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Identifying Vaccine-hesitant Subgroups in the Western Pacific: A Latent Class Analysis

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Abstract

Background: Vaccine hesitancy has seriously compromised the COVID-19 vaccine roll-out across the Western Pacific; nevertheless, evidence-based recommendations that account for the heterogeneity of vaccine-hesitant populations in this region remain lacking. To help design customized vaccine communication strategies, we sought to investigate the profile of the vaccine-hesitant populations in Cambodia, Japan, Lao PDR, Malaysia, Mongolia, Papua New Guinea, Philippines, Republic of Korea, and Viet Nam.

Methods: Using 16,408 survey responses from an international survey distributed in 2021 and 2022, we identified hidden subgroups by conducting latent class analysis (LCA) and examined their vaccine acceptance and booster uptake by using Ordinary Least Square (OLS) regressions.

Findings: Our LCA approach identified six classes: college students, distrusters of health care providers (HCPs), stay-at-home mothers, the elderly, compliant pragmatists, and general working population. Booster uptake were significantly low in two groups: college students [13 percentage points; 95% CI -0.21 to -0.05] and HCP distrusters [8 percentage points; 95% CI -0.15 to -0.01]; these groups' acceptance were also similarly low. Stay-at-home mothers' acceptance and uptake were comparable, but this group took a large portion of vaccine-hesitant people in the Philippines. The profiles of the vaccine-hesitant populations in each country were compared and categorized into four groups, depending on the composition of classes that account for the unvaccination population.

Interpretation: The results of this study suggest that drivers of vaccine hesitancy may vary by country and indicate that each country needs a customized strategy that reflects the profile of its vaccine-hesitant population. The proposed recommendations for each country can identify the target population for designing effective vaccine communication strategies.

Introduction

During the COVID-19 pandemic, heightened vaccine scepticism has become a serious public health challenge that undermines vaccine uptake in the Western Pacific region (WPR) and around the world.[1–6] Vaccine hesitancy, which includes refusal and delay in acceptance of recommended vaccines, existed before the COVID-19 pandemic and was declared among the top global public health challenges by the World Health Organization (WHO) in 2018.[7,8] However, the unprecedently rapid pace of COVID-19 vaccine development further stimulated fear and suspicion toward the vaccines.[9] Widespread vaccine misinformation increased the prevalence of mistrust in public health recommendations[10,11] and made people rely on unproven treatments for COVID-19, such as drinking alcohol or methanol, instead of vaccination.[12,13]

To design effective interventions for tackling vaccine hesitancy, it is essential to carefully identify the target segments of people who are most hesitant to vaccinate in the population. Tailored messages and

initiatives can specifically tackle the root cause of vaccine hesitancy and leverage people's needs and motivations.[14,15] Therefore, identifying the characteristics that are associated with vaccine acceptance and uptake in various circumstances has been an important research focus for many vaccine studies. In current knowledge, trust in government and the medical establishment, risk perception, and age are generally considered as salient factors of vaccine decisions in many different contexts.[16–23]

However, countries have diverse histories of vaccine hesitancy and need customized interventions to promote COVID-19 vaccination.[24,25] For example, in the Philippines, where more than a hundred children died from the side effects of a Sanofi Pasteur vaccine against Dengue fever, Dengvaxia, which was especially dangerous for children who had never been infected with Dengue,[26] vaccine hesitancy is likely to be strongly associated with parents and females.[27] As another example, widespread distrust in the central government exists in the society of Papua New Guinea (PNG), which consists of thousands of tribes commanded by big men or chiefs.[28] Under such circumstances, it is difficult to disseminate reliable information about COVID-19, and compliance with health recommendations from the government may be extremely low. Similarly, in a study conducted in New Zealand, vaccine-hesitant people were more likely to be younger, less educated, and females,[29] while another study focusing on Japanese people reported that vaccine hesitancy was associated with being female, low socioeconomic status, psychological distress, and solidarity.[30] As such, countries have diverse profiles of vaccine-hesitant people. However, the current state of knowledge in vaccine research is largely based on single-country studies or focused on few developed countries in the region, leaving other countries understudied.[31] In particular, evidence that accounts for the cultural and sociodemographic diversity has been in serious scarcity in the WPR[29,32] despite the reported challenges in vaccine roll-outs across the region.[5]

