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Adaptation and psychometric evaluation of the BANKS-SP biobanking survey in longstanding dengue virus cohorts in Colombia and Nicaragua

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Abstract

Background

Sample reuse and sharing are central to infectious disease (ID) research. Understanding the knowledge, attitudes, and self-efficacy of source community members around biobank participation can help cohorts develop targeted interventions and ensure continued support for biobanks. Validated, multiscale, and culturally relevant instruments to assess these constructs are scarce, particularly for Spanish-speaking populations in low- and middle-income countries (LMICs).

Methods

We conducted a cross-sectional survey using the Biobanking Attitudes and Knowledge Survey–Spanish (BANKS-SP) with parents or legal guardians of participants in long-standing dengue cohort studies in Bucaramanga, Colombia (N = 64), and Managua, Nicaragua (N = 60). Because the BANKS-SP was developed for cancer biobank participants in the US state of Florida, we first conducted cognitive interviews at each site to evaluate comprehension in the new context and made minor modifications. We assessed internal consistency using Cronbach's alpha, item-to-total correlations, and inter-item correlations; examined the factor structure using exploratory factor analysis (EFA) with promax rotation; and assessed construct validity using locally weighted regression (LOWESS) curves.

Results

The Self-efficacy Scale demonstrated adequate internal consistency in both Colombia (Cronbach's α = 0.79) and Nicaragua (α = 0.91). The Attitudes Scale showed lower internal consistency (Colombia: α = 0.63, below threshold; Nicaragua: α = 0.70). EFA identified a dominant altruism factor for the Attitudes Scale, a second factor comprising three reverse-coded items on perceived personal risks, and a two-item information security doublet; for the Self-Efficacy Scale it identified a broad motivational factor, a distinct physical capacity and bodily unease sub-dimension, and a two-item pain doublet. The two doublets indicate item redundancy rather than substantive sub-dimensions. Knowledge scores were higher in Nicaragua (mean = 56% correct) than in Colombia (mean = 46% correct). The hardest knowledge item across sites concerned whether researchers always contact participants when their samples indicate a disease risk (item difficulty = 0.14). LOWESS curves showed that attitudes increased with biobanking knowledge at both sites ($r = 0.29–0.42$, all $p \leq 0.023$); the knowledge–self-efficacy association was significant only in the combined sample ($r = 0.24$, $p = 0.009$), providing partial support for construct validity.

Conclusions

The BANKS-SP Self-efficacy Scale performed adequately in this new LMIC population, while the Attitudes Scale requires targeted revision before use in single-country LMIC samples. Knowledge of the governance and legal framework surrounding biospecimen donation was poor at both sites, indicating specific, addressable gaps in how informed consent and community education are delivered in infectious disease cohort research.

Background

Biobanking, the systematic collection, processing, storage, and distribution of biological samples and linked data for research, is central to infectious disease (ID) research. Biobanks provide the material basis for developing and evaluating diagnostic tests, understanding pathogen spread and evolution, and accelerating the development of preventive measures and treatments (Malsagova et al. 2020; Annaratone et al. 2021). Biobanking is particularly valuable in tropical and subtropical settings where dengue and other arboviral diseases impose a high burden of morbidity and mortality, and where longitudinal cohort studies generate irreplaceable collections of paired clinical and biological data (Narvaez et al. 2025).

Despite the clear scientific value of biobanking, community participation cannot be taken for granted. Willingness to donate samples to a research biobank is shaped by knowledge of what biobanks are and how they function, attitudes towards sample donation, perceived self-efficacy to act on those attitudes, and practical intentions to donate (Wells et al. 2014; Rodriguez Llorian et al. 2023). Concerns about privacy, misuse of clinical or genetic data, commercial exploitation of donated samples, and culturally embedded beliefs about the body can reduce participation (Shabani et al. 2014; Walshe et al. 2024). If biobank recruitment is systematically lower among certain demographic groups, resulting collections may not adequately represent source populations, limiting the generalisability and equity of research findings (Evertsz et al. 2023).

Understanding the knowledge, attitudes, and self-efficacy of potential biobank participants is a precondition for developing effective community engagement and communication strategies. Validated instruments are essential tools for researchers wishing to identify gaps, design interventions, and evaluate their impact. However, such instruments are scarce, particularly for Spanish-speaking populations in LMICs (Arevalo et al. 2016). Existing measures were mainly developed for high literacy levels, rely on single-item assessments, or have not been formally validated (Wells et al. 2014), limiting our ability to compare findings across populations.

The Biobanking Attitudes and Knowledge Survey (BANKS) was developed in English for cancer biobank participants in Florida, USA, through a rigorous community-engaged process including cognitive interviews, expert review, and pilot testing (Wells et al. 2014). The Spanish-language adaptation, the BANKS-SP, was subsequently developed using a similar iterative process with Spanish-speaking, Latino cancer biobank participants in the same region (Arevalo et al. 2016). Both instruments include three multi-item scales measuring knowledge, attitudes, and self-efficacy related to biospecimen donation, as well as single items assessing receptivity to learning more about biobanking and intention to donate.

The population and cultural milieu for which the BANKS-SP was developed, Spanish-speaking cancer biobank participants in the United States, differs substantially from parents and guardians of participants in long-standing dengue cohort studies in Latin America. Differences in disease context, socioeconomic setting, and the nature of biobank participation may all affect how instrument items are understood and answered. Before applying the BANKS-SP in a new population, adaptation and evaluation of its measurement properties are warranted (Garcia et al. 2018).

In this study, we report on the adaptation, administration, and psychometric evaluation of the BANKS-SP with parents or legal guardians of participants in long-standing dengue cohort studies in Bucaramanga, Colombia, and Managua, Nicaragua. We describe modifications made following cognitive interviews, present descriptive statistics for all scales, assess internal consistency, explore factor structure using exploratory factor analysis (EFA), and evaluate construct validity through LOWESS regression of knowledge–attitude and knowledge–self-efficacy associations.

Methods

Participant recruitment and study population

The target population for this study was parents or legal guardians of participants in two longstanding dengue studies. In Nicaragua, we recruited from a longitudinal prospective pediatric hospital-based study, ongoing for over 20 years (Narvaez et al. 2025). In Colombia, we recruited from the prospective cohort study "Identification of priority age groups to be vaccinated against dengue in the child and adolescent population," assembled between 2015 and 2018 (Estupiñán Cárdenas et al. 2020). Both source studies collected blood samples from participants at regular intervals: the Nicaraguan study collected blood three times during the acute phase (days 1–5) and once at convalescence (7–14 days). Those enrolled in the longitudinal arm of the study give samples at 3, 6, 12 and 18 months. The Colombian cohort collected four samples over 2.5 years. In Nicaragua, urine and saliva samples are also collected in the acute phase of disease. Participants were selected from current study lists in order of appearance. Field interviewers approached potential participants during regularly scheduled contact visits or follow-up calls using a structured recruitment script.

Included participants were adults capable of providing verbal informed consent who had signed an informed consent form (ICF) for source cohort participation in Colombia and parents or guardians of children enrolled in the hospital study in Nicaragua who were able to provide written informed consent. Adolescent participants in the Colombian cohort who provided verbal or written assent and whose parents consented were also eligible. Individuals unable to provide verbal consent in Colombia or written consent in Nicaragua or without a source cohort ICF were excluded. In Nicaragua, parents or guardians of children under 6 months old, weighing less than 8 kilograms at enrolment, or living outside Managua were also excluded. Of 132 potential participants approached, 8 refused, most due to scheduling conflicts. No surveys had missing data.

Pilot and modification of BANKS-SP

We conducted three cognitive interviews at each study site to evaluate participants' understanding of the BANKS-SP. Cognitive interviews were conducted with female cohort participants aged 18–34. We used the concurrent verbal probing method (Collins 2003) to explore understanding of questions and responses, relevance and grouping of items, and whether additional concerns in Managua and Bucaramanga were not captured by the BANKS-SP. Interviewers asked: "What do you think they are asking you here?" and used prompts including "Please repeat the question in your own words" and "What does that mean to you?" Interviews were conducted independently in Nicaragua and Colombia to assess whether comprehension and coverage were similar across sites.

Following the first round of cognitive interviews, we modified the survey as follows: (1) the terms "biological samples" and "biobanks" were defined within the instrument; (2) Knowledge Scale response options were changed from "yes" and "no" to "it is true" and "it is not true;" (3) "medical record" was changed to "medical history;" and (4) two negatively phrased statements were reworded as positive statements when participants had trouble understanding them (see Supplementary Text S1 for changes to BANKS-SP from the cognitive interview study). A second round of three cognitive interviews at each site identified no further comprehension problems; all modifications were retained. Understanding did not differ markedly between the two sites.

Data collection

We administered the modified BANKS-SP to 64 participants in Colombia and 60 in Nicaragua (N = 124). Data collection took place between August 2021 and April 2022 during the COVID-19 pandemic. In Colombia, the survey was conducted by telephone; in Nicaragua, in person, in keeping with social distancing regulations. De-identified data were recorded in a Google Form.

Data analysis

We conducted descriptive statistics for all survey scales, presented separately for Colombia, Nicaragua, and the combined sample. We recoded negatively worded items in the Attitudes and Intentions Scales so that higher values represented more positive responses (Supplementary Text S2. Codebook). We used the Mann–Whitney U test to compare responses to the Attitudes and Self-efficacy Scale between countries. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies (von Elm et al. 2007) in preparing this manuscript (Supplementary Table S1). Measurement properties of the BANKS-SP are reported in accordance with the COSMIN (COnsensus-based Standards for the selection of health Measurement INstruments) taxonomy, including structural validity, internal consistency, and construct validity (Mokkink et al. 2010) (Supplementary Table S2).

