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Posted Date: 16 January 2026

doi: 10.20944/preprints202601.1213.v1

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Article

Assessing Nurses' Knowledge and Attitudes Towards Biosimilars: Results from a National Survey

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Highlights

What are the main findings?

- Nurses in Spain generally demonstrate only basic knowledge of biosimilars.** Higher knowledge levels are more common among those who have completed industry-led training and/or work in units where biosimilars are already in use.
- Working in units where biosimilars are routinely administered or prescribed increases nurses' confidence in their safety and efficacy.** This confidence also rises progressively with higher levels of biosimilar knowledge.

What are the implications of the main findings?

- There is a substantial opportunity to improve nurses' knowledge of biosimilars in European countries, at a moment when they are willing to learn and recognize the benefits these therapies offer to patients and healthcare systems.
- Strengthening education should begin with integrating biosimilar content into academic undergraduate curricula and expanding diverse training modalities in collaboration with the pharmaceutical industry.

Abstract

Background/Objectives: Nurses play a key role in supporting patient adherence to biosimilars, a responsibility that depends on their knowledge and understanding of biological therapies. This study aimed to assess nurses' knowledge and attitudes toward biosimilars in Spain and to examine the demographic and professional factors that shape them. **Methods:** A self-administered, web-based survey was distributed in Spain between May and June 2024 to evaluate registered nurses' knowledge and attitudes toward biosimilars. Associations were explored using Spearman's correlation and Fisher's exact tests, and predictors were examined through ordinal regression models. **Results:** A total of 402 nurses responded. 63.7% reported at least basic knowledge of biosimilars. Access to industry-led training was strongly associated with higher knowledge levels ($OR = 11.256$; $p < .001$), whereas lack of awareness of biosimilar use in the workplace was associated with lower knowledge ($OR = 0.176$; $p < .001$). Nurses' confidence in the safety and efficacy of biosimilars increased with knowledge level—from basic ($OR = 3.823$; $p < .001$) to intermediate ($OR = 4.747$; $p < .001$) and advanced ($OR = 14.594$; $p < .001$). Confidence was also greater among nurses working with biosimilars in their units ($OR = 3.959$; $p = .004$) and those in hospital ambulatory care

services ($OR = 2.506$; $p = .022$). **Conclusions:** Nurses in Spain predominantly demonstrate basic knowledge of biosimilars, emphasizing the need for broader access to training. Industry-led courses emerged as the most relevant modifiable factor for improving both knowledge and confidence. Strengthening collaboration with the pharmaceutical industry may support informed clinical practice and improve patient adherence to biosimilar therapy.

Keywords: biosimilars; interchangeable products; knowledge; nurses; survey

1. Introduction

The use of biological medicines has markedly improved the treatment of numerous diseases [1]. However, their increasing utilization (driven by the growing burden of chronic conditions and their high costs) has led health systems to promote the development and prescription of biosimilars [2].

Biosimilars are medicines that are highly similar to their reference biologic products in terms of structure, quality, safety, efficacy, and immunogenicity [3]. Since the first biosimilar was approved in 2006, the European Commission has authorized 25 active substances across 131 medicines [4]. Approved biosimilars are considered scientifically interchangeable with their corresponding reference medicines. Clinical interchangeability between two biosimilars derived from the same reference product may also be possible [5].

The growing availability of biosimilars can enhance patient access to biological therapies and alleviate the economic burden on health systems, owing to their lower cost compared with reference medicines [6,7]. The introduction of biosimilars has led to price reductions in several European countries with the main adoption at hospital level [8]. In Spain, the use of biosimilars has led to a 28% reduction in costs compared to reference medicines, accounting for 7.7% (€981 million) of total pharmaceutical expenditure [9].

Despite the proven safety and effectiveness of biosimilars [5], patient misconceptions regarding quality and efficacy still compromise therapeutic adherence and clinical outcomes [10]. To address this challenge, multi-stakeholder approaches should involve physicians, pharmacists and nurses [11]. Nurses play a pivotal role in medication management, pharmacovigilance, and patient education regarding reference medicines and biosimilars, promoting understanding of interchangeability and thereby reducing the nocebo effect [12,13].