This study aims to identify population segments and compare their vaccine acceptance and uptake in nine countries in the WPR – Cambodia, Japan, Lao PDR, Malaysia, Mongolia, Papua New Guinea (PNG), Philippines, Republic of Korea (ROK), and Viet Nam – by using latent class analysis (LCA) and regression. LCA enables a more sophisticated interpretation of data by dividing the study sample into subgroups within which individuals share highly correlated categorical variables and helps us study the unobserved heterogeneity within typical sociodemographic categories.[33] For example, people who underestimate the risk of COVID-19 are less likely to accept COVID-19 vaccines,[16] but their willingness to vaccinate may also vary by the extent that they take the known side effects of the vaccines seriously. Using this method, we attempt to identify vaccine-hesitant subgroups and map out the profiles of the subgroups in the participating countries. We then conclude by providing customized strategies for promoting vaccination based on the differing profiles of vaccine-hesitant people.

Methods

Study design and participants

This study used 16,408 responses collected in nine countries in the WPR. The survey was fielded to investigate the status of vaccine confidence and uptake among adults aged over 18 across the WPR based on two rounds of data collection: between June 11th and August 25th, 2021 (round 1), and between May and June 2022 (round 2). The participants completed the survey either online or by telephone interviews (Table S1).

The initial dataset included 17,506 respondents. We excluded a total of 1,098 respondents (6.27%) with missing values in education (448 respondents) and age (509 respondents), gender (89 respondents), or employment status (52 respondents). The final sample included a total of 16,408 responses: 8,500 responses from survey wave 1 and 7,908 responses from survey wave 2 (Table S1).

Outcomes and covariates

We examined two outcome variables: COVID-19 vaccine acceptance (round 1) and booster vaccine uptake (round 2). The acceptance variable was a binary measure using a five-point Likert scale. The question was: "*As the new Coronavirus (COVID-19) vaccines become available, would you accept the vaccine? - For yourself?*" This measure was dichotomized into 1, if respondents answered "definitely yes," and 0 if they answered "unsure but leaning towards yes," "don't know/prefer not to say," "unsure but leaning towards no," or "definitely no." This cut-off point was determined due to the majority of responses being "definitely yes" (60.51%).

The booster uptake variable was coded as one if respondents had received three or more vaccine doses. Otherwise, they were coded as 0.

We used ten categorical variables known to be associated with vaccine hesitancy to identify latent classes. These included trust in local health care providers (HCPs), age, gender, educational attainment, five types of health-protective behaviours, and employment status.[22,29,30,34] Trust in HCPs was measured using the following questions: "*How much do you trust the local health care providers who would give you a COVID-19 vaccine? Would you say you trust them?*" This was dichotomized into 1 if respondents agreed or strongly agreed and 0 if otherwise. The health-protective behaviour variables had a value of 1 if respondents answered that they were doing the following a lot or a little more regularly compared to before the COVID-19 pandemic: mask-wearing, washing hands, covering nose or mouth when sneezing or coughing, having guests in house, and gathering socially in large groups. The employment status variable included five categories: employees, students, retirees, stay-at-home parents, and others including the unemployed.

Statistical analysis

We conducted LCA to identify subgroups of survey respondents based on the observed characteristics and regression analyses to statistically confirm the differences in vaccine acceptance among the identified subgroups. Assuming that there are variations within each of the observed categories,[35] a typical LCA process iteratively classifies the sample into a given number, calculates the model fit, and compares the performance by gradually increasing the number of classes to find the optimal number of

classes.[33] We used the maximum likelihood estimation with the Expectation Maximum (EM) algorithm for estimating the model fit. Given that the allocation of classes in the LCA procedures is random, we estimated the model 30 times in each iteration to achieve stability in the results. The final LCA model was selected by considering both the interpretability of the results and the following three metrics: the Bayesian Information Criterion (BIC), as the primary score, the Akaike Information Criterion (AIC), and entropy.[36,37] More specifically, we began with one class model and then increased the number of classes until we found an elbow of points in the fit indices or stopped estimating when identified classes were conceptually not plausible.[38] As a result, we finally selected the six-group model for the first round, as there was a significant decrease in the decreasing rate in the BIC score at the point of six subgroups. Whereas there was no clear “elbow” of points in the second round. Thus, we selected the five-group model for this round because additional classes from this point were not clearly defined by the used variables. LCA procedures were conducted separately for each survey round, as there were significant changes in people’s social distancing behaviours among the public between the two data collection periods (Figure S1).

We then used ordinary fixed-effects least square regression models to estimate the differences in the acceptance and uptake of COVID-19 vaccines among the identified subgroups. In these models, unobserved country-level variations were fixed, and standard errors were clustered at the country level.