Internal consistency

To assess internal consistency reliability and homogeneity, we used inter-item correlation, item-to-total correlation, and Cronbach's alpha. Item-to-total correlations indicate whether an item is consistent with the overall construct and contributes meaningfully to the scale. Values of 0.50 or above indicate a strong association, values of 0.30 to 0.49 an acceptable association, and values below 0.30 a weak association; negative values indicate a likely error, such as an item that has not been reverse-coded (Hajjar 2018). A Cronbach's alpha value ≥ 0.70 was considered to indicate adequate internal consistency (Adamson and Prion 2013). We used Spearman's *r* to estimate the average inter-item correlation for each item on the Attitude and Self-Efficacy Scales. Average inter-item correlations between 0.15 and 0.50 indicate a desirable level of homogeneity; values below 0.15 indicate a weak relationship between items, values above 0.70 suggest that items are redundant, and negative values indicate a potential problem such as an item operating in the reverse direction (Piedmont 2014). We could not estimate Spearman's *r* for the Intentions Scale (2 items) or the Receptivity Scale (1 item) due to the limited number of items. Inter-item correlations were estimated separately for Colombia, Nicaragua, and the combined sample.

Construct validity

Construct validity estimates the degree to which a scale measures its intended theoretical concept. We used scatterplots with locally weighted regression (LOWESS) to estimate relations between biobanking knowledge and attitudes, and between knowledge and self-efficacy, without assuming a parametric functional form. We did not complete LOWESS plots for the relationships between knowledge–intentions or knowledge–receptivity because those scales consist of two items and one item, respectively.

Factor structure

Prior work developing the BANKS and BANKS-SP did not formally assess the underlying factor structure of the component scales (Wells et al. 2014; Arevalo et al. 2016). We applied EFA with promax rotation to the Attitudes and Self-efficacy Scales. Promax (oblique) rotation allows correlation between factors (Field 2018), which was conceptually appropriate given the expected relationship between the attitude and self-efficacy sub-domains. We determined the number of factors to retain using parallel analysis, comparing each observed eigenvalue against the 95th percentile of eigenvalues obtained from 500 random datasets of the same sample size and number of items (Horn 1965). Parallel analysis was preferred to the Kaiser criterion, which applies to eigenvalues of the unreduced correlation matrix and is not appropriate for principal axis factoring.

Biobanking-related knowledge

We estimated the percentage of items answered correctly and the item-level difficulty score for the BANKS-SP Knowledge Scale. For the difficulty score, "Don't know" responses were coded as incorrect, consistent with prior BANKS studies (Wells et al. 2014; Arevalo et al. 2016). Item-level difficulty was estimated as the proportion of correct responses per item. We interpreted scores of < 0.30 as extremely difficult, 0.30–<0.50 as very difficult, 0.50–<0.70 as moderately difficult, 0.70–<0.90 as moderately easy, and 0.90–1.00 as very easy (Crocker & Algina 1986).

Forty-one participants (20 from Nicaragua, 21 from Colombia) had also participated in a prior cognitive interview study on understanding broad consent (Maxwell et al. 2023). We used a within-site two-tailed t-test to assess whether these participants differed from the other participants and found no statistically significant difference in total Attitudes Scale score at either site (Colombia: 45.57 among those who had completed the prior study versus 44.65 among those who had not, t=-1.10, df = 62, P = 0.28; Nicaragua: 52.30 versus 52.43, t = 0.09, df = 58, P = 0.93). All analyses were conducted in Stata SE (version 15.1). The analysis protocol was pre-registered with the Open Science Foundation (OSF) before analysis began (osf.io/vc8j6). Analysis code is available on openICPSR with the data (LM to insert DOI).

Ethics

Participants in Colombia provided verbal informed consent, and parents or guardians of study participants in Nicaragua provided written informed consent to participate in the one-time survey. The difference in consent modality reflects the one-time telephone or in-person survey format, social distancing practices at the time of interview, and the approvals of the responsible ethics review committees. No personally identifying information was collected. All procedures were conducted in accordance with the ethical standards of the responsible institutional and national committees on human experimentation and with the Declaration of Helsinki, as revised in 2000. The study protocol was reviewed and approved by the Heidelberg University Clinic Ethics Review Committee (ERC; S-312/2021), the Universidad Industrial de Santander ERC (CEIB 2719 2021), and the Comité de ética del Ministerio de Salud (MINSA) in Nicaragua (NIC-MINSA/CNDR CIRE-17/08/2021 – 115 Ver1.).

Results

Table 1 presents descriptive statistics for the study population. Of the 124 participants, 64 (52%) were from Bucaramanga, Colombia, and 60 (48%) from Managua, Nicaragua. In Colombia, 58% of respondents (N = 37) were parents or legal guardians, and cohort participants (N = 27) provided 42% of responses. In Nicaragua, where cohort participants were younger and therefore ineligible, all responses were provided by parents or legal guardians. The largest age group was 35–45 (N = 51, 41%), and 23% (N = 29) were over 45. Most respondents were female (N = 98, 79%). Most had at least a high school education (N = 79; 64%). Approximately 6% (N = 7) had not completed primary education or had no formal education. The level of education in Colombia was higher than that in Nicaragua where fewer participants had received formal education or higher levels of education. Close to half of participants (N = 55; 44%) were employed in the formal economy, and approximately 31% (N = 38) worked as unpaid homemakers.

Table 1
Demographic characteristics of survey respondents (N = 124)

	Colombia		Nicaragua		Total	
	N	(%)	N	(%)	N	(%)
	64	(52)	60	(48)	124	(100)
Role						
Study participant	27	(42)	0	(0)	27	(22)
Parent or tutor	37	(58)	60	(100)	97	(78)
Age						
under 25	19	(30)	0	(0)	19	(15)
25–34	12	(19)	13	(22)	25	(20)
35–45	18	(28)	33	(55)	51	(41)
over 45	15	(23)	14	(23)	29	(23)
Gender						
Male	20	(31)	6	(10)	26	(21)
Female	44	(69)	54	(90)	98	(79)
Education						
No formal education	0	(0)	2	(3)	2	(2)
Primary school not completed	2	(3)	3	(5)	5	(4)
Primary school completed	13	(20)	4	(7)	17	(14)
More than primary, less than high school	8	(13)	13	(22)	21	(17)
High school completed	21	(33)	20	(33)	41	(33)
Post-secondary education	20	(31)	18	(30)	38	(31)
Employment						
Work inside home with no pay (e.g., housewife)	15	(23)	23	(38)	38	(31)
Participate in the informal economy (e.g., selling food on the street)	10	(16)	4	(7)	14	(11)
Employed in the formal economy (e.g., nurse)	24	(38)	31	(52)	55	(44)
Student	13	(20)	1	(2)	14	(11)
Unemployed	2	(3)	1	(2)	3	(2)
*percentages add up to over 100 because of rounding						

Other was given as an option for gender, but was not selected by any participant

Biobanking attitudes, self-efficacy, intentions, and receptivity

Table 2 presents mean scores and standard deviations for each item on the Attitudes, Self-Efficacy, Intentions, and Receptivity Scales, by country and for the combined sample, together with Mann-Whitney U test p-values for cross-country comparisons. The overall mean score on the Attitudes Scale was 48.55 (SD = 5.55; range: 37 to 60 out of a possible 60), indicating broadly positive attitudes towards biospecimen donation across both sites. Nicaraguan participants scored higher than Colombian participants at the scale level (52.38 versus 44.95) and significantly higher on all 12 Attitudes Scale items (all $P \leq 0.001$ by Mann-Whitney U test). The highest-scoring items in the combined sample concerned giving a sample to support dengue research (item 9; mean = 4.37), helping prevent diseases (item 2; mean = 4.35), and helping future generations (item 5; mean = 4.35). The lowest mean scores were observed for the items concerned with the security of personal information (items 8 and 10; combined means of 3.51 and 3.53, respectively), indicating that certainty about information protection was the attitudinal dimension in which participants expressed the least confidence. Four items were negatively worded and reverse-coded prior to analysis so that higher scores reflect more positive attitudes towards biobanking across items (items 4, 6, 11, and 12).

The overall mean score on the Self-Efficacy Scale was 83.88 (SD = 23.23; range: 12 to 120 out of a possible 120), with Nicaragua scoring higher than Colombia at the scale level (89.73 versus 78.39). Significant country differences were observed for seven items: item 1 (giving a sample for the first time; $P < 0.001$), item 4 (giving a sample when feeling weak; $P < 0.001$), item 5 (giving a sample against family wishes; $P = 0.02$), item 8 (giving a sample when concerned about how the sample will be used; $P < 0.001$), item 9 (giving a sample when it does not feel right; $P < 0.001$), item 10 (giving a sample when afraid of needles; $P = 0.046$), and item 12 (giving a sample when it takes longer at the doctor's office; $P < 0.001$). The largest absolute difference between countries was observed for item 4, where Colombian participants reported lower self-efficacy for giving a sample when feeling physically weak (Colombia mean = 1.63;

Nicaragua mean = 5.37). Items 4 and 9, which concern physical capacity and bodily unease, showed the lowest mean scores in the combined sample (3.44 and 3.74, respectively), identifying these as the most commonly reported barriers to donation within both countries. Items 1 (never donated before; mean = 9.15) and 12 (takes longer at the doctor's office; mean = 8.76) showed the highest mean scores, indicating that prior inexperience and time constraints were perceived as the least significant barriers to biobank participation.