While most research has examined the knowledge and attitudes of physicians and pharmacists toward biosimilars [14–17], evidence on nurses' experiences remains limited [18]. Studies involving nurses have primarily examined knowledge and attitudes toward biosimilar use, with particular emphasis on reliance in their safety and efficacy as a key attitudinal component [19,20]. Friganović et al. [21] conducted an international survey and identified concerns about conflicting attitudes and knowledge gaps among nurses, which were recognized as threat to medication safety, patient trust and switching implementation [22]. Other studies have explored nurses' perspectives on barriers and facilitators to biosimilar implementation [11,18,23]. Nurses rely on diverse learning sources and platforms for information on biosimilars, and access to these resources may influence their knowledge and attitudes [21,24]. Moreover, nurses' knowledge and attitudinal characteristics (such as confidence in biosimilars) appear to be shaped by sociodemographic and professional factors [18,21]. However, none of these associations have yet been studied within the Spanish healthcare context.

To address these gaps, this study explores the current state of nurses' knowledge, attitudes and perceptions regarding biosimilars in Spain. In addition, we investigate what sociodemographic and professional factors may predict nurses' knowledge and reliance regarding biosimilars. The findings are expected to offer valuable insights into aspects of nursing competence that may require improvement, thereby informing strategies for continuous professional development and the design of academic curricula.

2. Materials and Methods

2.1. Study Design

This study was a self-administered, web-based survey designed to assess nurses' knowledge and attitudes toward biosimilars in Spain. It employed a cross-sectional, quantitative, descriptive and correlational design. The reporting of this study conforms to the statement "Strengthening the reporting of observational studies in epidemiology" (STROBE) [25], in conjunction with the Consensus-Based Checklist for Reporting of Survey Studies (CROSS) [26].

2.2. Questionnaire Details

The survey tool was developed in four stages. First, a comprehensive literature review and assessment of existing instruments were conducted. The initial questionnaire was adapted from the validated tool titled "Nurses' Knowledge Toward Biosimilars," previously used in studies across 11 countries [21]. The second stage involved a content validity assessment by an expert panel comprising five nurses with extensive clinical experience in the use of biosimilars. Three of these experts were selected from among the authors of the Guide to Biosimilar Medicines for Nurses [27], and they, in turn, identified two additional experts who had more than five years of clinical experience working with biosimilars. Based on the feedback obtained from this panel, the survey underwent further refinement during the third stage.

A 23-item self-administered questionnaire was developed to collect data, comprising single-choice, multiple-choice, and open-ended questions. General participant information included sociodemographic variables such as age, sex, region of work, years of professional experience, clinical setting (with two sub-questions on hospital areas and other areas), business sector, and postgraduate qualifications. Specific items assessed nurses' knowledge of biosimilars (e.g., self-assessed level of knowledge, definition of biosimilar, distinction between biosimilars and generics, and examples of known biosimilars), professional factors (e.g., the use of biosimilars in the workplace and access to training courses on biosimilars) and reliance toward biosimilars (e.g., reliance on biosimilars' safety and efficacy, willingness to receive training, perceived barriers and facilitators, perceived benefits, and nurses' role in biosimilar education). Additional questions about nurses' perception were included for descriptive purposes.

In stage four, a pilot survey was conducted to confirm feasibility in a small sample of nurses ($n = 40$). The pilot responses were included in the final sample and were also used, together with feedback from the expert panel, to confirm the content validity of the questionnaire. The survey tool is provided in Supplementary Table 1.

To facilitate statistical analysis, certain survey response categories were aggregated to ensure sufficient sample sizes for hypothesis testing and predictive modeling. This was accomplished by merging conceptually similar or low-frequency categories into broader groups, guided by theoretical considerations and observed distributional patterns. The grouping process preserved the original meaning of responses, and the resulting categories are presented in Supplementary Table 2.

2.3. Sample Characteristics

According to Zamora-Romero et al. [28], 296,462 nurses were employed in the Spanish healthcare system in 2022. The study used non-probabilistic convenience sampling and included registered nurses providing direct patient care in Spanish healthcare settings. Nurses working in non-clinical areas or on leave were excluded. Based on a 95% confidence level, a 0.05 margin of error, and an assumed proportion of 0.5, the required sample size was calculated as 380 respondents.

2.4. Survey Administration

The survey was administered via the EU Survey online platform (EU Public License, European Commission), which supported participation from mobile devices. According to the pre-test performed, completion time was estimated at 10–15 minutes, although no time limit was imposed. All items in the questionnaire were mandatory. To prevent automated submissions, the platform

required participants to complete a CAPTCHA challenge before submitting their responses. Additionally, each IP address was restricted to a single submission. The survey interface displayed a cover text outlining the purpose and importance of the study for nursing development and patient safety, emphasizing the absence of right or wrong answers and ensuring anonymity, confidentiality, and data privacy.

