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Research article

Evaluation of common trends and strategies of different institutions to support veterinary curricular renewal

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Abstract

The veterinary profession is diverse and rapidly evolving, requiring constant adaptation from veterinary schools. Reforms are often based on insights from other institutions and on the intended curriculum. The ongoing curricular renewal of the School of Medicine and Biomedical Sciences, University of Porto, Portugal, motivated the collection and comparison of national (i.e., Portuguese) and international veterinary curricula from fifteen institutions to identify overall trends and strategies. Our hypothesis was that comparing the curricula from different institutions would reveal common trends and strategies, which can guide curricular revisions. Most institutions followed a modified traditional veterinary curriculum, integrating electives, internships, and clinical rotations which also provide opportunities for specialization. Fundamental Sciences represented almost half of veterinary education. International institutions already implemented early clinical contact to develop technical skills. Non-technical skills (i.e., soft skills) have been gaining importance. In summary, the complexity of the veterinary profession requires the development of a core veterinary curriculum based on the fundamental principles of the profession, complemented by specialization opportunities offered by electives, internships, and clinical rotations.

Keywords: Core veterinary curriculum, Curricular reform, Curricular renewal, Veterinary medicine education.

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INTRODUCTION

Veterinary medicine is a profession that is developing rapidly and increasing in complexity in terms of balancing technical and clinical skills, societal and legal obligations, and professional and individual expectations (Armitage-Chan et al., 2016). The curricula must promote learning technical and clinical components aligned with the professional culture and current context of veterinary practice (Gordon et al., 2023). Therefore, recurrent veterinary curricular revisions are required, generally occurring every 4 to 7 years (Lane et al., 2017). Curricular renewal often focuses on knowledge integration, development of clinical and technical skills, and innovative teaching strategies (Lane et al., 2017). These revisions are difficult to implement because they disrupt existing curricular structures, create attrition between faculty members (Ilkiw et al., 2017a), and generate conflicts between the interests of students and the societal role of veterinarians. Many faculty members may also be unfamiliar with the veterinary curriculum, its needs, and its objectives (Foreman et al., 2017). Coverage of new areas can also be costly and time-consuming, especially when increasing the demand for human resources (Lane and Bogue, 2010). Additionally, there are uncertainties regarding the results of curricular renewal, its adequation to current professional needs, and its acceptance by the student body.

It has been suggested that curricular development in medical education must follow an outcome-based approach considering the career needs, bridged towards content by teaching, learning, and assessment (Prideaux, 2007). Yet, the intended curriculum is often the foundation for reforms (Jaarsma et al., 2009). Implementation of a bottom-up approach, by actively involving faculty members, may facilitate this process (Foreman et al., 2017). Indeed, curricular revisions often rely on input from colleagues or insights from other veterinary schools (Lane et al., 2017). For instance, the University of Gondar College of Veterinary Medicine and Animal Sciences, in Ethiopia, has developed a curriculum following the core veterinary curriculum guidelines of the World Organization for Animal Health (Hoet et al., 2020). The University of Montreal's Faculté de Médecine Vétérinaire, in France, has conducted surveys targeted at alumni and their employers to evaluate satisfaction and specific weaknesses in the curriculum (e.g., non-technical skills), which can be corrected during curricular reform (Doucet and Vrins, 2010). The University of Minnesota College of Veterinary Medicine, in the United States of America, has conducted weekly surveys on the progression, wellbeing, and perspectives of students to revise a newly implemented curriculum (Malone et al., 2020).

This study was motivated by the need for information to support the ongoing veterinary curriculum reform of the School of Medicine and Biomedical Sciences, University of Porto, Portugal. The objective was to collect and compare veterinary curricula (i.e., curricular units and disciplinary areas) of national (i.e., Portuguese) and international institutions, to assess overall trends and strategies for a core veterinary curriculum that addresses challenges of a diverse and changing profession. We hypothesized that the comparison of veterinary curricula from different institutions would reveal common trends and strategies that can be used in curricular renewal to develop a new core veterinary curriculum capable of addressing the diverse and evolving challenges in the profession.

MATERIAL AND METHODS

Data from national (i.e., Portuguese) and international veterinary curricula, selected based on data availability and global representation, were collected from each institution's website between January and May 2024. The database included all 8 Portuguese institutions teaching veterinary medicine; National institutions included the School of Medicine and Biomedical Sciences, University of Porto (PT-

ICBAS), Veterinary Medicine Faculty, University Lusófona (PT-UL), Universitary School Vasco da Gama (PT-EUVG), University Institute of Health Sciences, CESPU (PT-IUCS), Egas Moniz School of Health & Sciences (PT-EM), School of Sciences and Technology, University of Évora (PT-ECT), Faculty of Veterinary Medicine, University of Lisbon (PT-FMV), School of Agrarian and Veterinary Sciences, University Trás-os-Montes and Alto Douro (PT-UTAD). The 3 European institutions following the similar regulations; International institutions included Justus-Liebig Giessen University, Germany (DE), University of Pisa, Italy (IT), Santiago de Compostela University, Spain (ES), and other 4 international institutions spanning different continents; Prince Edward Island University, Canada (CA), Cornell University, United States of America (US), University of Melbourne, Australia (AU), Nigeria University, Nigeria (NRA).

The sample size was deemed sufficient to provide insights into different institutional strategies to support curricular reforms at the School of Medicine and Biomedical Sciences, University of Porto. The database was created based on publicly available information. An exhaustive review of institutions, or the contents of each curricular unit, were out of the scope of this work.

