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Original Research

Nurses' preferences regarding MenACWY conjugate vaccines attributes: a discrete choice experiment in Spain

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ABSTRACT

Objectives: Immunisation against preventable diseases as meningitis is crucial from a public health perspective to face challenges posed by these infections. Nurses hold a great responsibility for these programs, which highlights the importance of understanding their preferences and needs to improve the success of campaigns. This study aimed to investigate nurses' preferences regarding Meningococcus A, C, W, and Y (MenACWY) conjugate vaccines commercialised in Spain.
Study design: A national-level discrete choice experiment (DCE) was conducted.
Methods: A literature review and a focus group informed the DCE design. Six attributes were included: pharmaceutical form, coadministration evidence, shelf-life, package contents, single-doses per package, and package volume. Conditional logit models quantified preferences and relative importance (RI).
Results: Thirty experienced primary care nurses participated in this study. Evidence of coadministration with other vaccines was the most important attribute (RI = 43.78%), followed by package size (RI = 22.17%), pharmaceutical form (RI = 19.07%), and package content (RI = 11.80%). There was a preference for evidence of coadministration with routine vaccines (odds ratio [OR] = 2.579, 95% confidence interval [95%CI] = 2.210–3.002), smaller volumes (OR = 1.494, 95%CI = 1.264–1.767), liquid formulations (OR = 1.283, 95%CI = 1.108–1.486) and package contents including only vial/s (OR = 1.283, 95%CI = 1.108–1.486). No statistical evidence was found for the remaining attributes.
Conclusions: Evidence of coadministration with routine vaccines, easy-to-store packages, and fully liquid formulations were drivers of nurses' preferences regarding MenACWY conjugate vaccines. These findings provide valuable insights for decision-makers to optimize current campaigns.

Introduction

Neisseria meningitidis (*N. meningitidis*), also called meningococcus, is an aerobic, gram-negative diplococcus bacterium transmitted through respiratory secretions that colonises the nasopharyngeal tract of humans.[1]

N. meningitidis infection usually leads to asymptomatic colonisation of the human nasopharynx (between 5% and 20% of the general population are asymptomatic carriers).[2–5] Although the infection is usually self-limiting, a small proportion (<1%–5%) of carriers will develop an invasive meningococcal disease (IMD),[4] which is a life-threatening illness and is a leading cause of

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mortality and morbidity worldwide, with a case fatality rate of 8–15%.[4,6–8] For this reason, *N. meningitidis* poses a considerable challenge for public health.[9]

Of the 12 *N. meningitidis* capsular serogroups, the majority of worldwide cases of IMD are caused by six of these serogroups (A, B, C, W, X, and Y),[10] and the relative importance of each of the serogroups varies across countries and over time.[8] Quadrivalent meningococcal conjugate vaccines against serogroups A, C, W, and Y are widely and routinely recommended for children and adolescents in many countries worldwide.[11] Although the Meningococcus A, C, W, and Y (MenACWY) conjugate vaccines available in Spain have different age indications,[12–14] the recommendation to vaccinate the 12-year-old population represents the minimum requirement in the Spanish territory.[15] Currently, regions opted to start vaccination in the 12-year-old population, following the recommendations stated by several scientific societies.[16,17]

To ensure the proper implementation of an immunisation program, it is essential to understand the preferences of those who actively take part in it: nurses, physicians, patients, and caregivers. Preferences are increasingly considered an integral part of the evaluation of new prophylactic options and of the care process.[18,19] In Spain, the vaccines prescription relies on physicians. Moreover, public tenders are held for health institutions to select the company that will supply each vaccine in the respective campaigns, mainly based on clinical criteria such as efficacy or safety.[20–22] Nurses hold the ultimate responsibility in vaccine storage, manipulation, and administration. Although these issues remain as secondary features for decision-makers, some practical features of vaccines, such as size or requirements for vaccines' preparation, can facilitate the work of nurses in their daily work and, ultimately, lead to better results. Thus, understanding the nurses' needs could contribute to generate valuable insights and optimize current campaigns.

In recent years, preference-assessment techniques have been widely used to estimate preferences regarding the results of healthcare interventions. Among these techniques, the discrete choice experiment (DCE) is increasingly used as a quantitative method to assess the preferences of respondents without directly asking them. In DCEs, hypothetical interventions with different characteristics are presented to a respondent, who is asked to select the scenario with the attributes that make the selection preferable.[23–27]

The DCE methodology is being used to quantify the preferences of individuals likely to receive a health product and other interested parties, such as health professionals, for a wide range of diseases.[28–30] This methodology helps to understand the underlying attributes of the health intervention that influence the respondent's choice.[23–27] In this sense, to ensure that a preventive strategy is the best fit, it is crucial to identify the preferences of healthcare professionals involved in immunisation.