The survey link was distributed to nursing executives across public and private healthcare organizations, who subsequently invited potential participants via corporate email and through professional social networks, such as LinkedIn and the official WhatsApp channel of the Spanish Institute of Nursing Research. The survey remained open for responses from May to June 2024.

Respondent-related and measurement-related sources of common method bias (CMB) were addressed through procedural measures, including survey design strategies (e.g., clear instructions, assurance of anonymity, and avoidance of ambiguous items) and methodological separation (e.g., use of varied item formats and distinct measures for independent and dependent variables) [29].

2.5. Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki [30], and the protocol was approved by the Ethics Committee of the Príncipe de Asturias University Hospital in Madrid on March 19, 2024 (Approval No. 08/2024). Participation in the survey implied informed consent, and respondents were provided with information regarding the study’s purpose, confidentiality, and data privacy.

2.6. Statistical Analysis

Data were exported from the EU Survey platform into Jamovi (Version 2.5) [31] for analysis. Descriptive statistics (frequencies, percentages, means, and standard deviations) were calculated for continuous, ordinal, and nominal variables. Concordance between nurses’ self-reported knowledge and objective measures (correct definition, differences between generics and biosimilars, and number of biosimilars identified) was assessed using Kendall’s W coefficient (poor: <0.00; slight: 0.00-0.20; fair: 0.21-0.40; moderate: 0.41-0.60; substantial: 0.61-0.80; and almost perfect: 0.81-1.00) [32]. Correlations of nurses’ knowledge and reliance with ordinal variables were examined using Spearman’s rank correlation. Associations of nurses’ knowledge and reliance with nominal variables were tested using Fisher’s exact test due to small cell counts expected (< 5). Cramer’s V was used to measure the strength of association (weak: >0.05; moderate: >0.10; strong: >0.15; and very strong: >0.25) [33]. Variables showing statistical significance were included in ordinal regression models to identify factors predicting nurses’ knowledge and reliance on safety and efficacy toward biosimilars. A *p*-value < 0.05 was considered statistically significant for all analyses.

3. Results

The survey was distributed to 402 nurses across the country. Since all fields were mandatory for submission, all questionnaires were valid.

3.1. Sample Demographics

The distribution of sample demographics and their representativeness compared to available data on registered nurses in Spanish healthcare [28,34] are presented in Table 1. The most represented age group was 41–65 years (70.4%). Female participants comprised 84.8%, and the most frequent work region was the Community of Madrid (30.1%). Most participants were employed in the public sector (83.6%), and the majority worked in hospital-based care settings (69.2%). Regarding postgraduate education, most had completed continuing education courses (68.7%), while only 3.0% had earned a PhD.

Table 1. Distribution of sample demographics with representativeness compared to available data for registered nurses in Spanish healthcare

Demographic data (n=402)	Frequency (n)	Rate (%)	Frequency (N) ¹	Rate (%) ¹
AGE (years)				
22-30	35	8.7	42,690	14.4 ²
31-40	78	19.4	77,080	26.0 ²
41-50	147	36.6	80,637	27.2 ²
51-65	136	33.8	64,036	21.6 ²
≥66	6	1.5	14,823	0.5 ²
SEX				
Female	341	84.8	249,621	84.2
Male	61	15.2	46,841	15.8
REGION OF WORK				
Andalusia	32	8.0	45,279	15.3
Aragon	36	9.0	11,046	3.7
Asturias	5	1.2	7,679	2.6
Balearic Islands	2	0.5	7,721	2.6
Canary Islands	8	2.0	15,026	5.1
Cantabria	2	0.5	4,027	1.4
Castilla y León	44	10.9	16,892	5.7
Castilla-La Mancha	16	4.0	13,585	4.6
Catalonia	34	8.5	49,680	16.8
Region of Valencia	11	2.7	28,054	9.5
Extremadura	5	1.2	7,398	2.5
Galicia	15	3.7	16,588	5.6
Community of Madrid	121	30.1	37,316	12.6
Region of Murcia	36	9.0	9,938	3.4
Autonomous Community of Navarre	16	4.0	5,339	1.8
Basque Country	15	3.7	17,665	6.0
La Rioja	4	1.0	2,198	0.7
Ceuta y Melilla	0	0.0	1,031	0.3
PROFESSIONAL EXPERIENCE (Min=1; Max=45).			μ ³ =22.1	SD ⁴ =10.4
CARE SETTING				
Hospital Care ^a	278	69.2	201,406	67.9
Primary Care	71	17.7	42,094	14.1
Others ^b	53	13.2	53,123	18.0
5.a. HOSPITAL AREAS (n=266)				
Daycare Unit	21	7.9		
Intensive Care	31	11.7		
Inpatient unit	90	33.8		
Pharmacy Unit	6	2.3		
Outpatient Clinics	25	9.3		
Other	93	35.0		
5.b. OTHER (AREAS) (n=53)				
Social and health centre	19	35.8		
Out-of-hospital emergencies	11	20.8	3,959	7.45
Mutual insurance/ occupational health companies	8	15.1		
Other	15	28.3		
BUSINESS SECTOR				
Semi-private	32	8.0	25,190	8.5
Private	34	8.5	73,207	24.7
Public	336	83.6	198,065	66.8
POSTGRADUATE EDUCATION				