Data was organized in a Microsoft Office 365 Excel file, collecting information on the year, semester, credits, curricular unit, and institution. Each curricular unit was categorized according to internal categories of veterinary disciplinary areas adapted from the scientific areas of the Integrated Masters in Veterinary Medicine of the School of Medicine and Biomedical Sciences, University of Porto (approved by the Scientific Course Commission): i) Fundamental Sciences; ii) Animal Production; iii) One Health (including public health, zoonotic diseases, epidemiology, ecosystem health, welfare, deontology, and biomedical investigation); iv) Food Safety & Sanitary Inspection; v) Integrated Veterinary Medicine (i.e., propaedeutics and not species-specific) and ; vi) Companion Animal Medicine; vii) Equine & Livestock Medicine; viii) others (including electives, internships, and rotations); ix) final internship & dissertation. Additionally, subdisciplines were created inside disciplinary areas to better illustrate the progression through academic years. Data analysis was conducted on IBM SPSS Statistics 29, mainly through descriptive statistics.

RESULTS

Curricular data was collected on all eight veterinary schools in Portugal and seven international schools, spanning the globe (Table 1). A total of 715 and 465 datapoints on national and international curricular units (i.e., course units, including electives and internships) were collected, respectively.

Distribution of credits across disciplinary areas

Since the system of credits is equivalent to a standardized number of study or work hours expected from the students, it can be used to represent the weight of each disciplinary area in individual veterinary curricula. While the European Credit Transfer and Cumulation System (ECTS) is used in Europe, other credit systems are used around the world. Additionally, the veterinary course may last from four to six years, lasting five years and one semester in all Portuguese institutions, except the University Institute of Health Sciences, CESPU (PT-IUCS, six years). Therefore, a direct comparison of credits is not possible. Different curricula were compared by presenting data as the relative frequency (i.e., percentage) of credits attributed to a disciplinary area relative to (i.e., divided by) the total amount in the veterinary curriculum of that institution (Figure 1a).

Excluding electives, internships, and dissertations, greater variations were found between the weight of Food Safety & Sanitary Inspection (Coefficient of Variation, CV= 78.7%) and for an increased focus on a species, namely on

Companion Animal Medicine (CV=70.8%), revealing widely different strategies between institutions. Conversely, Fundamental Sciences was the disciplinary area least varying in weight between institutions (CV=20.5%), which constitutes a median of 41% of the weight in credits (i.e., workload) of the veterinary curriculum (Figure 2b).

Table 1 Institutions from where the veterinary curriculum was collected, respective abbreviations, and relative frequency (%) of the credit weight of each disciplinary area in the veterinary curriculum of national and international institutions (mean and standard deviation).

	Institution	Years	FS	AP	OH	FS	VM	CA	EL	E	IR	ID
National	School of Medicine and Biomedical Sciences, University of Porto (PT-ICBAS)	5.5	35.9 ± 2.1	8.1 ± 2.4	7.1 ± 1.5	5.0 ± 1.5	11.2 ± 3.8	5.0 ± 3.4	7.3 ± 4.0	4.5 ± 2.8	6.1 ± 6.1	10.0 ± 2.7
	Veterinary Medicine Faculty, University Lusófona (PT-UL)	5.5										
	Universitary School Vasco da Gama (PT-EUVG)	5.5										
	University Institute of Health Sciences, CESPU (PT-IUCS)	6										
	Egas Moniz School of Health & Sciences (PT-EM)	6										
	School of Sciences and Technology, University of Évora (PT-ECT)	5.5										
	Faculty of Veterinary Medicine, University of Lisbon (PT-FMV)	5.5										
	School of Agrarian and Veterinary Sciences, University Trás-os-Montes and Alto Douro (PT-UTAD)	5.5										
International	Justus-Liebig Giessen University, Germany (DE)	5	47.9 ± 8.2	8.2 ± 5.5	6.2 ± 3.5	3.0 ± 3.8	9.3 ± 5.6	3.3 ± 3.9	6.9 ± 4.6	1.2 ± 1.5	13.0 ± 7.4	1.1 ± 1.8
	University of Pisa, Italy (IT)	5										
	Santiago de Compostela University, Spain (ES)	5										
	Prince Edward Island University, Canada (CA)	4										
	Cornell University, United States of America (US)	4										
	University of Melbourne, Australia (AU)	4										
	Nigeria University, Nigeria (NRA)	6										

FS: fundamental sciences; AP: animal production; OH: One Health; FS: food safety & sanitary inspection; VM: integrated veterinary medicine; CA: companion animal medicine; EL: equine & livestock medicine; E: electives; IR: internship / rotation; ID: final internship / dissertation.

Diversity of curricular units in veterinary curriculum

The total amount of curricular units varied from 22 to 108 in international and from 60 to 92 in national institutions (Figure 1b). Again, strategies vary, with Justus-Liebig Giessen University, Germany, creating many curricular units due to the separation of theoretical from practical classes and the Cornell University, United States of America, concentrating many subjects in a single broader curricular unit

(i.e., modules, blocks). Clear differences between the number of electives and internships can be observed between different institutions. A median of 27 curricular units of Fundamental sciences can be expected in a veterinary curriculum (Figure 2a). Overall, Integrated Veterinary Medicine is represented in a greater number of curricular units (*n*=7) compared to Companion Animal Medicine *(n*=2) and Equine & Livestock Medicine (*n*=4).