LCA was conducted by using R (version 4.2.0) and the poLCA package, while regression analyses were based on STATA 17.0. Statistical differences among the identified subgroups were determined based on two-tailed tests and a 95% confidence level.

Results

Latent Class Analysis

Table 1 presents the characteristics of the study sample. Among 16,408 respondents in the data, 60.51% in the first round answered that they would definitely accept COVID-19 vaccines, and 52.16% had received three or more doses in the second round. Most respondents trusted local HCPs (84.14%). 45.14% of respondents agreed that the risk of COVID-19 had been somehow exaggerated.

Table 1
Descriptive Statistics

Variables	All Respondents	Round 1	Round 2
Number of observations	16,408	8,500	7,908
% Vaccine acceptance	-	60.51	-
% Not vaccinated	-	-	9.19
% Booster vaccination	-	-	52.16
% Trust local HCPs	84.14	81.55	86.91
% COVID-19 is exaggerated	45.14	44.36	45.97
% Female	49.29	49.14	49.46
Age			
% 18–24	18.30	18.29	18.30
% 25–34	26.00	25.48	26.56
% 35–44	21.89	21.49	22.32
% 45–54	16.50	15.60	17.46
% 55+	17.31	19.13	15.36
Education			
% Primary or lower	15.02	15.09	14.95
% Secondary	39.35	39.88	38.77
% Vocational post-secondary	9.09	9.86	8.26
% Tertiary	32.09	30.41	33.90
% Master+	4.45	4.75	4.12
Health-protective behaviors			
% Mask wearing	78.49	81.99	74.72
% Washing hands	80.14	82.54	77.57
% Cover when sneezing	51.32	76.64	24.10
% Having guests	37.38	14.91	61.55
% Gathering	38.65	16.81	62.11
Employment status			
% Employed	64.60	62.00	67.40

Variables	All Respondents	Round 1	Round 2
% Students	7.08	7.32	6.82
% Retirees	4.48	5.19	3.72
% Stay-at-home parents	12.24	12.66	11.79
% Unemployed or others	11.60	12.84	10.28

[Table 1 here]

Figure 1 compares model fit statistics by the number of classes, ranging from two to nine subgroups (see Figure S2 for the distribution of classes). The six-group model yielded (1) *college students* (738 in round 1, 831 in round 2), (2) *HCP distrusters* (641 in round 1, 809 in round 2), (3) *stay-at-home mothers* (906 in round 1, 1740 in round 2), (4) *elderly* (1,330 in round 1, 612 in round 2), and (5) *compliant pragmatists* (730 in round 2), *and* (6) *general working population* (4150 in round 1, 3,920 in round 2). *College students* represent students who are between 18 and 24. *HCP distrusters* are people who are likely to distrust health care providers and do not follow other public health recommendations, including mask-wearing, washing hands, covering noses when sneezing. *Stay-at-home mothers* are stay-at-home parents who are female. *The elderly* means those who are aged 55 or older. *Compliant pragmatists* are defined as people who tend to selectively follow public health recommendations – i.e., keeping personal protections while ignoring social distancing rules, such as having guests at home or attending social gatherings. Lastly, the *general working population* group represents employees who are without distinct characteristics in demographics. The five-group model for the second round did not include the *compliant pragmatists* group, reflecting that, in the second round, people tended to have more social interactions, including having guests and social gathering, while keeping up their personal protections against COVID-19 (Figure S1).

[Figure 1 here]

Figure 2 compares the characteristics of the six latent classes in the two survey rounds. Each sample yielded similar classes, except one group, *compliant pragmatists*, which was only identified in the first round. The first group was *college students*, of which more than 74% were identified as students and more than 96% were between ages 18 and 24 in both rounds. The second group includes people who are more likely to *distrust HCPs*. While 84.14% of the sample answered that they trust local HCPs, this group had only 61% and 76% who trusted local HCPs in each round, respectively. This group also showed the lowest percentages of engaging in personal health-protective behaviors (*i.e.*, mask wearing, washing hands, covering nose when sneezing, and physical distancing). The third group consists of *stay-at-home mothers*, among which 89–93% were stay-at-home parents, and 92–94% were female across the two rounds. The fourth group, *the elderly*, consists of people aged 55 years or older. The majority of this group tends to trust HCPs (88–96%) and followed all types of health-protective behaviors. The fifth group, *compliant pragmatists*, was only identified in the first round. People in this group tend to follow personal

protections but maintained their social interactions (*i.e.*, having guests at home and gatherings). For round 1, 54% of respondents in this group answered that the risk of COVID-19 is exaggerated. The last group is labeled as *general working population*, who represent the largest proportion of the study sample. Eighty-nine percent of this group were employed. This group contains the remaining respondents who do not belong to any of the following groups.

