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Short Report

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Reporting Heterogeneity and Evidence Gaps in Veterinary Nanomedicine: A Curated Dataset and Quantitative Analysis of Physicochemical and Pharmacokinetic Data (2002–2026)

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Abstract

Background. Veterinary nanomedicine has produced a rapidly growing primary literature, yet no structured secondary-data resource integrates formulation-level physicochemical measurements with pharmacokinetic outcomes across animal species.

Objective. To construct a curated, quality-controlled dataset of physicochemical and pharmacokinetic properties of nanomedicine-based drug delivery systems in veterinary and translational research (2002–2026), and to quantify reporting completeness and evidence gaps.

Methods. Data were manually extracted from 64 peer-reviewed publications (plus one conference abstract and one book chapter) into a 33-variable schema, yielding 75 formulation-level records. The in-vivo experimental analysis subset comprised 50 records. Quality control employed AI-assisted field-level review followed by human verification. The dataset was independently verified on Mendeley Data (DOI: 10.17632/jf2k3cdzyp.1).

Results. Among 50 in-vivo experimental records, numerical particle size was available from 41 (82%; median 81.9 nm) and numerical encapsulation efficiency from 22 (44%; median 83.3%). No cross-carrier particle size–encapsulation efficiency association was detected (Spearman $\rho = 0.064$, $p = 0.777$, $n = 22$). Nominal pharmacokinetic completeness was 84–92%, but numerical completeness was substantially lower: Cmax 34%, AUC 50%, t½ 46%, Tmax 24%. Only 16 of 50 records (32%) contained both a numerical particle size and a numerical AUC value.

Conclusions. The dataset documents systematic reporting heterogeneity that currently prevents quantitative cross-study synthesis and supervised machine-learning modelling. These findings define the minimum reporting standards required to make veterinary nanomedicine computationally tractable.

Keywords: veterinary nanomedicine; pharmacokinetics; nanoparticle drug delivery; physicochemical characterisation; curated dataset; reporting heterogeneity

Introduction

Nanocarrier-based drug delivery systems have been increasingly investigated for veterinary applications over the past two decades, with liposomes, polymeric nanoparticles, nanocrystals, and drug-eluting depot systems demonstrating proof-of-concept across antibiotics, antiparasitics, anti-inflammatory agents, and veterinary oncology drugs [1–5]. Despite this growth, the evidence base remains fragmented. Physicochemical characterisation is inconsistently reported across studies; pharmacokinetic outcomes are frequently expressed as qualitative comparisons ("AUC was significantly greater in the

nanoformulation group") rather than numerical estimates; and nanocarrier nomenclature is unstandardised [6,7]. These heterogeneities have been recognised in human nanomedicine [8,9] but have not been systematically quantified for the veterinary domain.

No existing publicly available resource was identified during the literature search conducted for this study that integrates formulation-level physicochemical properties with pharmacokinetic outcomes specifically for veterinary and translational nanomedicine. Database resources for nanomedicine including eNanoMapper [10] focus on nanotoxicology and materials characterisation. The present study constructs and releases such a dataset, characterises its evidence structure, and assesses its readiness for machine-learning applications.

Materials and Methods

Literature search and eligibility

PubMed, Web of Science, Google Scholar, and Semantic Scholar were searched between August and November 2026 combining nanocarrier type, veterinary/translational context, and pharmacokinetic/formulation outcome terms. No year restriction was applied. Publications were included when peer-reviewed and English full-text, describing a drug delivery system in veterinary, aquaculture, or translational research, and reporting at least one quantitative physicochemical or pharmacokinetic parameter. Review articles, book chapters, and in-vitro-only studies were included with explicit study-type coding. Two records with no nanoformulation (one prodrug PK study; one conventional tablet study) were retained for search transparency but excluded from all nanomedicine analyses.

Data extraction and in-vivo experimental subset

Data were manually extracted into a 33-variable schema covering bibliographic metadata, nanocarrier composition, physicochemical properties (particle size, PDI, zeta potential, encapsulation efficiency, drug loading), animal model and administration route, in-vitro release, and pharmacokinetic outcomes. Values not reported were coded as "Not reported"; not applicable values were coded as "Not applicable". AUC units were retained exactly as reported; harmonisation is required before cross-record comparisons.