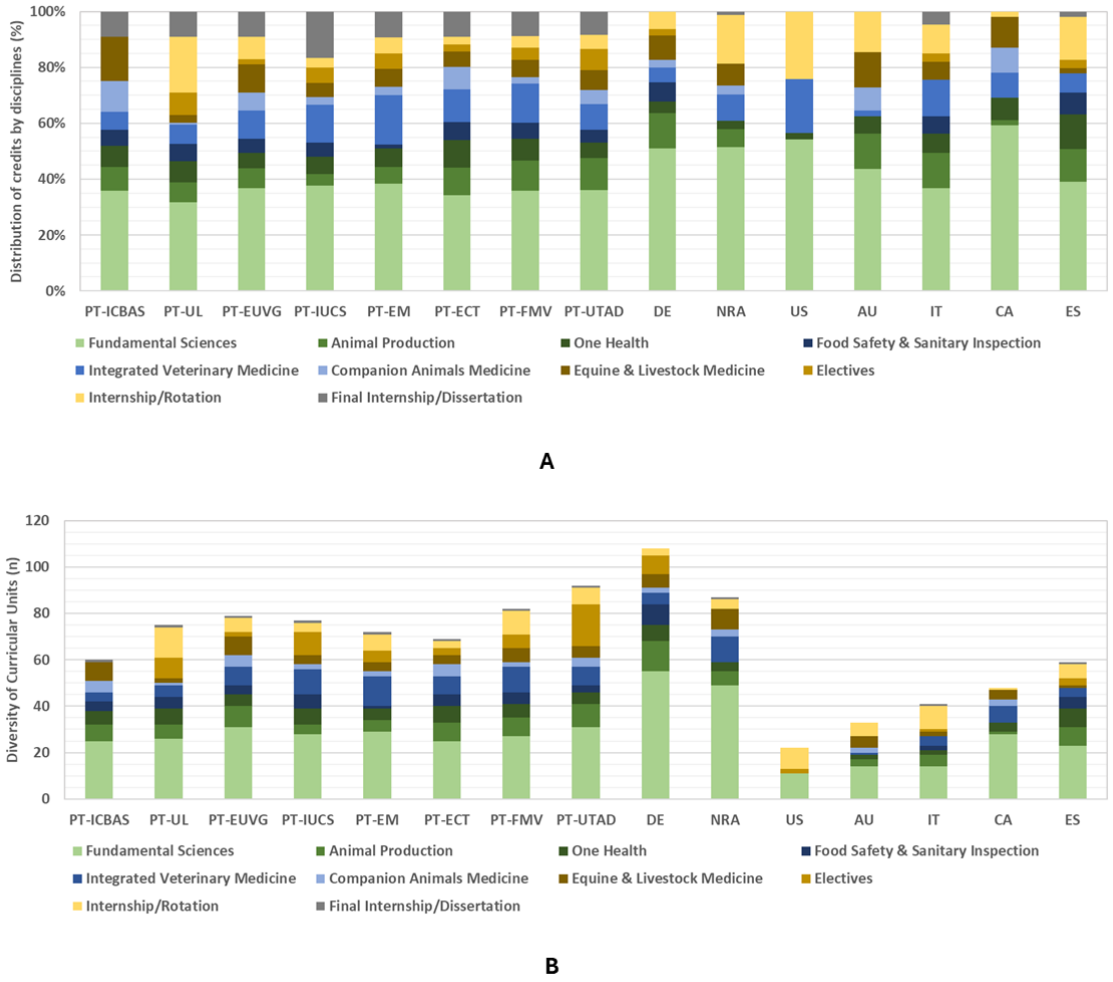

Figure 1 Comparison between veterinary curriculum: distribution of credits by disciplinary area (A) and diversity of curricular units (B) per institution.

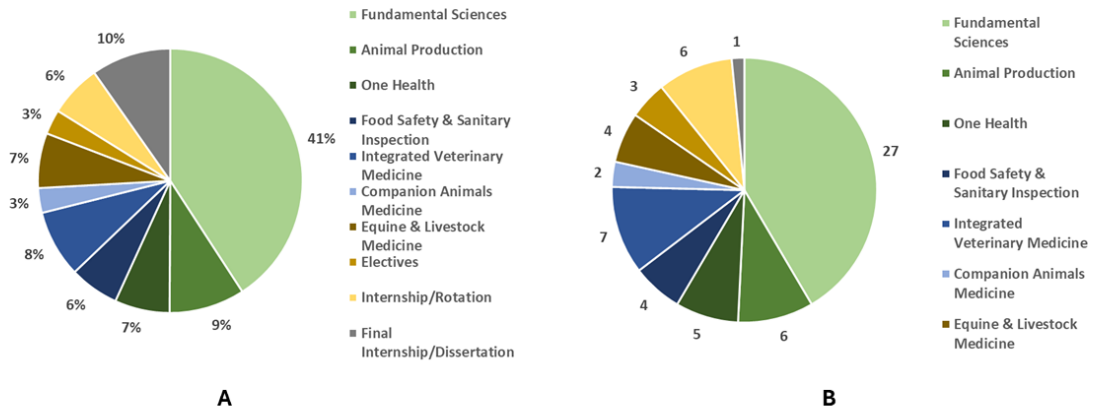

Figure 2 Median distribution of credits by disciplinary area (A) and median number of curricular units by disciplinary area (B).