Mean scores for the Intentions Scale items were 4.78 (SD = 0.64) for urine donation and 4.67 (SD = 0.79) for blood donation, indicating strong willingness to donate in both countries. Contrary to the pattern observed for Attitudes and Self-Efficacy, Colombian participants scored significantly higher than Nicaraguan participants on both Intentions items (urine: 4.92 versus 4.63, P = 0.002; blood: 4.77 versus 4.57, P = 0.04). The Receptivity item had a mean of 4.75 (SD = 0.81), with no significant country difference (P = 0.75), indicating near-universal willingness to receive further information about biobanking across both settings.

Table 2
Mean and standard deviation for BANKS-SP scale items, by country (N = 124).

	Colombia (N = 64)		Nicaragua (N = 60)		Overall (N = 124)		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**P-value***
Attitudes Scale†							
1. Giving biological samples to be stored in a biobank, for example, of blood or urine is for the good of all	3.94	0.47	4.73	0.45	4.32	0.61	< 0.001
2. People who give biological samples to help prevent diseases	4.03	0.44	4.70	0.50	4.35	0.57	< 0.001
3. People who give biological samples help cure diseases	3.69	0.66	4.52	0.75	4.09	0.82	< 0.001
4. Giving a biological sample is a waste of time for the person	3.95	0.55	4.60	0.49	4.27	0.61	< 0.001
5. Giving biological samples helps future generations	4.06	0.39	4.65	0.48	4.35	0.53	< 0.001
6. Giving a biological sample interferes with a person's health care	3.44	0.91	4.12	1.17	3.77	1.09	< 0.001
7. Giving a biological sample will help a person's family	3.86	0.43	4.38	0.90	4.11	0.75	< 0.001
8. A person's medical information is unlikely to be stolen from a biobank.	3.25	0.80	3.78	1.29	3.51	1.09	< 0.001
9. Giving blood to a biobank is a good way to help dengue research	4.03	0.40	4.73	0.58	4.37	0.60	< 0.001
10. It is unlikely that a person's personal information will be stolen from a biobank.	3.31	0.77	3.77	1.25	3.53	1.05	0.001
11. A person should not give biological samples because they could identify health problems.	3.70	0.68	4.37	0.82	4.02	0.82	< 0.001
12. Giving biological samples to a biobank could lead to more medical costs	3.69	0.61	4.03	0.92	3.85	0.79	< 0.001
Self-efficacy Scale							
1. I think I could give a biological sample to a biobank even if I have never done it before	9.33	2.26	8.95	1.77	9.15	2.04	< 0.001
2. I think I could give a biological sample to a biobank even if I had to go far to do so.	6.09	3.93	6.47	3.04	6.27	3.52	0.97
3. I think I could give a biological sample to a biobank even if it hurt me.	7.47	3.71	8.08	2.42	7.77	3.16	0.47
4. I think I could give blood to a biobank even if I feel weak.	1.63	1.46	5.37	3.27	3.44	3.12	< 0.001
5. I think I could give a biological sample to a biobank even if my family doesn't want me to do it.	8.53	3.12	8.48	2.25	8.51	2.72	0.02
6. I believe that I could give a biological sample to a biobank even if it goes against my cultural beliefs.	6.98	3.97	7.70	3.07	7.33	3.57	0.81
7. I think I could give a blood sample to a biobank even if it hurts me.	6.61	3.98	8.13	2.63	7.35	3.47	0.25
8. I believe that I could give a biological sample to a biobank even if I am concerned about how it will be used.	4.86	3.76	7.17	2.74	5.98	3.49	< 0.001
9. I think I could give a biological sample to a biobank even if it doesn't feel right.	2.53	2.85	5.03	2.93	3.74	3.14	< 0.001
10. I think I could give a biological sample to a biobank even if I am afraid of needles.	8.42	3.26	8.28	2.80	8.35	3.04	0.046
11. I believe that I could give a biological sample to a biobank even if it goes against my religious beliefs.	6.69	4.06	7.83	3.07	7.24	3.65	0.43
12. I think I could give a biological sample to a biobank even if it takes longer at the doctor's office.	9.25	2.21	8.23	2.40	8.76	2.35	< 0.001
Intentions Scale‡							
1. If you were asked to donate a urine sample for research purposes, would you be willing to do so?	4.92	0.37	4.63	0.82	4.78	0.64	0.002
2. If you were asked to donate a blood sample for research purposes, would you be willing to do so?	4.77	0.68	4.57	0.89	4.67	0.79	0.04

SD=standard deviation

*P-value for the Mann-Whitney test indicating whether there is a significant difference between scores for that item in Colombia and Nicaragua at α = 0.05

†5-level Likert scale (5 = strongly agree-1 = strongly disagree)

‡5-level Likert scale (5 = definitely yes-1 = definitely no)

§ 5-level Likert scale (5 = definitely yes-1 = definitely no); scale was limited to one item and no item-to-total statistic was calculated

	Colombia (N = 64)		Nicaragua (N = 60)		Overall (N = 124)		
	Mean	SD	Mean	SD	Mean	SD	P-value*
Receptivity scale§							
1. If you were asked to donate a biological sample for research purposes, would you be willing to hear more information about it?	4.73	0.86	4.75	0.81	4.75	0.81	0.75
SD=standard deviation							
*P-value for the Mann-Whitney test indicating whether there is a significant difference between scores for that item in Colombia and Nicaragua at α = 0.05							
†5-level Likert scale (5 = strongly agree-1 = strongly disagree)							
‡5-level Likert scale (5 = definitely yes-1 = definitely no)							
§ 5-level Likert scale (5 = definitely yes-1 = definitely no); scale was limited to one item and no item-to-total statistic was calculated							

Biobanking knowledge

Table 3 presents the distribution of correct, incorrect, and “don’t know” responses to the BANKS-SP Knowledge Scale and the item-level difficulty scores. Considerable variation in knowledge was found across items in both countries. On average, respondents answered 51% of items correctly across both sites (mean correct items: 8.15 out of 16), with Nicaraguan participants outperforming Colombian participants (Nicaragua: 56%, 9.00/16; Colombia: 46%, 7.36/16). The largest cross-country differences in performance were observed for item 9 (insurance companies can legally access donated biospecimens; Colombia ILD = 0.33, Nicaragua ILD = 0.70) and item 14 (a person can retrieve their biospecimen after providing it; Colombia ILD = 0.55, Nicaragua ILD = 0.82), with Nicaraguan participants more likely to answer both items correctly.

Three items were answered correctly by fewer than 30% of respondents in the combined sample and were classified as very difficult. Item 10 ("Researchers will always contact people if their biological samples show a risk of disease"; correct answer: No) was the hardest item overall (ILD = 0.14), with only 9% of Colombian and 18% of Nicaraguan participants answering correctly. The high proportion of incorrect responses (81% combined) indicates that most participants expected researchers to actively notify them of incidental findings, which is not a guaranteed practice and is rarely stipulated in standard informed consent forms. Item 13 ("People no longer own their biospecimens after they give them to a biobank"; correct answer: No) was also very difficult in both countries (ILD = 0.23 overall; Colombia = 0.28, Nicaragua = 0.18), with a substantial proportion of participants selecting "don't know" (19% combined). Item 3 ("Research results from biospecimens will show up in medical records"; correct answer: No) showed similarly low overall performance (ILD = 0.27), with approximately 50% of respondents in each country answering incorrectly and a further 23% to 31% selecting "don't know." Item 7 ("Police departments can legally obtain the biospecimens a person gives"; ILD = 0.50 overall) was answered correctly by 42% of Colombian and 58% of Nicaraguan participants.

A further five items fell in the difficult range (ILD 0.30 to 0.50): item 7 (police access; ILD = 0.50), item 6 (biospecimens can be sent to any requesting organisation; ILD = 0.34), item 11 (family members can obtain information about donated biospecimens; ILD = 0.32), item 12 (people can make money from donated biospecimens; ILD = 0.35), and item 15 (a person might be cloned if they donate a biospecimen; ILD = 0.40). High "don't know" rates were observed across several items in both countries, most notably for items 4 (biospecimens sold to drug companies; 46% DK in Colombia, 31% in Nicaragua), 6 (40% and 43%, respectively), and 15 (51% and 43%), indicating uncertainty rather than active misinformation for these topics. The easiest items concerned basic principles of research confidentiality and sample access: item 5 ("a scientist must keep a person's information private when doing research"; ILD = 0.90), item 1 ("a person has to spend money to give a biospecimen"; ILD = 0.89), item 8 ("biospecimens given to a biobank can be sold to anyone"; ILD = 0.85), and item 2 ("anyone can access the biospecimens a person gives"; ILD = 0.86). These items were answered correctly by more than 78% of participants in both countries, suggesting that basic privacy principles and the voluntary nature of donation were well understood.