Based on this methodology, the aim of this study was to assess the characteristics of the vaccines commercialised in Spain against meningococcal infectious disease caused by serogroups A, C, W, and Y, which are more relevant for nurses according to their field of action, focussing on a practical point of view for the implementation of a public immunisation program for children and/or adults.

Methods

Study design and committee

A DCE was conducted according to the International Society of Pharmacoeconomics and Outcomes Research (ISPOR)-published recommendations (Fig. 1).[23–27]

This study was led by a scientific committee formed by four experienced nurses with proven field backgrounds in close collaboration with an economist specializing in behaviour theory. This group received dedicated methodological and biostatistical support.

Selection of attributes and levels

The identification of attributes and levels is a key step in DCEs. These attributes refer to the characteristics of the intervention and are defined by specific levels.[27]

The number of attributes should be balanced to describe the interventions evaluated. Four to eight is the recommended number to reduce the inherent bias associated with a high number of attributes from which to choose.[27]

A systematic literature review (SLR) was conducted to identify the adequate attributes and levels to describe the commercialised MenACWY conjugate vaccines in Spain (MenQuadfi®,[12] Sanofi; Menveo®,[13] GSK; and Nimenrix®,[14] Pfizer), which are relevant for

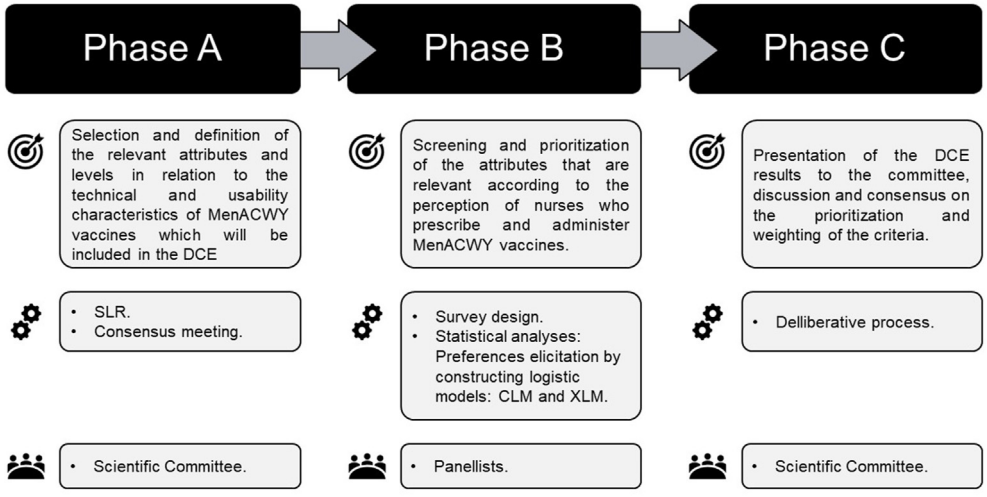

Fig. 1. Project phases. CLM: conditional logit model; DCE: discrete choice experiment; MenACWY: Meningococcus Serogroups A, C, W, and Y; SLR: systematic literature review; XLM: mixed-effects logit model. The project had methodological and biostatistical support during all phases.

nurses according to their field of action. The SLR (Supplementary Material 1) was designed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[31]

The literature search, performed in Medline (PubMed) and EMBASE, identified 47 potential eligible references, of which 29 were discarded and 18 were considered (Supplementary Material 1). The attributes and levels identified throughout the process were presented to the scientific committee through individual questionnaires. The committee evaluated the relevance and adequacy of each of them with a score from 0 (nonrelevant) to 5 (essential) and discussed additional attributes and/or levels. Their responses were analysed and presented for consensus to establish a performance matrix based on six attributes, on which the whole scientific committee agreed (Table 1).[24,25] According to the aim of the study, which was focussed on the everyday practice of vaccine administration, attributes as efficacy, safety, or costs were discarded.

Experimental design and survey instrument

The experimental design was constructed following ISPOR recommendations.[23] It consisted of a series of choice tasks obtained from combinations of the different attribute levels (hypothetical scenario alternatives).[32] These choice tasks were presented in a web-based survey. The survey included a mock DCE question unrelated to vaccines to train individuals in the methodology, 24 choice tasks comparing two choice sets (Fig. 2). Neutral option was disabled in the choice tasks, and attributes were randomly selected and organised, as explained in the following, but remained in the same order across respondents. Demographic questions were added at the end of the survey to characterize the sample. The questionnaire was reviewed and validated by the scientific committee members, and no third parties had access to participants' data.