Distribution of subdisciplines during the academic years

Curricular units and subdisciplines were classified into disciplinary areas, adapted from the internal criteria of the School of Medicine and Biomedical Sciences, University of Porto (PT-ICBAS). The distribution of disciplinary areas and subdisciplines across academic years for national and international institutions is represented in Figure 3. For Fundamental Sciences, a wider chronological distribution can be found in international veterinary curricula. For instance, chemistry & biochemistry is taught from year one to three, while in national institutions is always taught in the first year of the veterinary curriculum. Moreover, botanics and zoology are not part of the Portuguese veterinary curricula. Conversely, ethology is generally taught as an independent curricular unit in national institutions while it is generally associated with animal welfare or deontology & ethics in international institutions. Moreover, soft skills (i.e., non-technical skills) are taught in national institutions in any academic year, including communication skills, languages, and humanities. One Health subdisciplines are taught from the second year in national institutions and from the first year in international institutions. Similarly, medicine begins to be taught in the third year in national institutions and in the second year in international institutions, followed by specialized medicines (i.e., companion animals, equine, livestock) a year later. Electives and internships generally span the five years of the veterinary curriculum. The sixth year is not represented because it is generally constituted by the final internship and dissertation. Overall, compared to national institutions, international institutions have a higher spread of Fundamental Sciences throughout the years while anticipating specific areas of veterinary medicine in the curriculum. However, this representation solely translated the general trend, while distribution of curricular units varies from institution to institution.

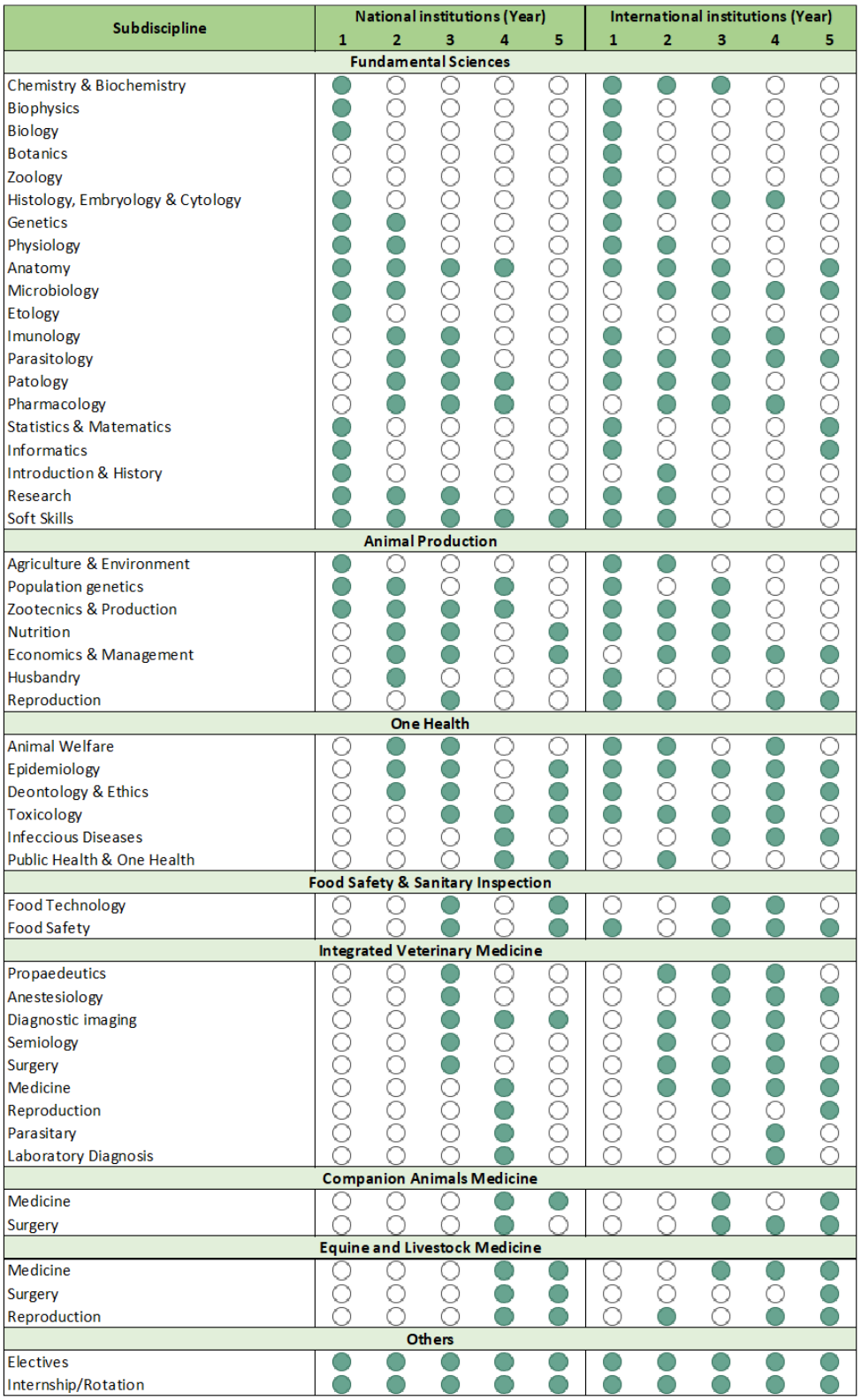

Figure 3 Heatmap of the distribution of subdisciplines across years of veterinary curriculum. Green represents that the subdiscipline is present in that academic year.