Demographic data (n=402)	Frequency (n)	Rate (%)	Frequency (N) ¹	Rate (%) ¹
PhD.	12	2.9		
MSc. /Nurse Specialist	189	47.0		
Expert Certificate	80	19.9		
Continuous training courses/ No postgraduate education	124	30.9		

1Data from the reference population of nurses in Spain (N = 296,462) [28,34].

2Age groups in the study sample follow a different distribution compared to the reference population: <30 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, >69 years.

3μ = Mean; 4SD = Standard Deviation.

3.2. Responses to Nurses’ Knowledge, Perception and Attitudes Toward Biosimilars

In the survey, 63.7% of participants reported having at least basic knowledge of biosimilars, while only 6.0% indicated advanced knowledge. The correct EMA definition of biosimilars (“a biological medicine that has lost its patent and is equivalent in efficacy and safety to its reference medicine”) [35] was selected by 46.5% of respondents. Additionally, 66.9% correctly identified the differences between biosimilars and generic medicines. The most recognized marketed biosimilars included Enoxaparin sodium (56.2%), followed by insulin glargine (48.5%) and rituximab (36.3%).

Among respondents, 89.3% expressed willingness to receive training, with the workplace being the preferred source of information (43.8%). However, only 14.2% reported having access to work-based training, and just 9.0% of those indicated that it was delivered by the pharmaceutical industry. Regarding the use of biosimilars in the workplace, 63.9% responded affirmatively, while 26.9% were unsure. The main perceived benefit of biosimilars was cost reduction (52.9%), whereas only 22.6% fully trusted their efficacy and safety. The most significant barrier to the safe use of biosimilars was insufficient knowledge and experience (68.7%).

The roles of healthcare professionals and nurses in the use of biosimilars were primarily related to patient education, administration, and promotion of therapeutic adherence, as reported by 58.7% of respondents. According to 65.4% of participants, all members of the multidisciplinary team share responsibility for providing patient information. Specific responsibilities were perceived as falling on pharmacists (46.3%), nurses (42.3%), and physicians (42.0%). Most participants (77.4%) believed that informing nurses would be the first step toward improving trust in the efficacy and safety of biosimilars. Complete answers to questions regarding knowledge, attitudes and perceptions are available in Supplementary Table 3.

3.3. Concordance of Nurses’ Self-Reported Knowledge with Objective Measures

Responses to self-reported knowledge demonstrated substantial agreement with objective measures, including correctly defining biosimilars, identifying biosimilars, and distinguishing between generic and biosimilar medicines (Kendall W=0.648; χ^2 (401) = 782; $p < .001$).

3.4. Nurses’ Knowledge and Reliance on Biosimilars vs Sociodemographic and Professional Factors

After grouping categories, the results of multivariate tests indicate that nurses’ knowledge of biosimilars was weakly correlated with age ($r_s = 0.111$; $p = .027$). Table 2 shows strong associations in bivariate tests between knowledge and hospital units, as well as very strong associations with access to training courses and the use of biosimilars in the workplace.

Table 2. Factors associated with nurses’ knowledge of biosimilars.