[Figure 2 here]

Vaccine Acceptance and Uptake

Figure 3 statistically examines the differences in vaccine acceptance and uptake among the subgroups in all countries (See Table S2 for the full regression outputs). Compared with *general working population* as the reference category, the likelihood of accepting COVID-19 vaccines was 14 percentage points higher among *elderly* class [95% CI 0.06 to 0.22] and 5 percentage points higher among the *compliant pragmatists* class [95% CI 0.00 to 0.10] (Fig. 3A). However, the likelihood of accepting COVID-19 vaccines was significantly lower among *college students* by 8 percentage points [95% CI -0.15 to -0.01] and lower among HCP distrusters by 15 percentage points [95% CI -0.28 to -0.03]. The likelihood of getting a booster shot was also significantly lower in these groups: 13 percentage points lower among college students [95% CI -0.21 to -0.05] and 8 percentage points lower among HCP distrusters [95% CI -0.15 to -0.01]. Stay-at-home mothers also had a lower likelihood of accepting a COVID-19 vaccine and getting a booster shot; however, these differences were not statistically significant.

[Figure 3 here]

The Composition of Vaccine-hesitant Population by Country

Figures 4 and 5 present how the profile of vaccine-hesitant populations varies across the WPR by deciphering the distribution of latent classes into the nine countries (see Figure S2 for more detail of how to read the radar charts). First, Fig. 4 categorizes the countries into four types, along with the composition of vaccine-hesitant respondents in round 1. In the first category (red area), including PNG, there were high proportions of HCPs distrusters and those who tend to underestimate the risk of COVID-19. The second category includes the Philippines, where the proportion of stay-at-home mothers accounted for large portion of vaccine-hesitant respondents. The third group includes four countries where the proportion of respondents who tend to distrust local HCPs and think that the government was doing a poor job in responding to COVID-19 was high among vaccine-hesitant respondents: Japan, Lao PDR, Malaysia, and the ROK. In the remaining countries, including Cambodia, Mongolia, and Viet Nam, the *general working population* made up the largest proportion of the sample.

Similarly, Fig. 5 highlights stay-at-home mothers and HCP distrusters and categorizes countries into three groups, depending on the profile of people who had not gotten a booster vaccine dose in the second round. The first group includes Cambodia, Japan, Lao PDR, Malaysia, and PNG, where HCP distrusters represented the largest proportion of respondents who had not gotten a booster shot. The second category is the Philippines. Similar to the vaccine-hesitant respondents in the first round, this country's

respondents without getting a booster shot had a high portion of stay-at-home mothers. The last group was identified as countries where there were no distinct risk groups found in the second round, being Mongolia, the ROK, and Viet Nam.

[Figure 4 and Fig. 5 here]

Discussion

This study aimed to examine the profile of vaccine-hesitant people in nine countries in the WPR by conducting LCA. Our analysis identified six latent subgroups:*college students*, *HCP distrusters*, *stay-at-home mothers*, *the elderly*, and *compliant pragmatists, and general working population*, among which three groups - *college students*, *HCP distrusters*, *stay-at-home mothers* – were less likely to accept COVID-19 vaccines and less likely to receive a booster vaccine shot than the other groups. Mapping out variations in the profiles of vaccine-hesitant people across the region, we categorized the countries into several categories to provide more tailored recommendations for addressing vaccine hesitancy.

The overall discussion of this study contributes to the vaccine literature by demonstrating the diversity in the profile of vaccine-hesitant populations across WPR using a subgroup approach. It has become almost axiomatic that vaccine hesitancy is a multidimensional problem;[24,25] yet, many countries in the WPR have been underrepresented in the literature.[29,32] The diverse profiles of vaccine-hesitant people in the WPR illustrated in Figs. 3 and 4 confirm that vaccine hesitancy in the region reflects the complex and diverse historical, cultural, and political landscapes of each country. There is a need for more data and research on countries that are still underrepresented in the literature.