A full factorial design was considered to generate the scenarios. In these designs, the totality of the combinations between attributes and levels is estimated as the product of the number of levels, raised to the number of attributes with that number of levels ($2^2 \times 3^4 = 324$ combinations for the present study). Given that the inclusion of every combination of attributes and levels was not feasible, the experimental design included an orthogonal fractional factorial design composed of 24 choice tasks (48 scenarios). The aim of the orthogonal fractional factorial design was to obtain the maximum information from the respondents. Thus, the design included the optimal choice sets (combinations of attributes and levels) and choice tasks (comparisons of choice sets), which maximizes the efficiency of the fractional design (D-efficiency) concerning its ability to provide the most informative results.[32] The D-efficient design was developed in R (version 4.1.2).

Study sample

The survey was addressed to nurses with a solid immunisation background in general vaccination and experience in MenACWY vaccines (considered as previous use of MenACWY vaccine during their professional career), within the national context. The Scientific Committee, on behalf of *Asociación Nacional de Enfermería y Vacunas* (ANENVAC), the Spanish Association of Nursing and Vaccines, contacted the respondents and asked for voluntary and non-lucrative anonymised participation. Three inclusion criteria that were considered are as follows: 1) nurses with two or more years of experience in immunisation in the last 3 years; 2) nurses working in primary care; and 3) nurses currently immunising (children and/or adults). Nurses without experience in MenACWY vaccine or vaccinating in other fields than primary care were excluded from the study.

For sampling, the scientific committee created a database including ANENVAC members. ANENVAC sent an invitation letter to the nurses registered in the database, including a description of the study, participation conditions, and legal and ethical issues. The accordance of the nurses who agreed to participate in the DCE with

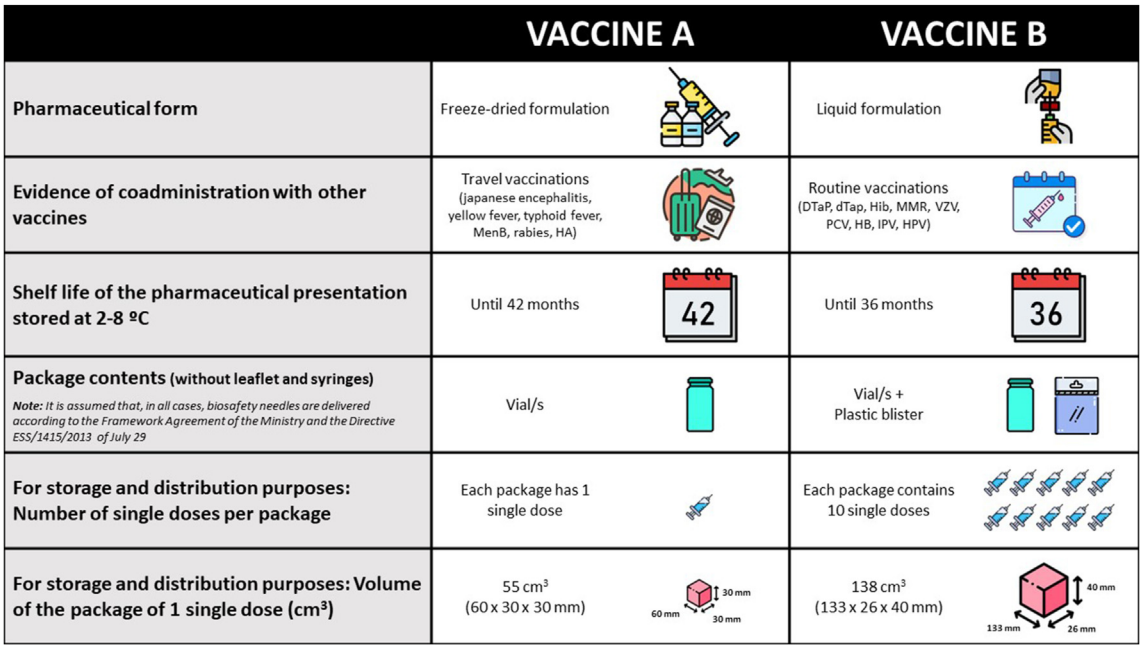

Fig. 2. Example of a DCE choice question. DCE: discrete choice experiment. DTaP: diphtheria, tetanus (acellular), *Bordetella pertussis*; Hib: *Haemophilus influenzae* B; HA: hepatitis A; HB: hepatitis B; HPV: human papillomavirus; IPV: injected poliovirus; MenACWY: Meningococcus A, C, W, and Y; MenB: Meningococcus B; MMR: measles, mumps, rubella; PCV: pneumococcal conjugated vaccine; VZV: varicella zoster virus. The attributes' definitions were presented as footnotes in the questionnaire to present a visible choice task, to facilitate the completion of the survey and to reduce the cognitive burden of the panellists.

Table 1
Performance matrix: Attributes and levels.