Species differentiation of the veterinary curriculum

As previously mentioned, institutions follow widely different strategies regarding species or sector differentiation. These are the disciplinary areas most widely variable between curricula. For each institution, a differentiation factor (DF) was calculated to express the degree of differentiation of the clinical sciences in the main curricula (i.e., not through electives) based on the number of credits attributed to Companion Animal Medicine (CA), Equine & Livestock Medicine (EL), and Integrated Veterinary Medicine (VM): DF = (CA+EL)/VM (Table 2). A higher DF represents a higher differentiation of the core veterinary curriculum of the institution. In national institutions, the School of Medicine and Biomedical Sciences, University of Porto (PT-ICBAS) presented the highest DF (4.1), with specialized medicine weighing 26.8% of the curricula compared to 6.5% of general medicine. In international institutions, the University of Melbourne, Australia (AU), presented the highest DF (9.9), with specialized medicine weighing 20.8% of the curricula compared to 2.1% of general medicine. However, some institutions also offer some degree of specialization through their elective courses. Overall, international institutions have a slightly higher average (4.7±3.5 vs. 1.3±1.2) and median (1.2 vs 0.6) DF than national institutions, possibly due to larger differences between different countries.

Table 2 Differentiation factors of the core veterinary curriculum of different institutions and the relative weight of disciplinary areas.

Institution		Differentiation factor	Weight in veterinary curriculum (%)		
			Integrated Veterinary Medicine	Companion Animal Medicine	Equine & Livestock Medicine
National institutions	PT-ICBAS	4.1	6.5	11.1	15.8
	PT-UL	0.5	6.7	0.9	2.7
	PT-EUVG	1.7	10.0	6.5	10.0
	PT-IUCS	0.6	13.6	2.8	5.0
	PT-EM	0.5	17.5	3.1	6.3
	PT-ECT	1.2	11.7	8.1	5.4
	PT-FMV	0.6	14.1	2.3	6.1
	PT-UTAD	1.3	9.2	5.1	7.1
	Mean±SD	**1.3±1.2**	**11.2±3.8**	**5.0±3.4**	**7.0±4.0**
International institutions	DE	2.1	5.3	2.7	8.7
	NRA	1.2	9.4	3.1	7.8
	US	0.0	19.2	0.0	0.0
	AU	9.9	2.1	8.3	12.5
	IT	0.5	13.0	0.0	6.4
	CA	2.2	9.0	9.0	10.9
	ES	0.3	6.8	0.0	1.9
	Mean±SD	**4.7±3.5**	**5.6±5.6**	**5.7±3.9**	**7.0±5.0**

School of Medicine and Biomedical Sciences, University of Porto (PT-ICBAS), Veterinary Medicine Faculty, University Lusófona (PT-UL), Universitary School Vasco da Gama (PT-EUVG), University Institute of Health Sciences, CESPU (PT-IUCS), Egas Moniz School of Health & Sciences (PT-EM), School of Sciences and Technology, University of Évora (PT-ECT), Faculty of Veterinary Medicine, University of Lisbon (PT-FMV), School of Agrarian and Veterinary Sciences, University Trás-os-Montes and Alto Douro (PT-UTAD), Justus-Liebig Giessen University, Germany (DE), University of Pisa, Italy (IT), Santiago de Compostela University, Spain (ES), Prince Edward Island University, Canada (CA), Cornell University, United States of America (US), University of Melbourne, Australia (AU), Nigeria University, Nigeria (NRA).

Electives in the veterinary curriculum

Electives correspond to a median of 3 curricular units and 3% of the veterinary curriculum. Six out of the fifteen institutions do not offer electives, including the School of Medicine and Biomedical Sciences, University of Porto (PT-ICBAS), which is the single case among national institutions. The number of

curricular units can reach up to 10, as offered by the University Institute of Health Sciences, CESPU (PT-IUCS), and be as diverse as allowing students to choose from 46 different curricular units, as presented by the University of Cornell (US). Electives tend to be included in the later formative years of the veterinary curriculum, with 52% being offered in the fourth and fifth years. This fact is not only agreeable with the predominance of Fundamental Sciences in the first years but also with electives offering students differentiation or specialization. For instance, Egas Moniz School of Health & Sciences (PT-EM) has no specialization in its core veterinary curriculum but offers it as part of elective modules, which allow students to choose between companion animals, equines, health and management of the animal population, and applied veterinary public health. However, it is worth considering that not all curricular information might have been available online and that often students are also given the opportunity to engage with other course's curricular units.

In summary, electives include the following topics: i) research and animal experimentation; ii) agriculture and environment; iii) animal production, including specialization (e.g., zootechnics, nutrition, livestock) or less studied systems (e.g., apiculture, aquaculture, biologic production); iv) specialization by systems (e.g., cardiology, neurology, pathology, endocrinology, toxicology, anesthesia, teratology, parasitology); v) specialization by areas of medicine (e.g., dentistry, oncology, forensics, conservation, emergency care, shelter, tropical region medicine, physical therapy, geriatrics, alternative and complementary practices); vi) diagnostics and laboratory techniques, both of clinical (e.g., diagnostic imaging, microbiology, clinical analysis, cytology) and public health importance (e.g., food analysis and quality, chemical analysis of residues in animal-derived foods); vii) behavior, training, and breeding of different animals (e.g., cats, dogs, equines); and viii) soft skills (e.g., languages, informatics, human resources, business and management). Interestingly, while national institutions do not offer zoology as part of the core veterinary curricula, the Veterinary Medicine Faculty, University Lusófona (PT-UL) offers *Medic Zoology* as an elective curricular unit.