The study findings can inform international and national policymakers in customizing interventions to tackle vaccine hesitancy. Figures 3 and 4 imply that there are three primary target groups on that WP countries should focus. First, in countries where HCP distrusters took a large portion of people who had not gotten a booster COVID-19 vaccine, especially in Cambodia, Japan, Lao PDR, Malaysia, and PNG, rebuilding public confidence in vaccines, the health care system, and the government is necessary to promote COVID-19 vaccines. Governments in these countries should make extraordinary efforts to be transparent, share timely information, and engage the public when promoting vaccines.[39] Moreover, causes of mistrust in institutions are notably contextual and vary by country. For example, mistrust in HCPs is likely to be rooted in the fragmented political system in PNG, where the political mistrust in the central government is generally high among thousands of tribes,[28] while, in Japan, it may reflect the historical vaccine hesitancy developed from the Measles, Mumps, and Rubella (MMR) vaccine scandal in the 1990s and the human papillomavirus (HPV) scandal in 2013.[40] Therefore, additional efforts to understand the root causes and histories of mistrust should be in tandem with the efforts to rebuild trust in these countries.

Second, the Philippines had a profile of vaccine-hesitant people that is somewhat distinct from that of other countries, where *stay-at-home mothers* represented a large portion of people without a booster

vaccine shot. More than one hundred children died in the Philippines as a consequence of the Dengvaxia scandal, resulting from the inappropriate administration of vaccines against Dengue fever.[26,27] Prior studies found that low-risk perception of COVID-19 and concerns over vaccine safety and side effects are highly influential barriers for parents in vaccinating their children.[41–43] Furthermore, recent studies observed that social media information has a growing impact on the vaccination choices of mothers and women of childbearing age.[42,44] Thus, measures to increase mothers' understanding of the safety of vaccines may be beneficial in the Philippines. In our case, *stay-at-home mothers* were more likely than other groups to believe that the government was not responding effectively to the COVID-19 pandemic, but to have trust in local HCPs. Therefore, vaccine-related messages or campaigns involving local HCPs may be a more effective means of combating vaccine hesitancy in the Philippines.

Lastly, in Mongolia, the ROK, and Viet Nam the general working population represented the largest proportion of the vaccine-hesitant population. As explained, this subgroup was the least vaccine-hesitant, among the identified subgroups, with a higher level of trust in local HCPs. Moreover, these countries have not suffered vaccine-related scaldals and have a higher income-level than other participating countries. The vaccination rate has also been sharply growing over the past year in these countries.[45] Therefore, these countries should pursue policy efforts that maintain the current status of public trust in government and medical establishments. Meanwhile, they could focus on consistent messaging from public health authorities while continuously monitoring possible risk factors for vaccine hesitancy, such as the spread of misinformation, instead of instituting a targeted strategy or campaign.

Our findings imply the existence of unobserved heterogeneity in the phenomenon of vaccine hesitancy conditional on typical demographic characteristics and further stress that continuous efforts should be made to identify and persuade hidden risk groups. Utilizing the LCA approach helped shed light on these under-researched patterns and further elaborated the profile of risk groups with low vaccine acceptance and uptake in each studied country. Our suggested recommendations for each country category may help policymakers develop customized vaccine communication strategies. More investigations and research are needed to develop more tailored interventions focusing on specific target groups. Only few empirical studies have been done focusing on developing countries and underrepresented populations, such as racial and ethnic minorities, in the WPR.[32] Future studies should focus on these populations that have not received sufficient attention in the scientific community.

Limitations

This study has the following limitation. Our LCA approach estimated the maximum likelihood function at the regional level and then examined distributions at the national level. Therefore, the number of identified subgroups might not maximize the likelihood function for each country and may vary by country. Despite this limitation, the international comparison in this paper still provides useful insight on how to vaccine promotion strategies can be tailored based on the profile of vaccine-hesitant subgroups in the country by generating comparable latent classes.

Declarations

Data Availability

The raw data that support the findings of this study are not available due to the sensitive nature of the data.

Declaration of Interests

One of the authors has been funded by multiple pharmaceutical companies, such as Merck and Glaxo Smith Kline, however, these funders had no influence on the conceptualization, data collection, analysis, and writing of this paper. Otherwise, the authors have no conflicts of interest to declare.

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Author Contribution

YC and LL conceptualised and designed the study. YC, KL, JW, HL, and LL accessed the data. YC conducted the data analysis. YC and LL contributed to manuscript writing. YC, KL, JW, HL, and LL contributed to the interpretation of the results and critically reviewed for drafting of the manuscript.