Attributes	Definition	Levels [Distribution in Experimental Design]
Pharmaceutical form	Provision to which the drug substance and excipients are adapted to constitute a drug	• Liquid formulation [24/24] • Freeze-dried formulation [24/24]
Evidence of coadministration with other vaccines	Vaccines for which it has been scientifically proven that the MenACWY vaccine can be administered simultaneously in the same visit to the health center	• Routine vaccines (DTaP, dTap, Hib, MMR, VZV, PCV, HB, IPV, HPV) [23/24] • Travel vaccines (Japanese encephalitis, yellow fever, typhoid fever, MenB, rabies, HA) [25/24]
Shelf life of the pharmaceutical presentation stored at 2 −8 °C	Time during which the vaccine maintains its immunising activity if stored at the temperature indicated by the laboratory (2−8 °C)	• Until 36 months [17/24] • Until 42 months [18/24] • Until 48 months [13/24]
Package contents (without leaflet and syringes)	Containers, products and/or accessories included in the vaccine carton (without considering the package insert) ***Note**: It is assumed that, in all cases, biosafety needles are delivered according to the Framework Agreement of the Ministry and the Directive ESS/1415/2013 of July 29*	• Vial/s [19/24] • Vial/s + Plastic blisters [17/24] • Vial/s + Plastic blisters + Needles without biosafety systems [12/24]
For storage and distribution purposes: Number of single doses per package	Number of single doses contained within a package according to their influence on storage and/or distribution	• Each package contains 1 single dose [16/24] • Each package contains 5 single doses [16/24] • Each package contains 10 single doses [16/24]
For storage and distribution purposes: Volume of the package of 1 single dose (cm^3)	Size of the package containing the vaccine	• 55 cm^3 (60 x 30 × 30 mm) [20/24] • 138 cm^3 (133 x 26 × 40 mm) [10/24] • 208 cm^3 (135 x 27 × 57 mm) [18/24]

DtaP: diphtheria, tetanus (acellular), *Bordetella pertussis*; Hib: *Haemophilus influenzae* B; HA: hepatitis A; HB: hepatitis B; HPV: human papillomavirus; IPV: injected poliovirus; MenACWY: Meningococcus A, C, W, and Y; MenB: Meningococcus B; MMR: measles, mumps, rubella; PCV: pneumococcal conjugated vaccine; VZV: varicella zoster virus.

the defined inclusion and exclusion criteria was evaluated by the scientific committee. The survey was provided to nurses fitting these criteria.

Access to the web-based survey was allowed until the target number of responses was reached. Given the number of choice sets, a sample size of 30 nurses was considered to provide sufficient robustness to this study, according to the following formula:[33]

$$N > \frac{500 \times c}{t \times a}$$

where "N" is the sample size, "c" is defined by the maximum number of levels for any attribute, "t" refers to the number of choice tasks, and "a" refers to the number of alternatives compared. According to this formula and the experimental design ($c = 3$; $t = 2$; and $a = 2$), a sample of more than 22 individuals was needed for conducting this DCE.

Statistical analyses

The web-based survey ended after 30 complete answers were registered as per the protocol. Descriptive analyses to determine frequencies were conducted to characterize the sample of nurses.

To study the nurses' preferences, statistical analyses were performed following ISPOR's recommendations.[26] A conditional logit model (CLM) was selected to analyse nurses' preferences according to the individual utility, which was estimated according to the following equation:[26]

$$U_i = V(\beta, X_i) + \varepsilon_i$$

where the individual utility "U_i" is defined by a "V" function that includes the levels of each attribute ("X_i"), the respective coefficients ("β"), and "εi", referring to a random error.

The CLM conditions the nurses' choices regarding the attributes of the unselected choice set. The coefficients obtained from this model informed the weight that each attribute and level had on the overall preference. The larger the coefficient's value (in absolute terms), the higher the weight associated with the level. Moreover, positive coefficients are indicative of preferences in favour of the level, and therefore, negative coefficients indicate preferences against the level.

The odds ratio (OR) of the preference for a level versus the defined reference level was also derived from the coefficients. In addition, the relative importance (RI) for each attribute was determined as follows:[34]

$$I_k = 100 \times \frac{V_{k1} - V_{k2}}{\sum_{j}^{J} (V_{j1} - V_{j2})}$$

where "I_k" is the RI of attribute "k"; "V_{k1} - V_{k2}" is the difference between the maximum and the minimum coefficients estimated for the levels of attribute "k"; and"$\sum_{j}^{J}(V_{j1} - V_{j2})$" is the sum of all attribute differences.

A CLM assumes independent and identically distributed error. Thus, a mixed-effects logit model (XLM) was also considered to address the CLM limitations related to the analysis of heterogeneity in the responses and preferences (Supplementary Material 2).[26]

In addition, subgroup analyses were conducted to test for heterogeneous effects as described in Supplementary Material 2.