Table 3
Distribution of responses to the BANKS-SP Knowledge Scale, by site (N = 124)

	Colombia (N = 64)							Nicaragua (N = 60)							Overall (N = 124)					
	Yes		No		DK			Yes		No		DK			Yes		No		DK	
	N	(%)	N	(%)	N	(%)	ILD	N	(%)	N	(%)	N	(%)	ILD	N	(%)	N	(%)	N	(%
1. A person has to spend money to give a biospecimen (No)	2	(3)	55	(86)	7	(11)	0.86	5	(8)	55	(92)	0	(0)	0.92	7	(6)	110	(88)	7	(6
2. Anyone can access the biospecimens a person gets (No)	3	(5)	50	(78)	11	(17)	0.78	2	(3)	57	(95)	1	(2)	0.95	5	(4)	107	(86)	12	(1
3. Research results from biospecimens will show up in medical records (No)	29	(45)	15	(23)	20	(31)	0.23	33	(55)	18	(30)	9	(15)	0.30	62	(50)	33	(27)	29	(2
4. Biospecimens given to a biobank will be sold to drug companies (No)	5	(8)	29	(45)	30	(47)	0.45	4	(7)	37	(62)	19	(31)	0.62	9	(7)	66	(53)	49	(4
5. A scientist must keep a person's information private when doing research (Yes)	54	(84)	1	(2)	9	(14)	0.84	58	(97)	0	(0)	2	(3)	0.97	112	(90)	1	(1)	11	(9
6. The biospecimens people give can be sent to any organization that requests them (No)	22	(34)	16	(25)	26	(41)	0.25	27	(45)	26	(43)	7	(12)	0.43	49	(40)	42	(33)	33	(2
7. Police departments can legally get the biospecimens a person gives (No)	13	(20)	27	(42)	24	(38)	0.42	19	(32)	35	(58)	6	(10)	0.58	32	(26)	62	(50)	30	(2
8. Biospecimens given to a biobank can be sold to anyone (No)	3	(5)	50	(78)	11	(17)	0.78	1	(2)	55	(92)	4	(6)	0.92	4	(3)	105	(85)	15	(1
9. Insurance companies can legally get the biospecimens a person gives (No)	21	(33)	21	(33)	22	(34)	0.33	6	(10)	42	(70)	12	(20)	0.70	27	(22)	63	(51)	34	(2
10. Researchers will always contact people if their biospecimens show risk for disease (No)	53	(83)	6	(9)	5	(8)	0.09	47	(78)	11	(18)	2	(3)	0.18	100	(81)	17	(14)	7	(5

	Colombia (N = 64)							Nicaragua (N = 60)							Overall (N = 124)					
	Yes		No		DK			Yes		No		DK			Yes		No		DK	
	N	(%)	N	(%)	N	(%)	ILD	N	(%)	N	(%)	N	(%)	ILD	N	(%)	N	(%)	N	(%
11. A person's family can get information about the biospecimens a person gives (No)	26	(41)	21	(33)	17	(26)	0.33	35	(58)	19	(32)	6	(10)	0.32	61	(49)	40	(32)	23	(1
12. People can make money from donated biospecimens (No)	10	(16)	25	(39)	29	(45)	0.39	14	(23)	19	(32)	27	(45)	0.32	24	(19)	44	(35)	56	(4
13. People no longer own their biospecimens after they give them to a biobank (No)	28	(44)	18	(28)	18	(28)	0.28	44	(73)	11	(18)	5	(8)	0.18	72	(58)	29	(23)	23	(1
14. After a person gives a biospecimen to a biobank, she/he can get it back (No)	5	(8)	35	(55)	24	(37)	0.55	4	(7)	49	(81)	7	(12)	0.82	9	(7)	84	(68)	31	(2
15. A person might be cloned if he/she donates a biospecimen to a biobank (No)	5	(8)	26	(40)	33	(51)	0.41	11	(18)	23	(38)	26	(43)	0.38	16	(13)	49	(40)	59	(4
16. A person can stop being in a research study after giving a biospecimen (Yes)	37	(58)	9	(14)	18	(28)	0.58	41	(68)	16	(27)	3	(5)	0.68	78	(63)	25	(20)	21	(1
	N	(%)						N	(%)						N	(%)				
Overall knowledge[§]	7.36	(46)						9.00	(56)						8.15	(51)				

DK = Don't know; ILD=item-level difficulty. Items were put to participants as statements to be judged "it is true" or "it is not true"; responses are reported here as Yes and No, and the correct answer for each item is shown in parentheses after the item text.

*Item-level difficulty is the proportion of correct responses divided by the total responses for that item

[§]Overall knowledge is the mean total proportion of correct responses over the total responses

Scale performance measures

Cronbach's alpha

Table 4 presents item- and scale-level measures of internal consistency for the Attitudes and Self-Efficacy Scales. For the Self-Efficacy Scale, Cronbach's alpha exceeded the conventional threshold of 0.70 in Colombia (α = 0.79), Nicaragua (α = 0.91), and the combined sample (α = 0.85), indicating adequate reliability across both settings. For the Attitudes Scale, internal consistency was more variable: Colombia fell below the threshold (α = 0.63), Nicaragua was borderline acceptable (α = 0.70), and the combined sample reached adequate performance (α = 0.82). The Intentions Scale showed a similar pattern of cross-country variation: adequate in Nicaragua (α = 0.79) but well below threshold in Colombia (α = 0.18; combined: α = 0.69). These results suggest that the Self-Efficacy Scale is sufficiently reliable for use in both settings in its current form, while the Attitudes Scale performs adequately only when data from both sites are combined. The persistence of below-threshold alpha in Colombia, even after reverse-coding the four negatively worded items, indicates that the problem

is not a scoring artefact but rather reflects genuine variability in how Colombian participants interpreted and responded to the attitude items. Item-level analysis, described below, helps identify which specific items are driving this heterogeneity.

Table 4
BANKS-SP estimates of scale reliability (N = 124)*

Attitudes Scale	**Colombia (N = 64; α = 0.629)**			**Nicaragua (N = 60; α = 0.704)**			**Combined (N = 124; α = 0.817)**		
	Item-to-item correlation	**Item-to-total correlation**	**α**	**Item-to-item correlation**	**Item-to-total correlation**	**α**	**Item-to-item correlation**	**Item-to-total correlation**	**α**
1. Giving biological samples to be stored in a biobank, for example, of blood or urine is for the good of all	0.145	0.169	0.625	0.237	0.312	0.693	0.463	0.584	0.797
2. People who give biological samples to help prevent diseases	0.214	0.177	0.623	0.327	0.450	0.680	0.494	0.635	0.795
3. People who give biological samples help cure diseases	0.037	0.099	0.643	0.225	0.270	0.694	0.404	0.431	0.807
4. Giving a biological sample is a waste of time for the person*	0.073	0.145	0.630	0.301	0.359	0.688	0.442	0.484	0.804
5. Giving biological samples helps future generations	0.199	0.307	0.608	0.25	0.266	0.696	0.435	0.542	0.802
6. Giving a biological sample interferes with a person's health care*	0.152	0.473	0.558	0.303	0.316	0.693	0.393	0.444	0.810
7. Giving a biological sample will help a person's family	0.037	0.110	0.632	0.343	0.410	0.674	0.442	0.446	0.806
8. A person's medical information is unlikely to be stolen from a biobank.	0.154	0.459	0.564	0.221	0.430	0.673	0.314	0.464	0.807
9. Giving blood to a biobank is a good way to help dengue research	0.148	0.258	0.614	0.239	0.408	0.681	0.466	0.598	0.797
10. It is unlikely that a person's personal information will be stolen from a biobank.	0.165	0.503	0.553	0.218	0.395	0.680	0.312	0.434	0.810
11. A person should not give biological samples because they could identify health problems.*	0.11	0.173	0.629	0.263	0.309	0.689	0.411	0.452	0.805
12. Giving biological samples to a biobank could lead to more medical costs*	0.167	0.384	0.587	0.269	0.392	0.677	0.349	0.438	0.806
Self-Efficacy Scale	**Colombia (α = 0.788)**			**Nicaragua (α = 0.913)**			**Combined (α = 0.851)**		
1. I think I could give a biological sample to a biobank even if I have never done it before	0.335	0.543	0.768	0.452	0.720	0.906	0.306	0.564	0.841
2. I think I could give a biological sample to a biobank even if I had to go far to do so.	0.219	0.414	0.776	0.384	0.512	0.913	0.273	0.448	0.846
3. I think I could give a biological sample to a biobank even if it hurt me	0.289	0.527	0.763	0.479	0.723	0.903	0.336	0.590	0.835
4. I think I could give blood to a biobank even if I feel weak.	0.145	0.235	0.789	0.222	0.410	0.919	0.111	0.366	0.851
5. I think I could give a biological sample to a biobank even if my family doesn't want me to do it.	0.213	0.468	0.770	0.464	0.754	0.902	0.285	0.554	0.838
6. I believe that I could give a biological sample to	0.285	0.556	0.759	0.504	0.699	0.903	0.346	0.613	0.833

Attitudes Scale	Colombia (N = 64; α = 0.629)			Nicaragua (N = 60; α = 0.704)			Combined (N = 124; α = 0.817)		
	Item-to-item correlation	Item-to-total correlation	α	Item-to-item correlation	Item-to-total correlation	α	Item-to-item correlation	Item-to-total correlation	α
a biobank even if it goes against my cultural beliefs.									
7. I think I could give a blood sample to a biobank even if it hurts me.	0.261	0.470	0.770	0.51	0.776	0.900	0.327	0.598	0.834
8. I believe that I could give a biological sample to a biobank even if I am concerned about how it will be used.	0.175	0.291	0.789	0.454	0.732	0.902	0.252	0.502	0.842
9. I think I could give a biological sample to a biobank even if it doesn't feel right	0.204	0.308	0.784	0.29	0.477	0.914	0.18	0.435	0.846
10. I think I could give a biological sample to a biobank even if I am afraid of needles.	0.164	0.318	0.784	0.538	0.764	0.900	0.295	0.493	0.842
11. I believe that I could give a biological sample to a biobank even if it goes against my religious beliefs.	0.306	0.560	0.758	0.495	0.651	0.906	0.354	0.603	0.834
12. I think I could give a biological sample to a biobank even if it takes longer at the doctor's office.	0.308	0.575	0.766	0.544	0.832	0.906	0.322	0.600	0.837

α = Cronbach's alpha. Item-to-item correlation = average Spearman's r correlation between pairs of individual items. Item-to-total correlation = the correlation between that one item and the overall score for the scale when excluding that item

*Negatively worded questions in the Attitudes Scale were recoded prior to analysis so that all items operate in the same direction (higher score=more positive attitudes towards biobanking)

Item-to-total correlation

After reverse-coding the four negatively worded items (items 4, 6, 11, and 12), all Attitudes Scale items showed positive item-to-total correlations (ITT). In the combined sample, every item reached at least the acceptable band (ITT ≥ 0.30) and four items (1, 2, 5, and 9) were strong (ITT ≥ 0.50), with items 2 (0.64) and 9 (0.60) showing the strongest associations with the overall scale score. However, in Colombia, seven of the twelve items were weak (ITT < 0.30), with items 3 ("people who give biological samples help cure diseases"; ITT = 0.10) and 7 ("giving a biological sample will help a person's family"; ITT = 0.11) showing the weakest performance. The ITT for item 7 showed the most pronounced cross-country discordance, with the item weak in Colombia (0.11) but acceptable in Nicaragua (0.41). This pattern indicates that the association between this item and the overall attitude construct differs substantially between settings, and may reflect differences in family-oriented rationales for biobank participation in each community.