Internship in the veterinary curriculum

Almost all veterinary curricula include internship or clinical rotations during the five years, which correspond to a median of six curricular units weighing 6%. The only institution without internship and clinical rotations is the School of Medicine and Biomedical Sciences, University of Porto (PT-ICBAS), which includes such activities as part of other curricular units. In national institutions, internships involve projects, laboratory, and complementary activities in the first year, animal production and clinical practice in the second year, and food safety and clinical practice from the third to the fifth years. In international institutions, clinical practice begins in the first year and internships and rotations provide students with a greater diversity of subjects. For instance, the University of Pisa (IT) provides fourth-year students with external internships in specific areas (e.g., nutrition, parasitology, zootechnics) followed by practical evaluations.

All national institutions require, in the first semester of the sixth year, a final internship evaluated as a report or a scientific dissertation. Interestingly, the Faculty of Veterinary Medicine, University of Lisbon (PT-FMV) also requires in the sixth semester a soft skill curricular unit titled *Veterinarian profession and communication in science*. Conversely, only three of the international institutions require a final internship or dissertation, namely the University of Pisa (IT) and Santiago de Compostela University (ES), in the fifth year, and the University of Nigeria (NRA), in the sixth year. The final internship or dissertation is a single curricular unit and has a median weight of 10%, generally being lower in international institutions, possibly due to a higher expression of internships during the remaining years.

DISCUSSION

Traditionally, the veterinary curriculum has been composed of a first part of foundational sciences and a second part of clinical sciences (Ilkiw et al., 2017a), progressing from healthy to sick animals, culminating in clinical practice in the last year (Lane et al., 2017). However, this traditional curriculum is not flexible to the demands of a rapidly changing profession (Losansky et al., 2022). Indeed, the veterinary profession is undergoing constant transformation, either due to changes in society, production, regulations, or advances in medicine, creating a constant need for curricular updates (Losansky et al., 2022). The veterinary degree also provides access to a wide variety of non-clinical careers, including industry, public health, academia, government, and biomedical research (Lane and Bogue, 2010; May and Silva-Fletcher, 2015). Moreover, the development of the veterinary curriculum is also strained by a rapidly expanding knowledge base, demand for new professional competencies, integration of the One Health approach, accreditation requirements, availability of resources, and student expectations (Lane et al., 2017).

It has been suggested that curricular development in medical education must follow an outcome-based approach considering career needs, bridged towards content by teaching, learning and assessment (Prideaux, 2007). However, the intended curriculum is often the foundation for reforms (Jaarsma et al., 2009). Opinions diverge regarding the prioritization of core curriculum or electives (Fletcher et al., 2015). Yet, it remains impossible to address all emerging areas of veterinary medicine in a core curricular structure. Instead, the core veterinary curriculum should account for common factors in the profession, such as general competencies, foundational knowledge, clinical theory, Day One competencies, and accreditation (Jaarsma et al., 2009; May and Silva-Fletcher, 2015). There has been a shift towards general competencies (e.g., problem-solving, lifelong learning) alongside technical and specific veterinary knowledge (Jaarsma et al., 2009). Strategies to deal with curriculum overload have included early species differentiation, elimination of content, or transferring content to electives (Jaarsma et al., 2009). However, the trend is to include new areas in the curriculum without explicit demotion of others (Cake et al., 2016). The World Health Organization for Animal Health provides guidelines for a core veterinary curriculum that can be adapted to each country or institution's needs (Figure 4).

Most innovations in curricula include integrated or block courses, problem-based learning, specific career path opportunities, development of soft skills or non-technical competencies, and early clinical experiences or simulations (Lane et al., 2017). Integration of the veterinary curriculum ensures progression and avoids repetition, allowing the integration of simple clinical concepts and practical techniques from early years which evolve into more complex concepts in later years (e.g., from techniques to clinical procedures to clinical cases) (May and Silva-Fletcher, 2015). Additionally, integrating topics across disciplines promotes deeper learning and a more comprehensive understanding of the subject, motivates students by focusing on outcome-based learning, and develops interpersonal skills (Ryan et al., 2004; Cavalieri, 2009). Integrated or block designs organize information on body systems or disciplines, increases flexibility within the course, and reduces the number of examinations students need to be subjected to (Foreman et al., 2017).

Subdiscipline	Sequence in curriculum		
	Early	Mid	Late
Biochemistry	●	○	○
Genetics	●	○	○
Anatomy	●	○	○
Physiology	●	○	○
Immunology	●	○	○
Biomatematics	●	○	○
Animal welfare & ethology	●	●	○
Parasitology	○	●	○
Pharmacology & Toxicology	○	●	○
Pathology	○	●	○
Transmissible diseases	○	●	○
Microbiology	○	●	○
Epidemiology	○	●	○
Rural economics, business management, and animal production	○	●	●
Clinical and diagnostic sciences	○	●	●
National and international veterinary legislation	○	●	●
Heard health management and management	○	○	●
Public health	○	○	●
Food safety / hygiene	○	○	●
Professional jurisprudence and ethics	○	○	●
Communication	●	●	●

Figure 4 The World Organization for Animal Health suggested core veterinary curriculum, green represent positive results (adapted from (World Organization for Animal Health, 2013)).