Level of Knowledge				
Advanced	Intermediate	Basic	No knowledge	Total

Hospital Unit					
ICU	0	3	11	17	31
Pharmacy	1	2	3	0	6
Ambulatory services	3	17	17	9	46
Inpatient	9	10	37	40	90
Other	13	13	37	30	93
Total	20	45	105	96	266
Cramer's V					0.214 ¹
Access to training					
No Access	9	43	152	141	345
Yes, delivered by pharmaceutical industry	13	14	9	0	36
Yes, delivered by my organization	1	3	6	4	14
Other	1	2	3	1	7
Total	24	62	170	146	402
Cramer's V					0.284 ¹
Use of Biosimilars					
No	2	1	21	13	37
Don't know	0	3	32	73	108
Yes	22	58	117	60	257
Total	24	62	170	146	402
Cramer's V					0.316 ¹

¹ p < .001. Outcomes between groups were compared using Fisher's exact test. Cramer's V was used to measure the strength of association (weak: >0.05; moderate: >0.10; strong: >0.15; and very strong: >0.25).

Nurses' reliance on biosimilars showed a moderate positive correlation with self-reported knowledge ($r_s = 0.521$; $p < .001$) and weak negative correlations with years of experience ($r_s = -0.112$; $p = 0.024$) and age ($r_s = -0.116$; $p = 0.020$). In addition, reliance was very strongly associated with the use of biosimilars in the workplace ($C_v = 0.382$; $p < .001$) and strongly associated with hospital unit ($C_v = 0.213$; $p = 0.002$).

3.4. Factors Predicting Nurses' Knowledge and Reliance on Biosimilars

Table 3 shows that access to work-based training delivered by the pharmaceutical industry and awareness of biosimilar use in the workplace were the strongest predictors of higher levels of nurses' knowledge about biosimilars. Furthermore, employment in hospital ambulatory care services (such as day-care units or outpatient clinics) demonstrated greater predictive strength compared with inpatient wards, ICUs or hospital pharmacy.

Table 3. Predictors for nurses' knowledge of biosimilars.

Variable (reference)	Predictor	Estimate	SE	Z	p	OR	95% CI Lower	95% CI Upper
Age (22-30)	31-40	0.390	0.476	0.818	0.413	1.476	0.5832	3.795
	41-50	0.421	0.437	0.964	0.335	1.524	0.6515	3.631
	51-65	0.484	0.459	1.055	0.292	1.623	0.6640	4.041
	≥66	-0.182	1.175	-0.155	0.877	0.834	0.0745	8.837
	ICU	-0.3518	0.441	-0.797	0.425	0.703	0.2917	1.660

Hospital Unit (inpatient)	Pharmacy	1.4932	0.789	1.893	0.058	4.451	0.9427	21.630
	Other	0.3285	0.319	1.029	0.303	1.389	0.7436	2.600
	Ambulatory	0.7598	0.373	2.037	0.042	2.138	1.0303	4.460
Use of Biosimilars (No)	Don't know	-1.739	0.519	-3.348	<.001	0.176	0.0626	0.482
	Yes	0.152	0.471	0.324	0.746	1.164	0.4617	2.940
Access to Training (No)	Yes, by organization	-0.3114	0.839	-0.371	0.711	0.732	0.1388	3.910
	Yes, by industry	2.4209	0.435	5.570	<.001	11.256	4.8895	27.040
	Other	0.9368	0.771	1.215	0.225	2.552	0.5428	11.810

Model fit statistics: Deviance=539; AIC=571; McFadden’s R²=0.176. Estimate=regression coefficient; SE= standard error of the estimate; Z=Z-score of significance (high>2); OR=odds ratio; CI=confidence interval..

Note. Dependent variable: Knowledge (None | Basic | Intermediate | Advanced).

Models estimated using N = 266.

Nurses’ reliance on biosimilars increased progressively with higher levels of self-assessed knowledge. Confidence was also higher among nurses who used biosimilars in their workplace and among those working in ambulatory care services or other hospital units, compared with those in inpatient settings. Neither age nor professional experience demonstrated a clear independent effect; however, professional experience acted as a moderator in the relationship between age and confidence. The results of the ordinal regression analysis are presented in Table 4.

Table 4. Predictors for nurses’ reliance on biosimilars.