The full dataset of 75 records was used for all descriptive analyses. For analyses requiring in-vivo pharmacokinetic endpoints, a pre-defined in-vivo experimental subset was used, comprising records classified as Original Research or Experimental with at least one in-vivo component. This subset excluded 14 review articles, 1 book chapter, 8 in-vitro-only studies, and 2 non-nanomedicine records, yielding 50 records (66.7%).

Quality control and statistical analysis

Quality control was conducted in two stages. First, GPT-4o (OpenAI, November 2026) was used as an auxiliary reviewing tool to flag candidate field-level problems, with every issue verified against the source PDF. This process identified three genuine errors: two column-displacement artefacts and one misencoded field (UV absorbance wavelength entered as EE%). Second, the final CSV was validated programmatically (Python csv.reader), confirming 75 rows × 33 fields with no structural anomalies. The dataset was independently verified on Mendeley Data (DOI: 10.17632/jf2k3cdzyp.1) by Claude (Anthropic). Data extraction was performed by one reviewer (NÇ). All analyses were performed in Python 3.12. Qualitative text comparisons ("significantly greater than control") were not counted as numerical measurements. Spearman rank correlation was used for the particle size–EE association (non-normal distributions; n = 22).

Results

Dataset composition

The dataset contains 75 formulation-level records from 64 peer-reviewed publications (plus 1 conference abstract and 1 book chapter) spanning 2002–2026. By study type: in-vivo experimental n = 50 (66.7%), in-vitro only n = 8 (10.7%), review n = 14 (18.7%), book chapter n = 1 (1.3%), non-nanomedicine n = 2 (2.7%). Publication years are skewed toward 2026 (n = 35, 46.7%), reflecting the literature search window. After broad classification, the most represented nanocarrier classes are polymeric NP (n = 16, 21.3%), liposomes (n = 11, 14.7%), and microparticles (n = 11, 14.7%). Rodent models are most frequent (rat 38%, mouse 16%). Canine models are the most common veterinary companion-animal species (n = 7 experimental records, 14.0%). Equine (n = 1), bovine (n = 1), caprine (n = 2), and aquatic (n = 1) species collectively contribute only 5 experimental records. Oral administration is the most frequent route (n = 18, 36.0%), followed by IM and SC (n = 8 each). Distributions are shown in Figure 1.