For the Self-Efficacy Scale, ITT correlations were strong across both countries and the combined sample for most items. In Nicaragua, 10 of 12 items were strong (ITT ≥ 0.50), with item 12 ("even if it takes longer at the doctor's office"; ITT = 0.83) and item 7 ("even if it hurts me [donate blood sample]"; ITT = 0.78) showing the highest values; the remaining two items fell in the acceptable band. In Colombia, items 4 ("even if I feel weak"; ITT = 0.24) and 8 ("even if I am concerned about how it will be used"; ITT = 0.29) were weak (ITT < 0.30), suggesting these items contribute less consistently to the self-efficacy construct for Colombian participants. Item 4 showed an acceptable ITT in the combined sample (0.37), indicating that the weakness may be specific to the Colombian context rather than a general property of the item.

Inter-item correlation

The average inter-item correlations (IICs) for the Attitudes Scale were 0.13 in Colombia, 0.27 in Nicaragua, and 0.41 in the combined sample. Colombia's value falls below the desirable range of 0.15 to 0.50, confirming that attitude items are not consistently related to one another in this sample and that the scale is measuring a heterogeneous set of constructs in Colombia; six of the twelve items returned an average IIC below 0.15 in Colombia. Nicaragua's value and the combined-sample value both sit within the desirable range, and no item on either scale exceeded 0.70, the level above which items would be considered redundant. The combined value is higher than either country-level value because pooling the two samples introduces between-country variation in attitudes, which raises pairwise correlations at the scale level; it should therefore not be read as evidence that the scale coheres within either country on its own.

For the Self-Efficacy Scale, average IICs fell within the desirable range overall and within countries (combined: 0.28; Colombia: 0.24; Nicaragua: 0.44). Item 4 (giving a sample when feeling weak) was the only item to fall below 0.15 in the combined sample (IIC = 0.11); item 9 (giving a sample when it does not feel right) sat at the lower end of the desirable range (IIC = 0.18). The combined ITT for Item 4, 0.37, is acceptable, meaning the item correlates meaningfully with

the total scale score but not with other individual items. An acceptable ITT paired with a low IIC is characteristic of an item that measures a distinct sub-dimension of the construct rather than evidence of misfit. Item 4 may capture a physical capacity barrier to donation that is not shared by the other items, which are more concerned with social, cultural, and motivational barriers. This interpretation is further supported by items 4 and 9 co-loading on Factor 3 in the exploratory factor analysis (Supplementary Table S4).

A systematic cross-country gradient is also evident in the Self-Efficacy Scale IIC values. In Colombia, IICs for items 5, 6, 7, 8, 10, and 12 are at least 0.20 lower than the corresponding values in Nicaragua. This pattern suggests that self-efficacy barriers to biospecimen donation are more heterogeneous and less intercorrelated in Colombia, whereas in Nicaragua the scale behaves more as a coherent unidimensional construct. This finding may relate to the greater history of community engagement in the Nicaraguan source study elaborated in the discussion.

Underlying factor structure

Scree plots for both scales, with the parallel analysis thresholds overlaid, are presented in Fig. 1. For the Attitudes Scale the first three eigenvalues were 3.98, 1.22 and 0.49; for the Self-Efficacy Scale they were 4.28, 1.05 and 0.86. A single dominant factor accounts for most of the common variance in both scales. Parallel analysis supported the retention of three factors for each scale. For the Self-Efficacy Scale the third factor exceeded the 95th percentile of random eigenvalues comfortably (0.86 versus 0.46). For the Attitudes Scale it exceeded that threshold only marginally (0.49 versus 0.47), which is consistent with our interpretation of the third Attitudes factor as an item doublet rather than a substantive sub-dimension. A fourth factor exceeded the random threshold by a negligible margin in both scales (0.009 and 0.013) and was not retained.

Exploratory factor analysis (EFA) with *promax* rotation identified a three-factor solution for each scale (Supplementary Tables S3 and S4). For the Attitudes Scale, Factor 1 captured seven of twelve items reflecting prosocial and altruistic motivations for biospecimen donation, including perceived benefits to society, future generations, and disease research. Factor 2 captured three items concerning perceived personal risks of donation: interference with health care (item 6), identification of a health problem (item 11), and higher medical costs (item 12). All three are reverse-coded, so this factor may reflect item wording as much as a distinct attitudinal dimension; the two cannot be separated in this design. Factor 3 comprised only items 8 and 10, which concern the security of personal information and load at 0.81 and 0.84 with negligible cross-loadings. Because these two items are near-paraphrases of one another, this factor is better read as an item doublet indicating redundancy than as a substantive sub-dimension. One of these two items should be removed in future revisions of the instrument.

For the Self-Efficacy Scale, Factor 1 captured eight of twelve items, reflecting broad motivational and values-based self-efficacy for donation across social, cultural, and practical barriers. Factor 2 comprised only items 3 and 7, which ask about donating despite pain and load at 0.92 and 0.89; as near-paraphrases they constitute an item doublet rather than a substantive sub-dimension, and one of the pair should be removed in future revisions. Factor 3 captured items 4 and 9, which concern physical capacity and bodily unease and are distinct in content rather than wording, representing a genuine sub-dimension not shared by the other items.

Construct validity: correlation between knowledge, attitudes, and self-efficacy

Figure 2 presents LOWESS curves of the relationship between the Attitudes and Knowledge Scales (Fig. 2A) and between the Self-Efficacy and Knowledge Scales (Fig. 2B) for Colombia, Nicaragua, and both sites combined (full correlation estimates are reported in Supplementary Table S5). Attitudes increased with biobanking knowledge across all groups (combined: $r = 0.42$, $p < 0.001$; Colombia: $r = 0.34$, $p = 0.006$; Nicaragua: $r = 0.29$, $p = 0.023$), with a consistent positive slope visible in all three LOWESS curves. The Colombian curve shows a relatively flat section at low knowledge scores (approximately 0.2 to 0.4) followed by a positive rise, whilst the Nicaraguan curve shows a steeper increase above the knowledge midpoint, suggesting the association may strengthen at higher levels of knowledge in that setting.

The knowledge-to-self-efficacy association was statistically significant in the combined sample ($r = 0.24$, $p = 0.009$) and in Nicaragua ($r = 0.32$, $p = 0.014$), but not in Colombia ($r = 0.06$, $p = 0.665$). The Nicaraguan LOWESS curve shows a clear positive trend across the knowledge range, whilst the Colombian relationship follows a non-monotonic pattern, which accounts for the near-zero overall correlation. The LOWESS curves provide good support for the construct validity of the Attitudes Scale across both settings and partial support for the Self-Efficacy Scale, where the unexpected relationship between self-efficacy and knowledge in the Colombian cohort warrants further investigation.

Figure 2. LOWESS curves comparing participant-level mean responses to the BANKS-SP Attitudes, Self-Efficacy, and Knowledge Scales with a scatterplot of mean responses for the related scales (Colombia N = 64; Nicaragua N = 60).

Discussion

This study describes the adaptation and psychometric evaluation of the BANKS-SP in a novel context, with parents or legal guardians of participants in a long-standing dengue cohort study in Colombia and a longitudinal, prospective paediatric hospital-based study in Nicaragua. To our knowledge, this is the first study to evaluate the measurement properties of the BANKS-SP in an LMIC infectious disease research context and the first study anywhere to assess its underlying factor structure. Our findings have implications for the use of the BANKS-SP in similar populations and for researchers designing biobanking communication strategies with cohort communities in Latin America and beyond.

Across both sites, participants expressed broadly positive attitudes towards biospecimen donation and high intentions to donate blood and urine for research purposes. These findings are consistent with prior evaluations of the BANKS in cancer biobank settings (Wells et al. 2014) and align with evidence from other LMIC contexts suggesting that long-standing research relationships with source communities can foster trust and openness to biobank participation (Broekstra et al. 2021; Andersson et al. 2015). The LOWESS curves demonstrated that biobanking attitudes increased with knowledge at both sites, providing good evidence for the construct validity of the Attitudes Scale and reinforcing the central role of knowledge in shaping attitudes towards

biobanking, consistent with a knowledge-attitudes-practice framework, which suggests that increased knowledge contributes to attitude formation and may subsequently influence behaviour (Glanz et al., 2015; Launiala, 2009).