Variable (reference)	Predictor	Estimate	SE	Z	p	OR	95% CI Lower	95% CI Upper
Experience	(covariate)	0.0348	0.0268	1.297	0.194	1.035	0.98173	1.09
Age (22-30)	31-40	-0.0785	0.5402	-0.145	0.884	0.924	0.32059	2.68
	41-50	0.1227	0.6370	0.193	0.847	1.131	0.32658	3.99
	51-65	-0.6845	0.8779	-0.780	0.436	0.504	0.09103	2.87
	≥66	-19.061	14.581	-1.307	0.191	0.149	0.00802	2.63
Hospital Unit (Inpatient)	ICU	-0.1022	0.4372	-0.234	0.815	0.903	0.38013	2.12
	Pharmacy	0.6958	0.9275	0.750	0.453	2.005	0.35757	15.92
	Other	0.7642	0.3242	2.357	0.018	2.147	1.14169	4.08
	Ambulatory	0.9188	0.4013	2.290	0.022	2.506	1.15183	5.58
Knowledge (No)	Basic	1.3410	0.3121	4.296	<.001	3.823	2.08957	7.12
	Intermediate	2.1412	0.4510	4.747	<.001	8.510	3.58394	21.12
	Advanced	2.6806	0.6647	4.033	<.001	14.594	4.30148	60.86
Use of Biosimilars (No)	Don't know	-0.5364	0.5207	-1.030	0.303	0.585	0.20968	1.63
	Yes	13.761	0.4765	2.888	0.004	3.959	1.56337	10.21

Model fit statistics: Deviance=434; AIC=466; McFadden’s R²=0.238. Estimate=regression coefficient; SE= standard error of the estimate; Z=Z-score of significance (high>2); OR=odds ratio; CI=confidence interval.

Note. Dependent variable: Confidence level (Low/None/Don’t know what a biosimilar is | Normal | High or total confidence). Models estimated using N = 266.

4. Discussion

This study represents the first nationwide survey of nurses in Spain on this topic and provides insight into their knowledge, attitudes, and perceptions of biosimilars, as well as the training resources available to them. It also identifies several sociodemographic and professional predictors of nurses’ knowledge and their reliance on the safety and efficacy of biosimilars.

Most participants reported having only basic knowledge. However, the likelihood of higher knowledge levels was greater among nurses working in hospital ambulatory care services, in settings where biosimilars are routinely used, and in contexts where training has been delivered by the pharmaceutical industry. Although age appeared to be associated with both knowledge and reliance, it was not identified as a significant predictor, underscoring the need to strengthen biosimilar-related training for nurses across all age groups. The knowledge-related findings of this study are consistent with those reported in other European countries [21], although their results suggested that age, gender, and educational level are associated factors. This discrepancy may be explained by differences in the representativeness of the populations studied. In our case, the sample closely reflected the available demographic data [28]. Previous studies have reported that most nurses exhibit low levels of knowledge about biosimilars, particularly when compared with physicians and pharmacists [19,20,22].

On the one hand, the higher levels of knowledge observed among nurses working in ambulatory care services may be explained by the types of therapies delivered in medical and oncology day-care units. The patient profile in these settings is also relevant, as many individuals receive treatment for oncological or chronic inflammatory conditions commonly managed with biosimilars. This exposure contributes to what Li et al. [36] referred to as “*clinical specialized knowledge*”, which encompasses, but is not limited to, understanding of the disease, drug administration and use, nursing and therapeutic procedures, and specific precautions related to biologic therapies.

On the other hand, our findings indicate that a lack of information and awareness regarding the use of biosimilars in the workplace significantly reduces the likelihood of improving nurses’ knowledge. This challenge has been reported previously among nurses in the United Kingdom [19], where one in three respondents did not recognize that biosimilars were included in their local formulary, results that were poorer than those observed among physicians and pharmacists in the same study. Similarly, Barbier et al. [37] identified the absence of practical, context-specific information on biosimilars as a major barrier preventing healthcare professionals from fully understanding their clinical use. Together, these findings highlight the need for strengthened organizational communication and improved shared governance processes to ensure that healthcare professionals receive timely, accurate, and practical information on biosimilars.

Self-reported knowledge was consistent with several objective indicators, including the accurate definition of a biosimilar, understanding of the differences between generics and biosimilars, and the number of biosimilars correctly identified. The accuracy rate for defining a biosimilar among Spanish nurses was lower than the 64.23% reported among Chinese nurses [20], but higher than the 25.8% observed in the Austrian study by Binder and Zeitlinger [22]. When compared with other healthcare professionals in Spain, nurses’ accuracy was similar to the 42% identified among primary care physicians [16], whereas the knowledge gap appears to be smaller among pharmacists and specialized hospital physicians [14].

