery barriers.
- P2 (Interdisciplinary diffusion hypothesis): As CBVE research shifts from “skills/assessment” toward One Health, well-being, and spectrum-of-care priorities, output will diffuse into broader veterinary/public health outlets, increasing cross-disciplinary citation and collaboration (Bessler *et al.*, 2024; Tucker *et al.*, 2024).
- P3 (Resource-gradient adoption hypothesis): The uptake and sustainability of CBVE assessment strategies will correlate with resource availability; resource-intensive methods will show larger implementation gaps across contexts, while scalable workplace-based approaches (e.g., structured entrustment decisions and longitudinal portfolios) will demonstrate greater cross-context feasibility.

THEMATIC EVOLUTION AS A THREE-STAGE MODEL: DRIVERS AND THE NEXT FRONTIER

The thematic trajectory supports a three-stage developmental model that reflects how CBVE scholarship is responding to real-world veterinary system demands. This model serves as a descriptive framework derived from the temporal overlay patterns, in which the stages are not mutually exclusive.

STAGE 1: DEFINITION AND MEASUREMENT OF COMPETENCE (WHAT TO TEACH AND HOW TO JUDGE IT?)

Early research focuses on skills training, assessment

validity, structured clinical evaluation, and simulation as a mechanism for repeatable practice and safer skill acquisition. Recent syntheses also support the effectiveness of simulation-based learning in higher education more broadly (Chernikova *et al.*, 2025), and CBVE-specific tools continue to formalize assessment practices (Foreman *et al.*, 2024).

STAGE 2: PROGRAMMATIC INTEGRATION (HOW TO EMBED CBVE IN TRAINING SYSTEMS?)

As measurement approaches stabilize, scholarship emphasizes curriculum redesign, EPAs, feedback systems, and longitudinal assessment architectures. Recent veterinary education studies illustrate this shift through iterative course redesign and learner feedback loops (Singh *et al.*, 2024), and emerging work on assessing communication/collaboration/professionalism under uncertainty within CBVE domains (Hinckley-Boltax and Coleman, 2025).

STAGE 3: SOCIAL ACCOUNTABILITY AND SUSTAINABLE VETERINARY PRACTICE (WHAT SHOULD COMPETENCE MEAN IN COMPLEX, CONSTRAINED, INTERCONNECTED SYSTEMS?)

Recent work increasingly ties veterinary competence to One Health responsibilities, ethical decision-making, and sustainable workforce functioning. This shift is consistent with the growing emphasis on One Health competency frameworks internationally, which highlight domains such as preparedness/response, communication, ethics, and leadership. In parallel, social accountability is being explicitly integrated into veterinary medical education in some settings (Wichtel, 2024), while systems-informed positive psychology approaches are being discussed as a pathway to professional flourishing (Corrigan *et al.*, 2025).

Drivers of the transition from Stage 2 to Stage 3 include: (i) heightened global attention to zoonoses and public health preparedness; (ii) increased recognition that veterinary services underpin food systems, community resilience, and disease surveillance; and (iii) workforce sustainability concerns. For instance, veterinary education work in Ethiopia explicitly frames One Health-oriented curriculum reforms as a means of strengthening national Veterinary Services to improve both animal and human health outcomes.

NEXT FRONTIER: COMPETENCE-IN-CONTEXT (INCLUDING SPECTRUM OF CARE)

Notably, spectrum-of-care-aligned education appears as a nascent discourse in late-window publications, though its keyword frequency remains low in co-occurrence maps. This positions it as an emerging signal, likely driven initially by a small number of visible contributions, which

warrants monitoring as a key frontier.

A particularly relevant frontier for AAVS readers is the integration of competence frameworks with care accessibility and feasibility. The AAVMC Spectrum of Care Initiative (SOCI) and the associated “Spectrum of Care Education Model” reflect a growing effort to prepare graduates to deliver contextually appropriate, evidence-based options across diverse client resources and clinical settings an agenda that directly links education to service delivery realities and animal welfare outcomes. Empirical educational implementations aligned with the CBVE model are beginning to appear, including spectrum-of-care rotations that operationalize competence-in-context (Read *et al.*, 2025).

Additionally, recent JAVMA work describes an evidence-based strategy by AAVMC to support veterinary programs in preparing students for spectrum-of-care practice (Fedesco *et al.*, 2025), further signaling that spectrum of care is moving from a discussion topic into an operationalizable educational strategy.

GLOBAL PERSPECTIVES AND ONE HEALTH: FROM ADOPTION TO CONTEXTUAL ADAPTATION

Although CBVE has matured conceptually, global implementation capacity remains uneven. Without explicit adaptation pathways, CBVE models risk becoming less equitable and less feasible in resource-constrained settings. The increasing integration of One Health into veterinary curricula offers a concrete route to align CBVE with animal/public health outcomes, but it also raises practical questions: how to operationalize One Health competencies into EPAs, how to assess interprofessional collaboration, and how to demonstrate downstream relevance. Recent studies propose interprofessional education that embeds One Health-related competencies as a practical response to emerging threats, but evaluation evidence remains heterogeneous and should be strengthened through programmatic assessment and longer-term outcomes tracking (Roopnarine *et al.*, 2025). Qualitative work across human and veterinary institutions also highlights practical intersections between One Health and interprofessional education that can inform assessment design (Tucker *et al.*, 2024).