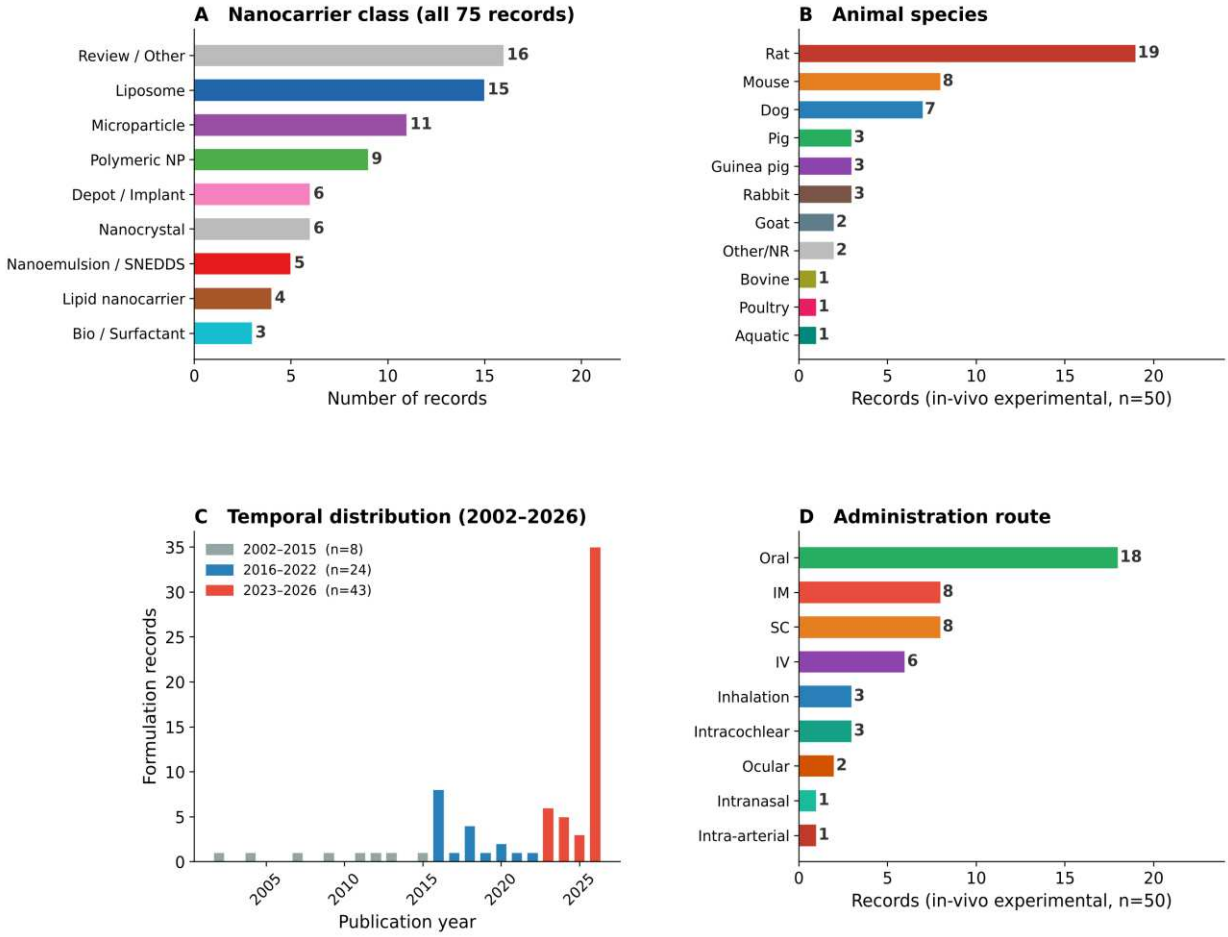

Figure 1. Distribution of nanocarrier types, animal species, publication years, and administration routes across the 75-record dataset. (A) All 75 records by nanocarrier class. (B) Animal species (in-vivo experimental, n = 50). (C) Temporal distribution 2002–2026. (D) Administration route (in-vivo experimental).

Physicochemical properties

Numerical particle size was extractable from 41 of 50 experimental records (82.0%; median 81.9 nm, IQR 33.2–274.0 nm, range 5.0–1455.0 nm). The 5.0 nm minimum derives from

dexamethasone crystal dimensions within a cochlear silicone implant matrix (Depot/Implant class [7]), not freely dispersed nanoparticles; excluding this record, the minimum is 9.46 nm. Numerical encapsulation efficiency was available from 22 experimental records (44.0%; median 83.3%, mean 71.6 ± 25.1%, range 4.5–100%). The distribution was left-skewed, consistent with publication bias toward optimised formulations. Spearman correlation between particle size and EE was ρ = 0.064 (p = 0.777, n = 22) — no detectable cross-carrier association. Summary statistics are presented in Table 1.

Table 1. Summary statistics for key quantitative variables (in-vivo experimental subset, n=50)

Variable	N (num.)	Range	Median	Mean ± SD
Particle size (nm) — in-vivo exp. (n=50)	41	5.0–1455.0	81.9 nm	268 ± 358
PDI (DLS; ≤ 1.0 only)	18	0.09–0.98	0.27	0.31 ± 0.21
Encapsulation efficiency (%) — in-vivo exp.	22	4.5–100.0	83.3%	71.6 ± 25.1
Drug loading (%)	22	0.3–34.0	5.0%	7.9 ± 8.9
Cmax (numerical values only)	19	Not harmonised†	—	—
AUC (numerical values only)	27	Not harmonised†	—	—
t½ (h, numerical only)	25	Not harmonised†	—	—

† AUC, Cmax, and t½ values reported in species- and dose-specific units across studies; numerical pooling was not performed. exp. = in-vivo experimental subset.