All statistical analyses were executed in R (version 4.1.2). The level of statistical significance was established at 0.05. All estimates were accompanied by the corresponding dispersion measures, including standard error (SE), standard deviation (SD) and 95% confidence interval (95% CI).

Deliberative process

A final deliberative process was held with the scientific committee to evaluate the results obtained, discuss possible rationales, and argue the strengths and limitations of the study, as per methodology requirements.[23–27]

Results

Socio-demographic characteristics of the participants

A total of 30 nurses completed the web-based survey. All participants met the inclusion criteria, and no responses were excluded from the analysis. The sample's demographics represented the characteristics of Spanish primary care nurses (Table 2): they were mainly female (86.7%), working in paediatrics (66.7%), aged between 40 and 59 (80%), and represented different Spanish regions. The sample was thought to be experienced in the field of nursing and immunisation, and all the nurses had experience in the administration of MenACWY conjugate vaccines.

Preference for attributes

A total of 1440 profiles were evaluated by the respondents in this DCE. Four out of the six items were found to be statistically significant ($P < 0.05$) in nurses' preferences. The CLM results (Table 3) showed that the coadministration evidence of MenACWY conjugate vaccines was the most important attribute (RI = 43.78%). The nurses stated strong preferences for coadministration evidence with routine vaccines at the expense of coadministration evidence with travel vaccines (OR = 2.579 [95%CI = 2.210–3.002], $P < 0.001$).

The package volume was the second attribute in relative importance (RI = 22.17%). Lower volumes were preferred when comparing the size of 55 cm^3 against 208 cm^3 (OR = 1.494 [95% CI = 1.264–1.767], $P < 0.001$). There was no significant difference between the sizes of 138 cm^3 and 208 cm^3 ($P = 0.335$).

The pharmaceutical form appeared to be the third attribute in weight (RI = 19.07%), with a preference towards a liquid formulation when compared to a lyophilized formulation, which requires reconstitution (freeze-dried) (OR = 1.510 [95%CI = 1.326–1.719], $P < 0.001$).

The package content was the last statistically significant attribute and the fourth in relative importance (RI = 11.80%). The nurses reported preferring less waste per package when comparing only the presence of vial/s, with the presence of vial/s, plastic blisters, and needles lacking biosafety systems (OR = 1.283 [95% CI = 1.108–1.486]). No statistical evidence was found when comparing vial/s and plastic blisters against vial/s, plastic blisters, and needles without biosafety systems ($P = 0.939$).

The coadministration evidence of MenACWY conjugate vaccines, the package volume, and the pharmaceutical form accounted for 85.02% of the weight on preference, a figure that increased to 96.82% when the package content was also considered. Statistical differences in the preferences were not found for the last two attributes: shelf life and the number of single doses per package.

The results obtained in the XLM and subgroup analyses (Supplementary Material 2) were aligned with the CLM estimations and confirmed the robustness of the results.

Table 2
Demographic characteristics of the nurses' sample.

	Frequency (N = 30)	Percentage
Sex		
Female	26	86.7%
Male	4	13.3%
Age		
Age 20–29	1	3.3%
Age 30–39	3	10.0%
Age 40–49	7	23.3%
Age 50–59	17	56.7%
Age 60–65	2	6.7%
Main vaccination field		
Paediatrics	20	66.7%
Adults (generalist nurse)	6	20.0%
Both (children and adults)	4	13.3%
Number of MenACWY vaccines administered per week (missing data: n = 1)[a]		
Occasionally	8	27.6%
1–9 doses per week	9	31.0%
10–20 doses per week	11	37.9%
More than 20 doses per week	1	3.4%

MenACWY: Meningococcus A, C, W, and Y.
[a] This question was a free question and not compulsory for the completion of the survey.

Discussion

The Spanish nurses considered the evidence of coadministration with other vaccines as the most preferable attribute of a MenACWY conjugate vaccine within their field of action. In addition, the volume of the package, the pharmaceutical form, and the package contents were also stated as important criteria in determining the nurses' preferences for a vaccine. According to the results obtained, the hypothetical ideal vaccine from the nurses' perspective and within the current choice set was presented as a liquid formulation, included in the smallest package possible, carried the least amount of waste (preferably only vial/s), and had scientific published evidence available regarding its compatibility with other routine vaccines.