Understanding the differences between generics and biosimilars was reported to be lower among nurses than among physicians in Spain [16], while remaining comparable to that observed among nurses in other European countries [21], as well as among physicians and pharmacists in similar studies [17]. This distinction is critical, as a clear understanding of how generics differ from biosimilars is essential for ensuring consistency in patient education and for fostering trust among patients and their families [38].

Among the biosimilars currently used in the Spanish clinical context, only four could be considered relatively well known by nurses. The remaining agents were substantially less familiar, and even the recognition rates for the most widely used biosimilars were unexpectedly low. One possible explanation for these findings is the frequent use of commercial brand names in routine clinical practice, which may hinder nurses’ ability to correctly identify the specific biosimilar prescribed [39]. Mico-Pérez et al. [16] similarly reported low familiarity with biosimilars, noting that six out of ten primary care physicians were unable to mention any marketed biosimilar, likely reflecting entrenched prescribing habits centered on reference biologics. In contrast, Barbier et al. [40]

found a more robust integration of biosimilars into clinical practice in their international survey, with more than half of respondents indicating that they regularly prescribed the biosimilars listed. These contrasting findings may reflect differences in professional roles, prescribing responsibilities, exposure to biosimilars, and national implementation strategies.

Regarding nurses' willingness to receive training in biosimilars, our study found encouraging results, particularly among participants with lower baseline knowledge. Only a small proportion reported having received any information about biosimilars during their undergraduate studies, highlighting important opportunities to strengthen most nursing bachelor's programs. These findings support the integration of biosimilar-related content into undergraduate nursing and pharmacy curricula [41].

In relation to training opportunities within the clinical environment, medical and oncology ambulatory care services are among the settings where pharmaceutical industry representatives are more likely to deliver educational sessions. Access to this type of training has been shown to enhance nurses' knowledge and, subsequently, to increase reliance on key aspects such as the effectiveness, safety, and cost-effectiveness of biosimilars; therefore, such training should ideally be provided before biosimilars are introduced into clinical practice [42]. Inequities in access to continuing professional development have been reported in other healthcare contexts, where disparities between urban and rural settings, as well as between hospital and non-hospital environments, have been identified [43].

Most nurses in Spain expressed a preference for remote training modalities (including online courses, guides, and webinars) mirroring trends reported among nurses in other European countries [21,24]. Although the use of online training has expanded substantially since the COVID-19 pandemic, the evidence indicates no significant differences in effectiveness between delivery modes (face-to-face, online, or blended). Instead, training approaches should be adapted to the specific educational context and learners' needs [44].

Overall, nurses' reliance on the efficacy and safety of biosimilars increases progressively as their level of knowledge improves. Exposure to biosimilar agents and to patients receiving these therapies also plays an important role in strengthening this confidence. As previously mentioned, younger age does not influence on reliance, although previous studies have shown that newly graduated nurses typically demonstrate medication-management competence at an advanced-beginner level [45–47]. This suggests that targeted training and early clinical exposure may help bridge initial gaps in confidence and support more consistent reliance on biosimilars across experience levels.

The proportion of respondents who were able to identify the benefits of using biosimilars and recognize the nurse's role in patient education was consistent with their overall level of confidence in the safety and efficacy of these medicines. However, some concerns emerged regarding perceived limitations when administering a biosimilar without providing adequate patient information. Educating patients and involving them in shared decision-making are essential strategies to foster trust in biosimilars [38]. Nurses working in ambulatory care services and community settings are particularly well positioned to support this process, with the potential to enhance clinical outcomes across a wide range of conditions [1]. Moreover, growing awareness of the financial implications of treatment decisions reflects a broader shift toward economic and quality-driven decision-making in healthcare compared with two decades ago [48].

Nonetheless, nurses are not viewed as isolated agents in this process; rather, they emphasize that all members of the multidisciplinary team should be involved in providing patients with information about biosimilars. These findings align with previous reports in which nurses also assumed pivotal roles within interdisciplinary teams [40,49]. Overall, a multistakeholder approach—encompassing healthcare professionals, scientific societies, regulatory bodies, and patient associations—is essential to ensure effective patient education on biosimilars [12].

In general, our study indicates a positive trend toward enhancing nurses' knowledge and attitudes regarding biosimilars. This is reflected in their willingness to develop greater competence in the use of these therapies, while at the same time acknowledging persistent gaps in access to

adequate training—an issue also reported by Oqal et al. [50]. Addressing these gaps through the implementation of standardized educational resources could not only strengthen professional competence but also improve communication with patients during biosimilar switching processes, as demonstrated with the digital platform developed by Marras et al. [51].