WELL-BEING AND MORAL DISTRESS: COMPETENCE REQUIRES SUSTAINABILITY

Well-being has become increasingly visible in CBVE-related discourse, reflecting a conceptual shift: competence is not only achieving proficiency at a point in time, but sustaining safe, ethical performance under stress and uncertainty. In veterinary practice, ethical conflict and moral distress are increasingly recognized as drivers

of burnout and disengagement, with implications for professional fulfillment and workforce retention (Kogan and Rishniw, 2023). This framing also resonates with SDG 3 (Good Health and Well-Being), which underscores that protecting the well-being of the health workforce is integral to sustaining safe and effective service delivery. Recent syntheses of veterinary student mental health further detail common stressors and coping strategies that may inform CBVE program design (Islam *et al.*, 2025).

This evidence base supports treating well-being as a CBVE design constraint affecting assessment load, feedback culture, supervision practices, and psychological safety rather than as an auxiliary support service. Importantly, treating well-being as a design constraint does not necessarily require adding “more content” to an already fixed-duration curriculum; rather, it often implies a critical re-evaluation of curricular priorities to support sustainable proficiency. This directly addresses the inevitable trade-off question: what might be de-emphasized to create space? The answer lies not in reducing robust technical training, but in rigorously streamlining redundant or low-value assessment and content. By designing efficient, integrated learning experiences that minimize cognitive overload and moral distress, programs can protect the time and mental capacity needed for deep technical learning while fostering the resilience required for “Day One” readiness. Thus, well-being as a constraint becomes a catalyst for designing more effective, not merely expanded, curricula.

Complementary recent work also documents the high prevalence of burnout in veterinary medicine and highlights the need for scalable interventions, reinforcing why well-being should be structurally integrated into training design (Takefuji, 2025). This aligns with recent calls to integrate well-being resources throughout training and early career transitions (Bookbinder, 2025) and to frame flourishing as a systems property rather than an individual trait alone (Corrigan *et al.*, 2025).

METHODOLOGICAL LIMITATIONS

Several limitations should be acknowledged. First, the dataset was restricted to the Web of Science Core Collection and English-language publications, which may underrepresent regional scholarship and non-English CBVE innovations.

Second, bibliometric indicators measure visibility and influence rather than educational effectiveness or downstream animal health impact. Thus, bibliometric mapping should be interpreted as a foundation for hypothesis generation and research prioritization rather than causal evidence of pedagogical superiority.

Third, results depend on VOSviewer parameterization (e.g., counting method, normalization, threshold selection) and on manual preprocessing decisions (e.g., keyword harmonization), which can alter network density and cluster boundaries. VOSviewer is optimized for transparent visualization and network construction but is less suited for advanced longitudinal modeling, inferential testing, or topic modeling compared with alternatives such as Bibliometrix (R), CiteSpace, SciMAT, or custom workflows in Python. Accordingly, we report thresholds explicitly and interpret clusters as robust “patterns” rather than definitive taxonomies.

FUTURE DIRECTIONS

Based on the findings and the propositions above, future research should prioritize:

1. Cross-context implementation studies evaluating feasibility and adaptation of CBVE tools (including EPA systems) under different resource constraints;
2. One Health-aligned CBVE evaluation, including interprofessional competence assessment and public health preparedness outcomes;
3. Education-to-service linkage studies connecting CBVE approaches to service accessibility, welfare outcomes, and spectrum-of-care decision-making in real clinical ecosystems (Croney *et al.*, 2025);
4. Well-being and ethics integration, testing whether interventions that reduce moral distress and burnout improve entrustment decisions, learning trajectories, and workforce sustainability.
5. Publishing norms and equity, investigating how guidelines such as requiring a “Feasibility in Resource-Constrained Contexts” section for new tools or curricula can enhance the transparency, transferability, and equitable adoption of CBVE innovations.

CONCLUSION

CBVE research has expanded rapidly and has moved beyond a narrow focus on skills assessment toward a broader agenda that increasingly incorporates EPAs, One Health, professional well-being, and spectrum-of-care considerations. At the same time, the field remains structurally concentrated in a limited set of journals and high-income countries, raising concerns about global representativeness and the cross-context feasibility of dominant CBVE models. Future work should prioritize context-sensitive implementation studies, One Health-aligned and interprofessional assessment, and longitudinal evaluation linking CBVE to service accessibility, workforce sustainability, and animal health-relevant outcomes. To advance from description to theory-testing, future research should evaluate three key propositions: replicating mappings across databases to correct visibility bias (P1),

tracking interdisciplinary diffusion as system-facing themes expand (P2), and evaluating resource-gradient feasibility of assessment architectures (P3).

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The authors declare that this manuscript is original, has not been published elsewhere, and is not under consideration for publication in any other journal.

NOVELTY STATEMENTS

This study provides a comprehensive bibliometric review that systematically maps the evolution and thematic frontiers of CBVE using VOSviewer, offering an evidence-based roadmap for future inquiry and application.

AUTHOR’S CONTRIBUTION

LZ conceived the study and led the analysis. KTN and MP designed the search strategy and curated data. YZ, BY, and TL performed visualization and drafted sections. All authors contributed to manuscript revision and approved the final version.

ETHICAL STATEMENT

As this manuscript does not involve research on humans or animals, nor does it include vulnerable populations, an ethical statement is not applicable.

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ETHICS APPROVAL

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CONSENT FOR PUBLICATION

All the authors have read and approved the work.

DATA AVAILABILITY STATEMENT

All data have been included in the article or referenced in the article.

GENERATIVE AI AND AI-ASSISTED TECHNOLOGY STATEMENT

The authors declare that no generative AI or AI-assisted technologies were used in the writing or preparation of this manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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