The steeper rise of the Nicaraguan attitude curve above the knowledge midpoint may reflect a threshold effect, whereby higher biobanking knowledge translates into more pronounced attitudinal gains in a community with greater prior engagement with research. For the Self-Efficacy Scale, the significant and positive association between knowledge and self-efficacy in Nicaragua is consistent with the expectation that greater knowledge of biobanking supports confidence in donation, and provides evidence for construct validity. The non-monotonic Colombian self-efficacy-to-knowledge curve, in which self-efficacy declines among participants with higher knowledge scores, is difficult to interpret and requires qualitative investigation. This relationship may reflect a ceiling effect at lower knowledge levels, an inverse relationship between knowledge and perceived barriers in some domains, or the greater variability in the correlation between items in the Self-Efficacy Scale in Colombia.

Nicaraguan participants scored significantly higher on all Attitudes Scale items and demonstrated higher biobanking knowledge than Colombian participants, despite Colombian participants having higher formal educational attainment. This pattern may reflect the long history of community-based participatory research embedded in the Nicaraguan source cohort, including large-scale community mobilisation campaigns for dengue prevention (Ledogar et al. 2017), community-based platforms for arbovirus vector control (Holston et al. 2021) and the high-quality clinical care they receive when they participate in these long-term studies. These findings suggest that sustained community engagement, which builds two-way communication between researchers and communities, may foster biobanking knowledge and positive attitudes independently of formal educational attainment, and should be understood as an active mechanism for strengthening research literacy rather than simply an ethical requirement of cohort research. Researchers working in settings without such a history may need to invest more deliberately in community education before biobanking activities.

The finding that Colombian participants reported significantly higher donation intentions than Nicaraguan participants, despite lower scores on the Attitudes Scale and Self-Efficacy Scale, warrants close, careful interpretation. This finding may reflect a social desirability effect operating differently across the two data collection modalities, telephone in Colombia and face-to-face in Nicaragua, or it may indicate that intention to donate and attitude towards biobanking are more loosely coupled in the Colombian context than in Nicaragua. The two items that consistently showed the lowest self-efficacy scores in both countries were Item 4, “Giving a sample when feeling physically weak,” and Item 9, “Giving a sample when it does not feel right.” This finding suggests that community engagement should acknowledge physical limitations and instinct as legitimate reasons to defer donation, and provide clear guidance on participants' right to decline without consequence, to build trust in biobanking processes.

While negatively worded survey items are a common feature of questionnaires designed to reduce acquiescence bias and identify response sets (Tourangeau et al., 2000), they may also increase cognitive burden and contribute to response error (Swain et al. 2008). We found that these items were confusing to participants and required verbal rewording for most respondents. Future research should explore how negatively worded scale items function in populations with less exposure to survey research and formal questionnaire administration.

Knowledge

The biobanking knowledge results highlight two distinct gaps that have important implications for informed consent and community education. The first concerns researchers' obligations related to communicating incidental findings. The near-universal misunderstanding of item 10, in which over 80% of participants across both countries believed that researchers are obligated to contact participants when their samples indicate a health risk, suggests that community members hold expectations about the duty of care embedded in biobank participation that are not routinely met in practice. These expectations may be more than a simple knowledge gap. In Colombia, 1993 Resolution 8430 establishes a duty to inform research participants of findings relevant to their health, which may have shaped participant expectations less as explicit knowledge of the regulation and more as a background normative assumption about what research participation entails (Ministry of Health of Colombia 1993). The subsequent enactment of Colombia’s National Biobank Law (Law 2287 de 2023) institutionalises this expectation by establishing specific protocols for the communication of incidental findings (Congress of Colombia 2023), and underscores the salience of this finding for the Colombian context. At the international level, the CIOMS International Ethical Guidelines (2016) affirm researchers’ obligations to consider the management of incidental findings, albeit under context-specific criteria (Council for International Organizations of Medical Sciences 2016). The gap in understanding of plans to communicate incidental findings may be less related to unreasonable participant expectations and more to the absence of clear explanations within the informed consent process itself, of how and under what criteria incidental findings are managed. Informed consent processes should explicitly address what participants can and cannot expect to be told as a result of giving a sample, and community education materials should clearly distinguish biobank participation from clinical follow-up care.

Managing incidental findings from biobank research requires carefully balancing uncertain clinical relevance, participant expectations, and the transfer of confidential information from researchers to care providers to evaluate and communicate findings as needed based on clinical relevance and patient consent (Beskow and Burke 2010, Geiger et al. 2023). Recently developed consensus workflows for the communication of incidental findings to sample donors emphasise structured evaluation and clinician-mediated disclosure while foregrounding the importance of respecting participants’ right to know or not know, but do not explicitly incorporate the sample donor and the importance of evaluating their understanding of, and agreement with, their consent to be told or not told (Geiger et al. 2023). Our prior research, which included 52 cognitive interviews with cohort participants in Colombia and Nicaragua, suggested that participants believe clinically important results will be communicated to them, even when the informed consent form explicitly states that incidental findings will not be communicated to sample donors (Maxwell et al. 2023). Ethics committees and biobank teams should prioritise participant understanding of incidental findings policies as a measurable outcome of the consent process; workflows for communicating incidental findings should begin with verified comprehension rather than assumed understanding.

The second gap concerns the understanding of sample governance and legal protections. Items about insurance company access (item 9), sample ownership (item 13), and police access (item 7) were among the most difficult across both sites, with high rates of "don't know" responses indicating genuine

uncertainty rather than misinformation. This uncertainty is not unique to lay participants. A qualitative study of ethics review committee members in Colombia found that experts also experienced uncertainty about the governance of broad consent precisely because of the absence of dedicated legislation (Miranda Montoya et al. 2022), meaning that institutional ambiguity in regulatory oversight parallels community participants' uncertainty. The convergence of participant and expert uncertainty strengthens the argument that item difficulty in this domain reflects the actual state of institutional and legal ambiguity in Colombia prior to the Biobank Law, rather than a failure of participant comprehension or engagement. At the time of data collection, neither Colombia nor Nicaragua had specific legislation governing police or insurance company access to research biobank samples. Colombia's National Biobank Law (Law 2287), which restricts sample use to biomedical research purposes and requires donor consent for any transfer to third parties, was enacted in January 2023 (Congress of Colombia 2023). In the absence of dedicated biobanking legislation, participants lack a clear legal framework against which to assess these questions, which likely explains the high levels of uncertainty for items 7 and 9. At the international level, law enforcement access to research biospecimens remains inconsistently regulated across jurisdictions. The lack of clear protections in the communities when and where this study was conducted underscores both the importance and the complexity of addressing research participants' legal rights in community education and informed consent processes in the absence of national biobanking legislation. The substantially better performance of Nicaraguan participants on governance items, including items 9 (insurance company access) and 14 (sample retrieval), is consistent with the higher knowledge scores in Nicaragua and may reflect the greater depth of community engagement. These findings highlight the specific domains, including communication of incidental findings, legal protections, and sample ownership, that should be prioritised in participant-facing education and consent materials for biobanking initiatives.

Internal consistency

The Self-Efficacy Scale demonstrated adequate internal consistency in both Colombia (α = 0.79) and Nicaragua (α = 0.91), with strong ITT correlations across most items in both settings, consistent with the high internal consistency reported for the original BANKS-SP (α = 0.95; Arevalo et al. 2016). This supports its use within similar infectious disease cohort study communities in Latin America, with the caveat that items 4 (I think I could give blood to a biobank even if I feel weak.) and 9 (I think I could give a biological sample to a biobank even if it doesn't feel right.) may measure a distinct physical-capacity sub-dimension that does not fully fall within the scale's general motivational domain. Researchers who wish to use a short form of the Self-Efficacy Scale in future studies should retain at least one of these items to preserve coverage of this sub-dimension.

The alpha of 0.63 for the Attitudes Scale in Colombia falls below the conventional threshold of 0.70, indicating some concern about internal consistency. The cross-country discordance in the ITT on item 7 (Giving a biological sample will help a person's family; Colombia ITT = 0.11; Nicaragua ITT = 0.41) indicates that this item may measure something structurally different in these two contexts. Family-oriented rationales for DENV cohort participation may carry different cultural weight across the two settings. This item warrants further qualitative investigation before the instrument is re-administered in Colombia. The low average IIC in Colombia (0.13) and correspondingly low alpha indicate that the attitude items are not functioning as a coherent unidimensional scale. Revision of the item pool to better reflect the attitudinal dimensions that are salient to Colombian biobank cohort communities is recommended before wider deployment. The lower alpha observed in Colombia relative to the original BANKS-SP validation study (α = 0.77; Arevalo et al. 2016) may reflect a different population, a smaller sample size (N = 64 versus N = 85), or genuine differences in item performance. These findings reinforce the importance of item-level scrutiny when adapting psychometric scales to new populations, and suggest that the Attitudes Scale requires further revision to achieve adequate reliability in single-country LMIC samples.