The findings from this study may be applied to broader research contexts focused on the safe use of biosimilars and on understanding the drivers needed to implement actions that promote equitable and sustainable adoption of newly developed biological therapies in healthcare settings.

Study Limitations

This study has several limitations related to potential sources of population bias arising from the use of convenience sampling, which may affect population validity and introduce self-selection and non-response bias, as commonly observed in survey-based research. Additionally, the study did not compare nurses' access to training between urban and rural areas, which represents a limitation when assessing potential inequalities that may influence nurses' knowledge of biosimilars. These factors may reduce the external validity of the findings. Future research should address these limitations by employing probabilistic sampling strategies for specific population groups to enhance representativeness and reduce the risk of bias.

Although procedural measures were implemented to mitigate common method bias (CMB), statistical techniques for its assessment could not be applied because they typically require continuous or normally distributed indicators [52]. In our study, most questionnaire items were nominal, which would have required specialized adaptations and analytical tools that were not accessible to the research team at the time of analysis. Consequently, conclusions regarding the strength of the observed relationships should be interpreted with caution.

5. Conclusions

Several demographic and professional factors influence nurses' knowledge of and reliance on biosimilars in Spain, including working in hospital ambulatory care services, employment in clinical units where biosimilars are frequently used, and participation in training activities delivered by the pharmaceutical industry. Although the overall level of nurses' knowledge presents a substantial opportunity for improvement, there is clear willingness to learn and broad recognition of the potential benefits that biosimilars offer to both patients and healthcare systems. Notably, significant gaps and inequalities in access to training remain unaddressed.

Given nurses' pivotal role within interdisciplinary teams (particularly in medication management and patient education) national and European multistakeholder action plans should prioritize equal access to training opportunities. Such initiatives should begin with the integration of biosimilar-related content into academic curricula and the adaptation of diverse training modalities in collaboration with the pharmaceutical industry. Future research should explore how nurses' competence in biosimilars influences patient education, acceptance, and therapeutic adherence, thereby informing strategies to improve the safe and effective use of these treatments.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org, **Supplementary Table 1:** Questions and categories of the survey tool. Some questions may have been skipped due to demographic characteristics of the participants or their responses to certain questions, **Supplementary Table 2:** Aggregation of categories to adjust effect bivariate and multivariate models, **Supplementary Table 3:** Nurses' responses to knowledge, attitudes and perceptions toward biosimilars.

Author Contributions: Conceptualization, S.D.F., M.G.R. and R.G.M.; methodology, S.D.F. and R.G.M.; validation, M.G.R., N.C.S., A.M.D.M. and P.B.C.; formal analysis, S.D.F., S.M.M. and R.G.M.; investigation, S.D.F. and M.G.R.; resources, G.F.V.; data curation, R.G.M.; writing—original draft preparation, S.D.F., M.G.R., N.C.S., A.M.D.M., P.B.C. and S.M.M.; writing—review and editing, R.G.M.; supervision, R.G.M.; funding acquisition, G.F.V. All authors have read and agreed to the published version of the manuscript.

Funding: The APC was funded by the Spanish Association of Biosimilars (Biosim), a non-profit organization representing companies that develop, produce, or market biosimilars in Spain, focused on promoting their use and awareness. Apart from this, this study did not receive any specific grant from other funding agencies in the public, commercial, or not-for-profit sectors.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Príncipe de Asturias University Hospital in Madrid on March 19, 2024 (Approval No. 08/2024).

Informed Consent Statement: Participation in the survey implied informed consent, and respondents were provided with information regarding the study’s purpose, confidentiality, and data privacy.

Data Availability Statement: The data that support the findings of this study are openly available in EUSurvey at <https://ec.europa.eu/eusurvey/publication/biosimilares>.

Acknowledgments: The authors express their gratitude to all study participants for their valuable contributions, and to Dr. Beatriz Rodríguez Martín from the Nursing Department at the Universidad de Castilla-La Mancha for her proofreading of the manuscript, which helped enhance its overall quality.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Abbreviations

The following abbreviations are used in this manuscript:

ICU	Intensive Care Unit
OR	Odds Ratio
r_s	Spearman’s rank correlation statistics (also known as rHO)
C_v	Cramer’s V statistics

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