The evidence of coadministration with other routine vaccines was the most preferable attribute of a MenACWY conjugate vaccine, mainly due to the time savings derived from the administration of several vaccines in the same vaccination act, a potential better compliance and a reduction in the number of extra consultations. Two commercialised MenACWY conjugate vaccines have coadministration data focussed mainly on routine paediatric vaccines.[12,14] The remaining one is indicated in children aged over 2 years, leading to a lack of data on coadministration with several vaccines scheduled under that age. Thus, although there is some information in relation to the coadministration of this last MenACWY vaccine with diphtheria, tetanus, and *Bordetella pertussis* (Tdap), or human papillomavirus, its evidence is more oriented towards travel vaccines.[13] The national immunisation programme (NIP) is constantly evolving, and the MenACWY conjugate vaccine that keeps providing updates in coadministration data with new vaccines included in the NIP might be most valuable according to these results.

The pharmaceutical form is often regarded as an important criterion because of the advantages and disadvantages derived from each presentation. In the case of MenACWY conjugate vaccines, the fully liquid form has several advantages from the care viewpoint that could make it preferable: 1) reduction of the time spent in vaccine reconstitution; 2) securing a successful immunisation act by diminishing the probability of dosing or reconstitution

Table 3
Conditional logit model estimates.

Attributes	Levels	Coefficient	SE	Z	*P*-Value	OR	95% CI	RI
Pharmaceutical form	Liquid formulation	0.412	0.066	6.216	<0.001 *	1.510	1.326–1.719	19.07%
	Freeze-dried formulation	−0.412[a]	[Reference][b]					
Evidence of coadministration with other vaccines	Routine vaccines[c]	0.946	0.078	12.102	<0.001 *	2.579	2.210–3.002	43.78%
	Travel vaccines[d]	−0.946[a]	[Reference][b]					
Shelf life of the pharmaceutical presentation stored at 2–8 °C	Until 36 months	−0.061	0.083	−0.735	0.463	0.941	0.799–1.108	2.64%
	Until 42 months	0.072	0.082	0.885	0.376	1.075	0.916–1.261	
	Until 48 months	−0.011[a]	[Reference][b]					
Package contents (without leaflet and syringes)	Vial/s	0.249	0.075	3·331	<0.001 *	1.283	1.108–1.486	11.80%
	Vial/s + Plastic blisters	0.006	0.080	0.076	0.939	1.006	0.860–1.177	
	Vial/s + Plastic blisters + Needles without biosafety systems	−0.255[a]	[Reference][b]					
For storage and distribution purposes: Number of single doses per package	Each package contains 1 single dose	0.006	0.085	0.074	0.941	1.006	0.852–1.188	0.55%
	Each package contains 5 single doses	0.006	0.081	1.119	0.263	1.095	0.934–1.284	
	Each package contains 10 single doses	−0.012[a]	[Reference][b]					
For storage and distribution purposes: Volume of the package of 1 single dose (cm^3)	55 cm^3 (60 x 30 × 30 mm)	0.402	0.086	4.693	<0.001 *	1.494	1.264–1.767	22.17%
	138 cm^3 (133 x 26 × 40 mm)	0.077	0.080	0.964	0.335	1.080	0.923–1.264	
	208 cm^3 (135 x 27 × 57 mm)	−0.479	[Reference][b]					
Constant/Intercept		−0.077	0.104					
Model fit summary statistics								
Observations						Iterations = 30/n = 1440/Number of events = 720		
Concordance						0.781 (SE = 0.022)		
Likelihood ratio test						287.3 ($P < 0.001$)		
Wald test						176.8 ($P < 0.001$)		
Log-rank test score						244.6 ($P < 0.001$)		

CI: confidence interval; DtaP: diphtheria, tetanus (acellular), *Bordetella pertussis*; Hib: *Haemophilus influenzae* B; HA: hepatitis A; HB: hepatitis B; HPV: human papillomavirus; IPV: injected poliovirus; MenACWY: Meningococcus A, C, W, and Y; MenB: Meningococcus B; MMR: measles, mumps, rubella; OR: odds ratio; PCV: pneumococcal conjugated vaccine; RI: relative importance; SE: standard error; VZV: varicella zoster virus.
* Statistically significant (*P* value < 0.05).
[a] The coefficient for the reference categories was estimated following the ISPOR recommendations (Hauber et al., 2016)[26]: $0 - \Sigma(\beta_i)$, where β_i refers to the coefficient of the other levels of the attribute.
[b] The reference category is the level against which all other levels of the same attribute are compared in a logistic regression.
[c] DtaP, dTap, Hib, MMR, VZV, PCV, HB, IPV, and HPV.
[d] Japanese encephalitis, yellow fever, typhoid fever, MenB, rabies, and HA.

errors during the preparation; 3) limitation of the insecurity generated by having followed the steps for the reconstitution correctly; 4) prevention of the need for repeat doses and the arrangement of additional appointments; and 5) addressing the risk of lack of protection and improving the nurses' safety while preparing the vaccine.[35–37] However, its RI in the present study might have been diluted by the volume of the package as a smaller volume per package implies the availability of more storage space. In any case, the RI of both attributes showed minimal differences in terms of their respective weights on the overall preference.