Factor structure

The EFA identified a dominant first factor for both scales, consistent with the broadly unidimensional structure of the Self-Efficacy Scale's strong alpha values, while indicating potentially meaningful sub-dimensions for instrument refinement. The three-factor structure of the Attitudes Scale (altruism; perceived personal risks; information security) is conceptually coherent and aligns with frameworks for biobanking attitudes that distinguish prosocial motivations for donation from concerns about safety and harm (Shabani et al. 2014; Walshe et al. 2024). The two information security items (8. A person's medical information is unlikely to be stolen from a biobank.; 10. It is unlikely that a person's personal information will be stolen from a biobank.) formed a factor of their own. Because the two are near-paraphrases, this is better understood as an item doublet than as an independent attitudinal dimension; beliefs about data protection nonetheless warrant targeted community communication, particularly given that these items showed the lowest mean attitude scores in both countries. The second factor comprised three reverse-coded items concerning perceived personal risks of donation: health interference (item 6), identification of a health problem (item 11), and higher medical costs (item 12). These items share both negative wording and negative content, so the analysis cannot establish whether the factor reflects a substantive risk dimension or a response artefact arising from reverse coding. Either reading supports revising these items before the instrument is used again.

The Self-Efficacy Scale resolved into a broad motivational and values-based factor, a two-item pain doublet (items 3 and 7), and a physical capacity and bodily unease factor (items 4 and 9). Setting the doublet aside, this confirms that barriers related to physical capacity are structurally distinct from motivational and values-based barriers and should be addressed through tailored messaging in community engagement programmes. For example, participants who felt unable to provide a sample against family wishes or cultural beliefs (Factor 1) may benefit from family-inclusive consent discussions, whilst those who express concern about physical weakness or discomfort during donation (Factor 3) could be offered detailed procedural information and reassurance. In both scales the EFA isolated a redundant pair as a factor in its own right: items 8 and 10 in the Attitudes Scale and items 3 and 7 in the Self-Efficacy Scale. Removing one item from each pair would reduce respondent burden without meaningful loss of construct coverage.

Strengths and limitations

This study has several strengths. We conducted a systematic adaptation of the BANKS-SP using cognitive interviews at two sites prior to administration and assessed a broader range of psychometric properties than in the original validation studies, including EFA, LOWESS curves, and inter-item correlations. The cross-country design enabled comparison across infectious disease cohorts in two Latin American settings with different histories of community

engagement. Reporting followed the COSMIN taxonomy of measurement properties (Mokkink et al. 2010), providing a standardised framework for interpreting and comparing our psychometric findings with those from other validation studies.

Our study had several limitations. The sample size (N = 124) was modest and may limit the precision of some estimates, particularly the EFA. Participants were embedded in long-standing research studies, which likely inflated positive attitudes toward biobanking relative to the general population such that findings may not generalise to individuals without prior research exposure. The Attitudes Scale's internal consistency remained below the 0.70 threshold in Colombia (α = 0.63), indicating residual item heterogeneity that should be addressed through item revision before wider use. The knowledge–self-efficacy association was significant only in the combined sample, limiting evidence for construct validity for the Self-efficacy Scale. Data collection during the COVID-19 pandemic meant that surveys were conducted by telephone in Colombia and in person in Nicaragua, potentially introducing mode effects. The Intentions Scale has only two items, and the Receptivity Scale has a single item, precluding meaningful inter-item reliability assessments.

Implications for practice

Our findings suggest that, while useful, the BANKS-SP requires targeted evaluation and revisions before wider deployment in similar LMIC infectious disease-related biobanking initiatives. We recommend: (1) reviewing the negatively worded Attitudes items to ensure these are well understood by participants for possible rewording as positively framed statements, given that residual item heterogeneity persisted in Colombia even after reverse-coding; (2) reviewing the redundant item pairs (Attitudes items 8 and 10; Self-efficacy items 3 and 7) with biobanking scientists and community members to determine which item to retain and (3) engaging social scientists and biobank participants to assess whether the factor structures identified here adequately represent the theoretical constructs the BANKS-SP is intended to measure. Future validation studies should also prioritise confirmatory factor analysis in larger samples and examine the instrument's performance across diverse cultural and research contexts.

We summarise the policy recommendations that arise from this study's findings in Fig. 3. This and prior studies suggest that informed consent processes do not ensure participant understanding (Maxwell et al. 2023), with important misconceptions about incidental findings, data access, and sample ownership, indicating the need to move from disclosure to verified comprehension. Mismatches between participant expectations and researcher obligations, alongside uncertainty about legal protections, suggest the need for clearer, participant-facing governance and approaches to consent that validate understanding of key issues, such as the communication of incidental findings. Higher levels of knowledge and more positive attitudes in Nicaragua, despite lower levels of formal education, underscore the central role of sustained community engagement in building research literacy and trust. Finally, an uneven understanding of privacy and governance, combined with the lack of validated measurement tools, supports investment in both targeted communication on data protection and robust instruments to assess knowledge, attitudes, and practices, which are essential precursors to equitable, AI-ready biomedical data and sample reuse.

Validated instruments for assessing biobanking knowledge, attitudes, and self-efficacy remain scarce in LMIC infectious disease settings, a gap that will widen as biobank-dependent genomic research, including infectious disease research, expands in these regions. The BANKS-SP offers a promising foundation, but requires careful adaptation and psychometric evaluation when applied outside its original context. Researchers should conduct cognitive interviews before deployment in new settings, verify the scoring direction of negatively worded items, and report item- and scale-level reliability statistics alongside findings. The knowledge gaps identified here, particularly around incidental findings, police access to samples, and sample ownership after donation, highlight concrete areas where communication and consent practices can be strengthened in biobanking initiatives in Colombia, Nicaragua, and similar settings.

Conclusions

This study evaluated the measurement properties of the BANKS-SP biobanking survey, a rigorously developed survey of biobanking knowledge, attitudes, self-efficacy, and intentions, in two LMIC infectious disease cohort settings. We identified both strengths and areas requiring revision before wider deployment. The Self-Efficacy Scale demonstrated adequate reliability and construct validity across both countries, whilst the Attitudes Scale requires targeted item revision, particularly for use in single-country samples. Biobanking attitudes and intentions were broadly positive across both settings, yet knowledge of the legal and governance framework surrounding sample donation was poor, with participants consistently overestimating researchers' obligations to report incidental findings and showing limited awareness of their rights regarding sample ownership and third-party access. These knowledge gaps point to specific, addressable shortcomings in how informed consent and community education are delivered in infectious disease cohort research in the region, and suggest that community engagement programmes should explicitly address participants' rights and the boundaries of researchers' obligations alongside the more commonly covered topics of sample use and confidentiality.

These findings provide a roadmap for revising and further validating the BANKS-SP for use in LMIC infectious disease cohort settings, and identify specific knowledge gaps that should inform community education programmes for cohort participants. Our findings demonstrate that the BANKS-SP provides a useful foundation for assessing community perspectives on biobanking in LMIC ID settings, but that targeted revisions and further validation are required before broader use. By identifying both psychometric issues and concrete knowledge gaps among participants, this study provides actionable guidance to improve biobanking survey instruments, strengthen informed consent processes, and support more transparent engagement with cohort communities.

As biomedical data and sample reuse become foundational to AI-driven research and innovation, where progress depends on access to large, high-quality, and interoperable datasets and sample collections for training and validating models and enabling personalised medicine approaches to addressing infectious disease, investment in adapting, evaluating, and reusing high-quality scales to understand variation in knowledge, attitudes, and practices for biomedical data and sample reuse should become more widespread. Our research group's recent evaluation of the quality of survey development and reporting of measurement properties found that most instruments were not rigorously developed, with limited pilot testing, minimal reporting of measurement properties, and insufficient information to assess validity and reliability (Maxwell et al. 2026). While costly, rigorously developed surveys that

are adapted and evaluated in new populations to assess their measurement properties and understand the quality of inference are central to informed interventions that address community concerns and build understanding and trust in research. Psychometric evaluations are highly technical and often do not produce the desired results, which complicates their use in global health where researchers may depend on rapid survey development and deployment that does not allow for the piloting, psychometric evaluation, and adaptation needed to ensure scales measure what they are intended to measure in the original and novel populations. This barrier to rigorous development and evaluation of surveys on data and sample reuse should be addressed as the pervasiveness of AI applications in biomedical research means that data and sample reuse will become increasingly important, making accurate measurement of community knowledge, attitudes, and preferences a strategic focus for funders, researchers, and other stakeholders.

List of abbreviations

AI Artificial intelligence

BANKS Biobanking Attitudes and Knowledge Survey

BANKS-SP Biobanking Attitudes and Knowledge Survey – Spanish

COSMIN COnsensus-based Standards for the selection of health Measurement INstruments

EFA Exploratory factor analysis

ERC Ethics Review Committee

ICF Informed consent form

ID Infectious disease

IIC Average inter-item correlation

ITT Average item-to-total correlation

LMICs Low- and middle-income countries

LOWESS Locally weighted scatterplot smoothing

MINSA Ministerio de Salud

OSF Open Science Foundation

SD Standard deviation

STROBE Strengthening the Reporting of Observational Studies in Epidemiology

Declarations

Competing interests

Lauren Maxwell, Mahir Bhatt, Harold Suazo Laguna, María Consuelo Miranda Montoya, Luz Leegstra, Jackeline Bravo Chamorro, Jacqueline Mojica Diaz, and Josefina Coloma declare that they have no competing interests.

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Author Contribution

LM conceived the study, wrote the study protocol, and secured funding. LM, MCMM, JC and HSL secured ethics clearance. LL, JC and MCMM oversaw field data collection. JBC, JMD and HSL conducted field data collection and cleaned the data. LM analysed and interpreted the data. LM wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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Data Availability

Anonymised participant-level data are available on openICPSR (/openicpsr/251392). The analysis code is available on GitHub (https://github.com/lamaxwelll/BANKS-SP_Analysis.git).