Despite the apparent advantages of an integrated veterinary curriculum, only 47% of 38 institutions of the American Association of Veterinary Medical Colleges surveyed in 2017 deviated from a traditional curriculum structure, including offering tracking options, problem-based learning or integrated courses, blocks, early clinical experiences, or electives (Lane et al., 2017). Similarly, few institutions in the present sample follow an integrated veterinary curriculum. Only two out of the seven international institutions follow an integrated curriculum, namely Cornell University, United States of America (US) and University of Melbourne, Australia (AU). Of the eight national institutions, the Egas Moniz School of Health & Sciences (PT-EM) is the only one following an integrated curriculum with curricular units such as *Function of the animal organism* and *Medicine and surgery*, both composed of ten parts. As previously mentioned, this institution allows students to choose a species or discipline specialization through an elective track in the fifth year. Interestingly, the veterinary course has only been granted accreditation in this institution in 2021 by the Portuguese higher education accreditation agency (A3ES). This is aligned with the idea that the creation of newer courses allows for greater creativity and innovation compared to the inertia associated with the curricular revision of long-existing courses (Lane et al., 2017). Of international institutions, the University of Melbourne, Australia (AU), has the most integrated curriculum, with the curricular unit *Veterinary bioscience* which takes many iterations to address each organ or system. Cornell University, United States of America (US) also

concentrates subjects into curricular units such as *Host, agent, and defense* or *Animal disease and health*.

Despite the previously mentioned benefits (e.g., content organization, flexibility, fewer exams), block units may also pose challenges. In 2005, the University of California implemented an integrated block curriculum as part of a curricular revision (Ilkiw et al., 2017b). The restructuring process posed several challenges, including: i) scheduling blocks within the academic calendar; ii) managing the fragmentation of disciplines shared across blocks (e.g., pharmacology); iii) avoiding excessive specialization in elective blocks; iv) disrupting well-established courses; v) needing frequent redesigns of block courses; vi) requiring regular staff coordination meetings; and vii) difficulties in appointing block leaders. In 2011, the block curriculum was implemented and restructured to incorporate problem-based learning within the block format (Zamor et al., 2017). Additional challenges emerged, including inconsistencies in teaching methods and student workload across blocks, difficulties in facilitating small group activities, insufficient time to cover the material, and concerns about downsizing content. Yet, the relatively low popularity of integrated veterinary curricula may not reflect its educational effectiveness but rather the inertia in curricular revisions and the challenges of coordinating large blocks involving many faculty members.

While blocks or integrated curricula were not popular, most institutions offered electives (10/15) and internships or clinical rotations (14/15). Electives provide opportunities to complement the existing core veterinary curriculum or offer species or discipline specialization. However, it is important not to overemphasize electives, as an excessive number can overwhelm or confuse students (Ilkiw et al., 2017a). The 2005 University of California curriculum followed a 3:1 core to elective curriculum, followed by the selection of one of eight clinical tracks (Ilkiw et al., 2017a). The Egas Moniz School of Health & Sciences (PT-EM) also offers similar elective specialization modules. An alumni survey in the Netherlands also indicated an interest in pursuing dedicated species tracks (Jaarsma et al., 2008). However, electives only constitute a small portion of the veterinary curriculum (0 – 8%) in the studied institutions. Internships and clinical rotations constitute a larger portion of the veterinary curriculum (0 – 24%), which is even greater when accounting for the final internship or dissertation (2 – 29%).

There is a trend for early exposure to clinical topics either through contextualization (e.g., case-based learning), simulation, or clinical rotations, while teaching Fundamental Sciences (Fletcher et al., 2015; Ilkiw et al., 2017a; Lane et al., 2017). Foreman et al. compare learning clinical skills to learning an instrument: practicing as often as possible is more likely to ensure mastery (Foreman et al., 2017). Internships and clinical rotations strengthen clinical skills and self-learning, address growing needs for technical skill development, and improve student's self-confidence at graduation (Fletcher et al., 2015; Foreman et al., 2017; Lane et al., 2017) . Internships and rotations also allow the integration of students into practical learning while managing increasing workloads on faculty members (Fletcher et al., 2015). The 2009 University of Illinois curriculum includes clinical rotations from the first years: students learn on models, then on cadavers, then on live shelter animals, and then on clinical practice (Foreman et al., 2017). Similarly, the 1993 Cornell University curriculum aimed at promoting: i) exposure to clinical practice from the first year; ii) a 2:1 foundational core and elective curriculum; and iii) active learning and engagement (e.g., through problem-solving learning) (Fletcher et al., 2015). In the present sample, both national and international institutions have electives, internships and rotations spread throughout the five years of the curriculum. Differences were observed for national institutions that concentrated Fundamental Sciences in the first years and clinical sciences later in the curriculum, which may hinder some of the benefits of early internships and rotations. A greater intersection between basic and clinical sciences may also ensure greater returns from early exposure to clinical practice, even when following more traditional veterinary curricular structures.