In relation to the package contents, nurses preferred to receive exclusively the vaccine vial/s rather than the vial/s accompanied by plastic blisters and needles without biosafety systems, which could be explained mainly because of waste production. Moreover, the Scientific Committee highlighted the risks derived from the inclusion of needles lacking a biosafety mechanism in terms of nurses' safety and regulative issues.[38]

In relation to the shelf life, primary care nurses in Spain receive vaccines in periods of 1–3 months. As there is no need to store vaccines for long periods, the expiration of vaccines is infrequent, which could explain the lack of statistical significance for this attribute.

Similarly, significant differences were not found for the number of single doses per package. The inclusion of several single doses in the same package increases the storage capacity. However, the fact that respondents were not from the administration offers a plausible explanation of the results.

To the knowledge of the authors, this is the first DCE to elicit nurses' preferences regarding MenACWY conjugate vaccines in Spain. The present study complements previous studies determining paediatricians' preferences related to meningococcal vaccines considering attributes as age at which protection began, cases of disease, disability or death avoided, the number of administrations, the number of additional visits, booster dose requirements in 5 years, or acquisition costs.[39] Other DCEs included meningococcal vaccine users (and/or their families) to define their preferences, focussing on meningococcus B[40,41] or not specifying the serogroup.[42] The attributes included in those studies were effectiveness, protection duration, adverse-event frequency, the number of injections, availability of recommendations, age of vaccination, or costs.

It should be noted that the nurses' preferences and choices were constrained to the attributes and levels included in the choice sets. Thus, other attributes unexplored in the present study may be determinants of preference. Several potential attributes were proposed by the scientific committee, and their adequacy was discussed. The aim of the present study was to determine the preferable attributes for nurses that could facilitate and secure the successful implementation of public vaccination campaigns. Thus, the attributes considered reflected practical aspects from a nurse perspective related to the handling of the vaccines currently commercialised in Spain. Their effectiveness or vaccine age indication was beyond the scope of this project. Additionally, the frequency of adverse events was excluded as the safety profiles of the commercialised vaccines were similar.

Other proposals were discarded because of the inability to define distinctive levels. Most of them were excluded because of the heterogeneity between Spanish healthcare regions. For administrative purposes, the quick-response code or barcode in the package, aiming to facilitate the registration of the vaccines, despite being an interesting attribute for the Scientific Committee, had to be discarded since it is requested *ad hoc* in a few regional tenders and since it is not an intrinsic attribute of any commercialised vaccine.

Following DCE's good practice recommendations,[23–27] an attribute related to the risk of mistakes during reconstitution was dismissed for being closely related to the pharmaceutical forms available for MenACWY conjugate vaccines.

Other aspects that could influence nurses' preferences include the visible presentation of the immunogen written with the same font and size of the trademark or the design of packages to avoid confusing vaccines.

Study limitations

Even when the results obtained had a basis on nurses' clinical practice, this study is not exempted from constraints.

First, the DCE does not allow simulation of the real-world, where the emotional component and the real consequences of the choice become more important. Thus, slight differences between DCE and real-world choices could be found.

The cognitive burden might be another DCE-related methodological aspect to be discussed. The nurses' responses could have been less precise for the last choice tasks of the 24 included in the survey when comparing it to other vaccine-centred DCEs, with choice tasks ranging between four and eighteen.[43,42] To reduce that burden in the present study, the demographic questions were included after the DCE. In contrast, a learning curve in participants could be expected, reducing the time spent answering the subsequent choice tasks while moving forward throughout the survey and, in this case, the data quality would increase. In addition, the order of the attributes was not randomised across respondents, which could influence the effect of the respective attributes.

Several analyses could be performed to test the cognitive burden and learning curve, such as measuring the response time for each choice task. In this sense, other potential analyses could test for the profile and task effect, allowing the evaluation of whether a profile shown at the beginning or at the end of a choice task influences the response and whether the order of the choice tasks in the survey modifies the results obtained. Nonetheless, the software selected for the web-based survey made it impossible to conduct these analyses. Instead, the platform proved to be more familiar for participants, facilitating their participation in the DCE.

A diverse representation of the multiple national healthcare regions was obtained. Moreover, during the definition of the performance matrix, the scientific committee discussed specific-regions conditions which might influence preferences, and the attributes and levels were worded to avoid these issues.

However, given that the study population was exclusively from Spain, the results obtained should be interpreted in this context, and the generalisability of the results should be performed with caution. Moreover, the sample of respondents could be considered small for a DCE, even though it was estimated based on widely used published formulae.[33] Despite other DCEs oriented to define vaccine-related preferences including 50 to 2000 participants,[43] the demographics of the sample were a faithful reflection of primary care nurses' characteristics, and the results could be thought to be generalisable.