Pharmacokinetic completeness: nominal vs numerical

Among 50 experimental records, PK variables carried high nominal completeness rates (Cmax 84%, AUC 92%, t½ 64%, Tmax 34%), but numerical completeness — the fraction of records with an extractable numerical value rather than a qualitative text statement — was substantially lower: Cmax 34%, AUC 50%, t½ 46%, Tmax 24% (Figure 2A). This discrepancy is the central finding of this study: the majority of PK reporting consists of qualitative comparisons ("AUC significantly greater for nanoformulation vs free drug") rather than numerical point estimates. Machine-learning readiness is shown in Figure 2B and Table 2. Only the PS + AUC combination approaches — but does not achieve — the practical minimum of 30 complete-case records required for supervised modelling.

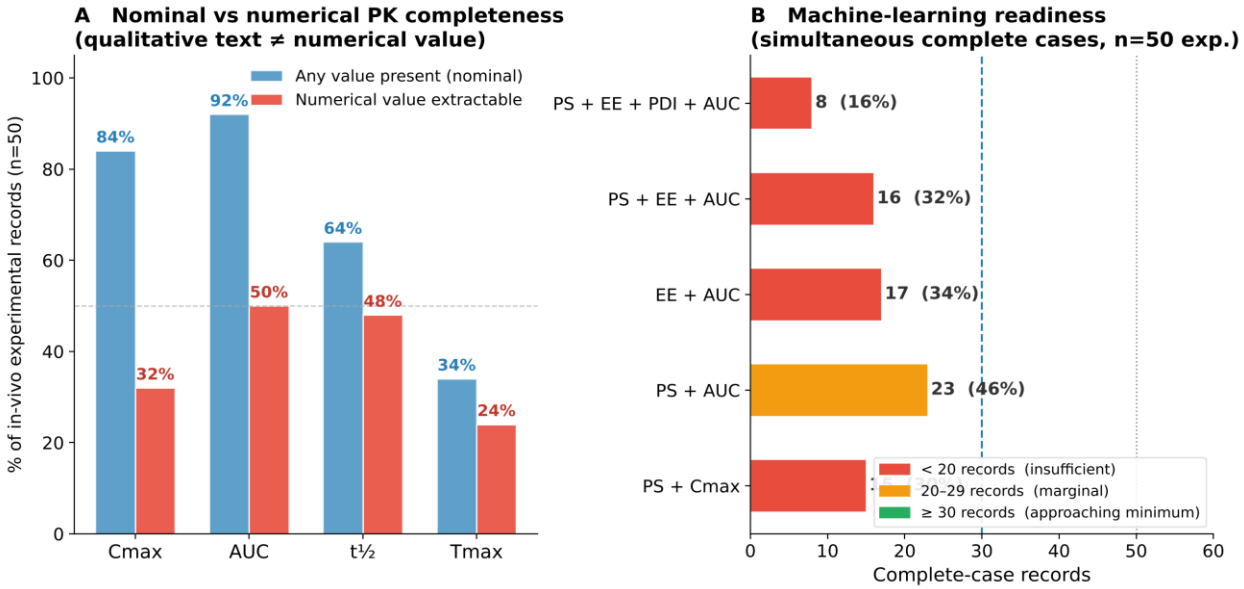

Figure 2. Data completeness and machine-learning readiness (in-vivo experimental records, n = 50). (A) Nominal completeness (any value present) versus numerical completeness (numerical value extractable) for four pharmacokinetic variables; qualitative text comparisons do not constitute numerical measurements. (B) Complete-case record counts for physicochemical–pharmacokinetic feature pairs; the dashed line marks a practical minimum of 30 records for ML modelling.

Table 2. Machine-learning complete-case readiness (in-vivo experimental subset, n=50)

Feature–outcome pair	Complete-case records (n)	% of in-vivo exp. (n=50)	Assessment
PS + Cmax	15	30%	Insufficient (< 30)
PS + AUC	23	46%	Marginal (approaches 30)
EE + AUC	17	34%	Insufficient
PS + EE + AUC	16	32%	Insufficient
PS + EE + PDI + AUC	8	16%	Insufficient

PS = particle size; EE = encapsulation efficiency; PDI = polydispersity index. Minimum practical threshold for supervised ML: n ≥ 30 complete-case records.