Fundamental Sciences still dominate the veterinary curriculum, with 11 – 55 curricular units and 32 – 59% of the credit weight. While there is a trend to reduce foundational or core areas to the detriment of electives (Fletcher et al., 2015), there is an opposing force to strengthen general competencies (Jaarsma et al., 2009), which might justify the current preponderance of basic sciences. These also constitute the common factors of the profession that must be addressed through a core veterinary curriculum (Jaarsma et al., 2009; May and Silva-Fletcher, 2015), followed by differentiation through electives, internships and clinical rotations. The same applies to clinical sciences, which include the prioritization of Integrated Veterinary Medicine disciplines (2.1 – 19.2%) over Companion Animal Medicine (0 – 11.1%) and Equine & Livestock Medicine (0 – 15.8%) in the core veterinary curriculum. In the Faculty of Veterinary Medicine of Utrecht University curriculum, differentiation begins in year one when students choose a species track (Jaarsma et al., 2009). The final internship or dissertation also allows students to specialize or complement their education (Foreman et al., 2017). Yet, Fundamental Science resources, such as a veterinary anatomy museum, may promote interdisciplinary learning (e.g., histology and anatomy), cohesive research within the institution, and learning opportunities for the neighboring community (Kongtueng and Yotanyamaneewong, 2021).

While some basic sciences are seen as irrelevant to the profession (e.g., zoology, botany, physics, biometrics) (Losansky et al., 2022), soft skills (i.e., non-technical skills) have been gaining increasing importance among the foundational sciences (Lane & Bogue, 2010). These are important to accompany the rapidly changing role of veterinarians in society. For instance, livestock veterinarians are increasingly responsible for preventive medicine and population management (Lane and Bogue, 2010). On the other hand, research skills are important for critical thinking and lifelong learning (Janicke et al., 2020). Competencies that have a perceived higher importance in the success of the veterinary profession include collaboration, communication, critical thinking, ethics, and resilience (Lane and Bogue, 2010; Cake et al., 2016). Additionally, One Health offers opportunities to integrate disciplines in collaborative problem-based learning (Wilkes et al., 2019).

Non-technical skills, such as communication and public health awareness, are increasingly prioritized to reflect the expanding scope of the veterinary profession. In the present study, it was observed that all international institutions presented curricular units that might include soft skills, such as *Introduction to the veterinary profession* (AU), *Professional foundations* (CA), *Professional studies: communication and ethics* (DE), *Principles of economy for veterinary medicine* (IT), *Ethics, bioethics, and veterinary legislation* (ES), *Social sciences* (NRA), and *Communication and entrepreneurship* (US). All national institutions presented similar curricular units, such as *Economy and management* (PT-ICBAS), *Introduction to veterinary medicine* (PT-UL), *Personal and professional competencies* (PT-EUVG), *Deontology, ethics and legislation in practice* (PT-IUCS), *The veterinarian and society* (PT-EM), *Communication strategies* (PT-ECT), *Deontology and bioethics* (PT-FMV), and *Economics, management and marketing in animal health* (PT-UTAD). Therefore, most current soft skill courses in the reviewed institutions address the veterinary profession, its societal roles, ethics and legislation, communication skills, and entrepreneurship. Additional competences may be sought through elective courses (e.g., the elective *Veterinary management: human resources and business strategy* in PT-IUCS).

Based on the findings of the present study, the following strategies can be suggested: i) implementation of early problem-based learning and clinical contact to improve technical skills; ii) overlapping foundational and clinical sciences to motivate students; iii) maintaining a broad undifferentiated core curriculum while providing specialization opportunities through electives, internships and clinical rotations; iv) prioritizing non-technical skills as a critical component of professional development; v) coordinating content between different curricular units, even when not applying an integrated block design; vi) promoting periodic curricular revisions

based on feedback from faculty, students, *alumni*, and employers; and vii) supporting faculty development by encouraging cohesion and providing training on non-technical skills and innovative teaching methods.

The limitations of the study include the number of institutions examined (n=15) and the lack of accessible veterinary curricular data from many institutions. Future research could explore the challenges of implementing an integrated curriculum based on course modules, compare student learning outcomes between modified traditional and integrated curricula, and investigate the primary forces shaping curricular structures. This study offers an overview of curricular strategies in national (Portuguese) and international institutions and the fundamental principles driving them, providing a foundation for curricular renewal to meet the evolving challenges of the veterinary profession.

CONCLUSIONS

Curricular data was collected from fifteen national (i.e., Portuguese) and international veterinary courses in 2024 to identify common trends and strategies that can guide curricular renewal. Despite the rapid transformation of the veterinary profession, most institutions still adhere to a modified traditional veterinary curriculum, with foundational sciences comprising approximately 41% of the curriculum, emphasizing general competencies essential for clinical and non-clinical roles. Widespread implementation of an integrated veterinary curriculum organized in blocks or modules has not yet taken place and seems to be more likely to occur in new veterinary courses. Internationally, there is a growing trend to overlap basic and clinical sciences across the academic timeline, which promotes student learning, motivation, and technical skill development. Early clinical exposure, facilitated through case studies, simulations, live animal practice, and rotations, further strengthens these skills. Electives, internships, and clinical rotations allow students to pursue a specialization while allowing the core veterinary curriculum to remain undifferentiated. Problem-based learning is also becoming more prevalent, aligning with the trend of integrating foundational and clinical sciences over time. Developing a core veterinary curriculum remains challenging but must align with the profession's core principles: common factors of the profession (e.g., veterinarians as comparative practitioners and public health promoters), adherence to Day One competencies, and accreditation standards. A successful curriculum balances these demands with resource availability and faculty and student expectations.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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