Although no differences in the direction of nurses' preferences were observed in the subgroup analyses, differences in terms of RI should be evaluated. Most differences in the importance of the attributes were minor; however, when comparing to the results for the entire study population, several subgroup results should be highlighted: 1) the attribute concerning the number of single doses per package was higher in all subgroups; 2) the RI of the volume of the package decreased for nurses aged less than 50 years, working only with adults or both children and adults, and administering less than 10 doses per week; 3) the RI of package contents increased in nurses administering 10 or more doses per week; and 4) the RI of the attribute related to the evidence of administration with other vaccines was higher for nurses working only with adults or both children and adults but decreased for nurses administering 10 or more doses per week. Since the present study was not aimed to assess differences in nurses' preferences according to their profile, further research designed to evaluate these differences, as well as the possible reasons leading to them, would be necessary.

Study Strengths

Beyond the limitations inherent to any scientific research, this study also has several strengths that should be highlighted.

The statistical analyses considering an XLM and subgroup analyses (Supplementary Material 2) to address the limitations of the CLM are one of the main strengths of this project. Given that similar results were obtained, the findings were robust. Other logistic models as the latent class could have been selected for the analyses. Nonetheless, the sample was considered small for those approaches.

The study design and execution following good practice recommendations is another strength to emphasise.[23–27] First, the selection of six attributes is aligned with DCE recommendations (4–8 attributes per study).[27] Second, the process for identifying attributes and levels in any DCE included all methods described in guidelines: SLR, expert consultation, and qualitative research.[43] Finally, the funding source name was not presented to the respondents to avoid biased answers. In contrast, this study was endorsed by ANENVAC.

Conclusion

This project attempted to elucidate current nurses' preferences for MenACWY conjugate vaccines; nurses represent an important profile of health care providers within the field of immunisation. Overall, this study suggests that the evidence of coadministration with other routine vaccines, presentation in liquid form, use of the smallest package possible, and inclusion of only vial/s are the preferable characteristics of a MenACWY conjugate vaccine for primary care nurses. Understanding nurses' preferences is essential to design optimised vaccination strategies from a practical point of view.

Nonetheless, future research in other countries encompassing other clinical professionals, central storage workers, and patients should be considered to obtain an overall picture and advance towards optimal decision-making.

Author statements

Ethical approval

None sought.

Funding

This project was funded by Sanofi unconditionally to the results. The funding source proposed the scientific committee members but had no role in selecting or contacting the panellists' sample or

in the analysis of the data. In addition, the company name, brand, and logo of the funding source remained anonymous throughout the project and were not presented to the sample of panellists in any case.

The sponsor of the study, Sanofi, has assumed all remuneration. No payments were made related to authoring this manuscript, and the authors state that the research results described in this manuscript, as well as their analysis and interpretation, resulted from the free expression of opinion and from the agreement of the publication coauthors and that no conflicts, either in obtaining or in disclosure of such results, exist. The authors report no other conflicts of interest for the present study. No payments were made to the sample of panellists.

Competing interests

JAFS has received fees for his collaboration in this project. The author is the president of ANENVAC and has received fees from private companies for lectures and conferences.

ICE has received fees for her collaboration in this project. The author has participated in other relevant projects during the past four years and is a member of the ANENVAC board of directors.

AGP has received fees for his collaboration in this project. The author has participated in other relevant projects during the past three years and is a member of the ANENVAC board of directors.

RS has received fees for her collaboration in this project. The author works in the Public Health Department of the Basque Government, is a member of the ANENVAC board of directors and has received fees from private companies for lectures and conferences.

PRB has received fees from PORIB in compensation for his consulting work throughout the project. The author declares no conflicts of interest.

GCB, GD and JLLB are employees of Sanofi and may hold shares and/or stock options in the company.

ADG, MGB and MAC are employees of PORIB, a consultant company specialized in economic evaluation of health interventions and health results investigation, which received financial compensation for the methodological support throughout the project.

Author contributions

JAFS, ICE, AGP, and RS participated in the design of the performance matrix, validation of the questionnaire, interpretation of the results, and manuscript review.

PRB provided methodological support for the design of the performance matrix and participated in the interpretation of the results and manuscript review.

GCB, GD, and JLLB participated in the conceptualisation, project administration, supervision, and manuscript draughting and review.

ADG, MGB, and MAC participated in the conceptualisation of the project and provided methodological support for the design of the performance matrix, design of the model, development of the questionnaire, data analyses, interpretation of the results, and manuscript draughting.

All authors agree to be accountable for all aspects of the work and give their consent to publish this study.

Data sharing

Anonymized data will not be shared in any case, as it was indicated to the sample of study participants to improve their confidence in the study and encourage their participation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2024.02.026.

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