Discussion

The principal finding of this study is a systematic and quantified evidence gap. The veterinary nanomedicine literature, examined at the formulation level across 64 peer-reviewed publications and 24 years, produces a body of evidence too heterogeneous in reporting practices to support quantitative cross-study synthesis or supervised machine-learning modelling. The null particle size–EE correlation ($\rho = 0.064$, $p = 0.777$, $n = 22$) confirms that particle size and encapsulation efficiency are independently determined by

carrier type, not universally coupled — a finding that corrects a potentially misleading trend visible when carrier types are pooled in a single regression.

The discrepancy between nominal and numerical PK completeness (up to 58 percentage-point gap for Cmax) documents a reporting practice that inflates the apparent usability of this evidence base. A field that reports 92% nominal AUC availability but only 50% numerical AUC availability cannot currently support the kind of comparative pharmacokinetic analysis that would justify nanoformulation development costs in veterinary medicine.

The minimum viable reporting standard implied by these findings is: particle size (nm, with measurement method), encapsulation efficiency (%, with calculation method), route, species, and at least Cmax and AUC with explicit units. This standard is currently met by approximately 32% of experimental publications in this dataset. We propose that veterinary nanomedicine journals, including Veterinary Research Communications, consider adopting this as a minimum requirement for original research submissions, analogous to the ARRIVE guidelines for in-vivo study reporting.

The species distribution confirms a persistent gap: equine, bovine, and caprine nanomedicine together contribute only 5 of 50 experimental records, while these species represent the largest share of global veterinary drug expenditure. The dataset is freely available through Mendeley Data (DOI: 10.17632/jf2k3cdzyp.1) to serve as a pilot resource for future standardised data collection in these underrepresented species.

Limitations. The dataset comprises 50 in-vivo experimental records — insufficient for supervised ML. Data were extracted by one reviewer (NÇ); duplicate extraction was not performed. Publication bias toward optimised formulations is reflected in the left-skewed EE distribution (median 83.3%). 46.7% of records originate from 2026 because the literature search was conducted in that year, precluding reliable temporal trend analysis. AUC values are reported in a variety of units that cannot be compared directly.

Conclusions

This short communication presents a 75-record, 64-publication curated dataset of physicochemical and pharmacokinetic properties of nanomedicine-based drug delivery systems in veterinary and translational research (2002–2026), freely available via Mendeley Data (DOI: 10.17632/jf2k3cdzyp.1). The central finding — that the majority of pharmacokinetic values in this literature are qualitative rather than numerical — directly motivates the adoption of standardised minimum reporting requirements. The machine-learning readiness assessment provides a quantitative baseline against which future standardised data collection can be measured.

Data Availability

Sezgin Y, Çermik N (2026). A Curated Dataset of Physicochemical and Pharmacokinetic Properties of Nanomedicine-Based Drug Delivery Systems in Veterinary and Translational Research (2002–2026). Mendeley Data, V1. DOI: 10.17632/jf2k3cdzyp.1. The repository was independently verified by Claude (Anthropic) during quality control.

Ethics Statement

This study is based entirely on previously published, peer-reviewed literature. No new experiments involving human subjects or animals were conducted.

Funding

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Declaration of Competing Interests

The authors declare no competing financial interests or personal relationships that could have influenced the work reported here.

CRediT Author Statement

Neslinaz Çermik: Conceptualization; Data curation; Formal analysis; Methodology; Software; Validation; Writing (original draft); Writing (review and editing). Yasemin Sezgin: Supervision; Validation; Writing (review and editing).

Declaration of Generative AI and AI-Assisted Technologies

During manuscript preparation, the authors used ChatGPT (OpenAI) for language editing and verification of data consistency, and Claude (Anthropic) for statistical analysis, figure generation, and forensic data audit. Claude also independently verified the Mendeley Data repository (DOI: 10.17632/jf2k3cdzyp.1). All outputs were reviewed and edited by the authors, who take full responsibility for the final content.

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