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Figures

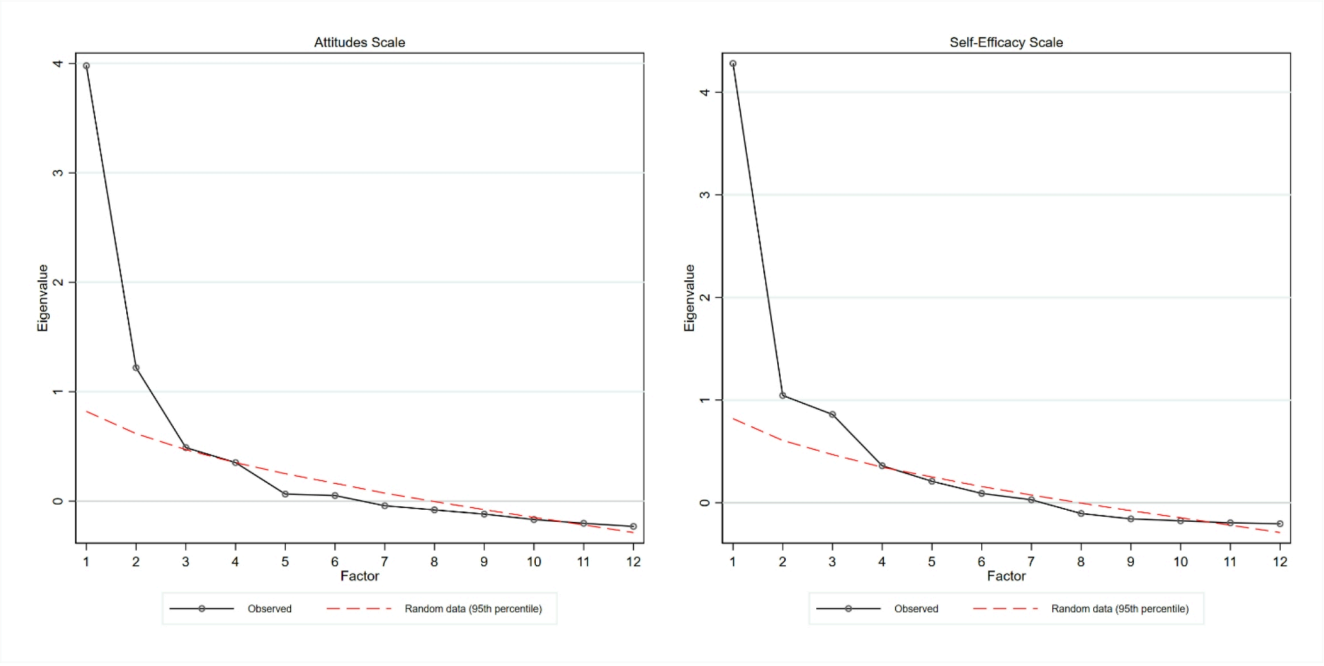


Figure 1

Scree plots with parallel analysis for the BANKS-SP Attitudes and Self-Efficacy Scales (N=124). Black line with open circles: observed eigenvalues from principal axis factoring. Dashed red line: 95th percentile of eigenvalues from 500 random datasets of the same sample size and number of items. Factors are retained while the observed eigenvalue exceeds the random value; comparisons below zero are not informative.

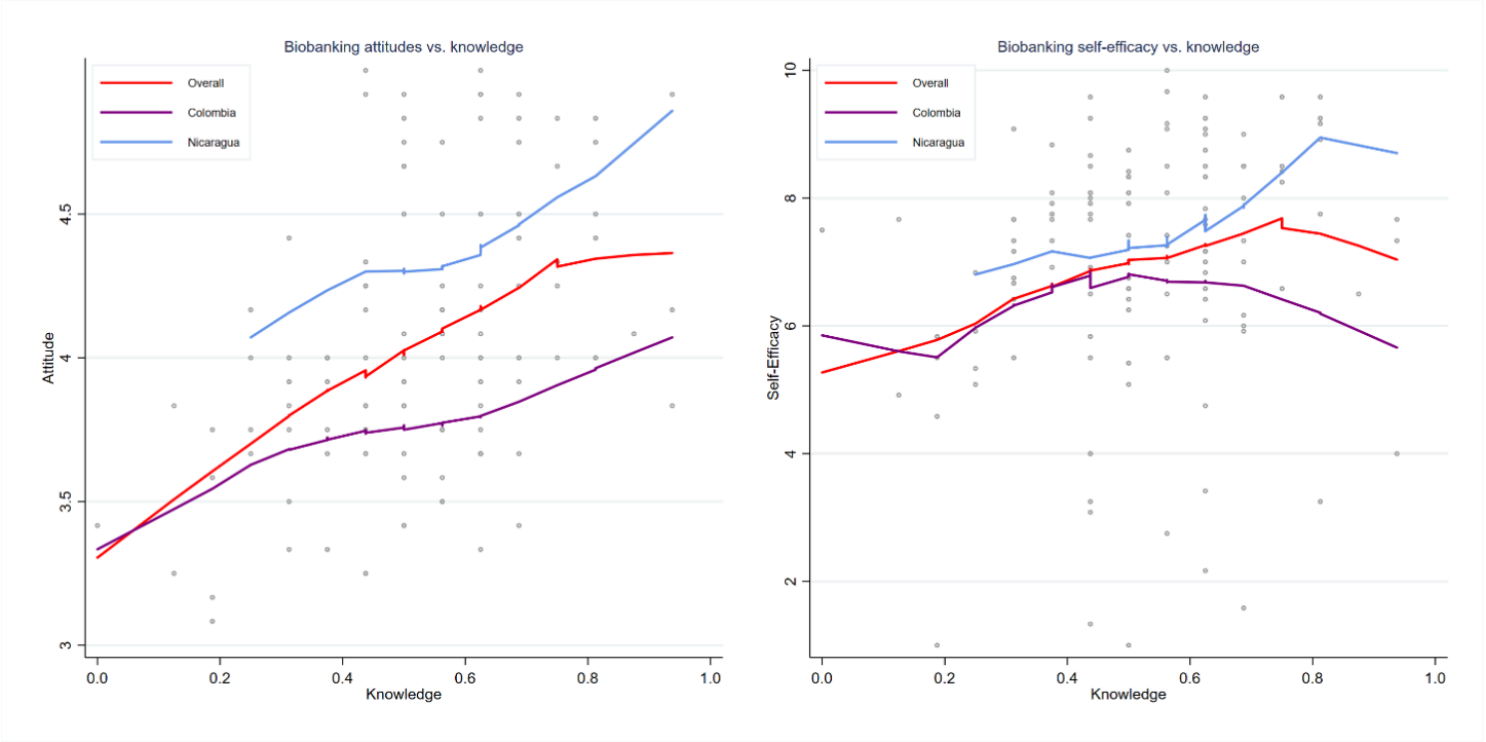


Figure 2

LOWESS curves comparing participant-level mean responses to the BANKS-SP Attitudes, Self-Efficacy, and Knowledge Scales with a scatterplot of mean responses for the related scales (Colombia N=64; Nicaragua N=60).

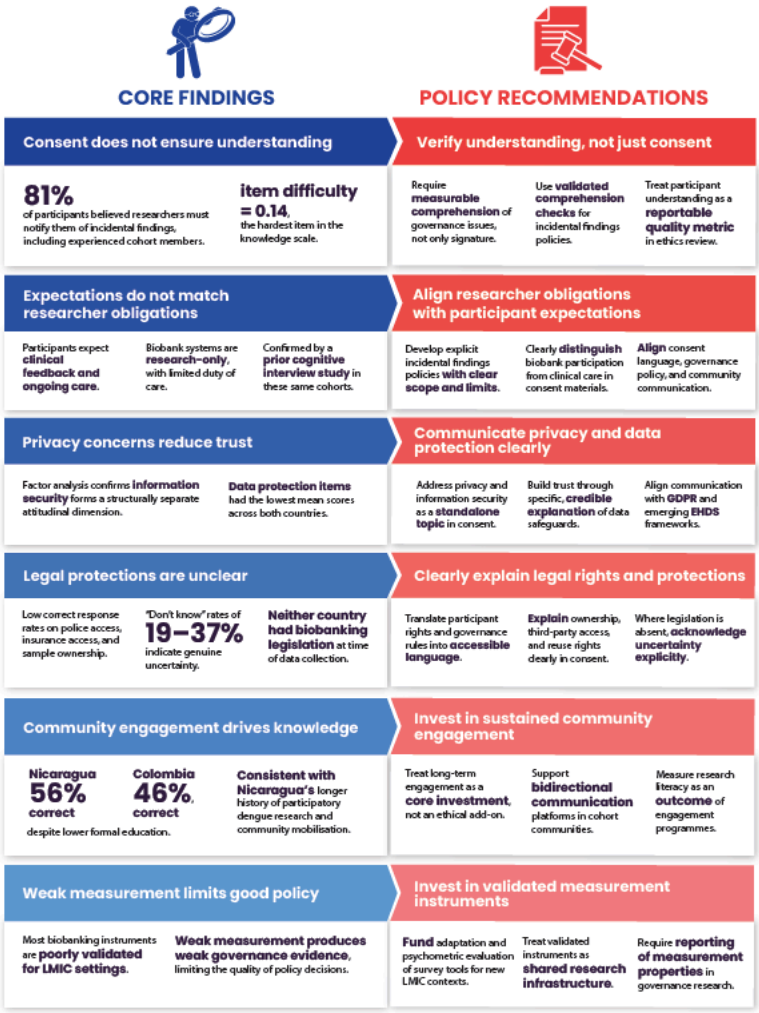


Figure 3

Core findings and corresponding policy recommendations

Supplementary Files

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