References

1. Ball P, Maxmen A. The Epic Battle Against Coronavirus Misinformation and Conspiracy Theories. *Nature* 2020; **581**: 371–4.
2. Krause NM, Freiling I, Beets B, Brossard D. Fact-Checking as Risk Communication: The Multi-Layered Risk of Misinformation in Times of COVID-19. *J Risk Res* 2020; **23**: 1052–9.
3. Dror A, Eisenbach N, Taiber S, *et al.* Vaccine Hesitancy: The Next Challenge in the Fight Against COVID-19. 2020. DOI:10.21203/rs.3.rs-35372/v1.
4. Larson HJ, Broniatowski DA. Why Debunking Misinformation Is Not Enough to Change People's Minds About Vaccines. *Am J Public Health* 2021; **111**: 1058–60.
5. World Health Organization. Regional Office for the Western Pacific. Enhancing Acceptance and Demand for Vaccination in the Western Pacific Region: A Guide for Programme Managers on

Strategies for Assessing and Addressing Hesitancy and Sustaining Vaccination Uptake. e, 2021 https://apps.who.int/iris/handle/10665/340353.

6. Ghaznavi C, Yoneoka D, Kawashima T, *et al.* Factors associated with reversals of COVID-19 vaccination willingness: Results from two longitudinal, national surveys in Japan 2021-2022. *Lancet Reg Health - West Pac* 2022; : 100540.
7. MacDonald NE, Eskola J, Liang X, *et al.* Vaccine Hesitancy: Definition, Scope and Determinants. *Vaccine* 2015; **33**: 4161–4.
8. The World Health Organization (WHO). Thirteenth General Programme of Work 2019-2023. The World Health Organization, 2018.
9. Poland GA. Tortoises, hares, and vaccines: A cautionary note for SARS-CoV-2 vaccine development. *Vaccine* 2020; **38**: 4219–20.
10. Roozenbeek J, Schneider CR, Dryhurst S, *et al.* Susceptibility to Misinformation About COVID-19 Around the World. *R Soc Open Sci* 2020; **7**: 201199.
11. Lee JJ, Kang K-A, Wang MP, *et al.* Associations Between COVID-19 Misinformation Exposure and Belief With COVID-19 Knowledge and Preventive Behaviors: Cross-Sectional Online Study. *J Med Internet Res* 2020; **22**: e22205.
12. Coleman A. 'Hundreds Dead' Because of Covid-19 Misinformation. BBC News. 2020; published online Aug 12. https://www.bbc.com/news/world-53755067 (accessed June 8, 2022).
13. Islam MS, Sarkar T, Khan SH, *et al.* COVID-19–Related Infodemic and Its Impact on Public Health: A Global Social Media Analysis. *Am J Trop Med Hyg* 2020; **103**: 1621–9.
14. Boey L, Roelants M, Vandermeulen C. Increased vaccine uptake and less perceived barriers toward vaccination in long-term care facilities that use multi-intervention manual for influenza campaigns. *Hum Vaccines Immunother* 2021; **17**: 673–80.
15. MacDonald L, Cairns G, Angus K, de Andrade M. Promotional Communications for Influenza Vaccination: A Systematic Review. *J Health Commun* 2013; **18**: 1523–49.
16. Hilverda F, Vollmann M. The Role of Risk Perception in Students' COVID-19 Vaccine Uptake: A Longitudinal Study. *Vaccines* 2021; **10**: 22.
17. Rane MS, Kochhar S, Poehlein E, *et al.* Determinants and Trends of COVID-19 Vaccine Hesitancy and Vaccine Uptake in a National Cohort of US Adults: A Longitudinal Study. *Am J Epidemiol* 2022; **191**: 570–83.
18. Viswanath K, Bekalu M, Dhawan D, Pinnamaneni R, Lang J, McLoud R. Individual and Social Determinants of COVID-19 Vaccine Uptake. *BMC Public Health* 2021; **21**: 818.
19. Rikitu Terefa D, Shama AT, Feyisa BR, *et al.* COVID-19 Vaccine Uptake and Associated Factors Among Health Professionals in Ethiopia. *Infect Drug Resist* 2021; **Volume 14**: 5531–41.
20. Burch AE, Lee E, Shackelford P, Schmidt P, Bolin P. Willingness to Vaccinate Against COVID-19: Predictors of Vaccine Uptake Among Adults in the US. *J Prev* 2022; **43**: 83–93.

21. Memon KN, Ariser KN, Shah R, Siddiqui MI, Chouhan S, Almas S. Community Insights Regarding COVID-19 Vaccine Uptake Intention versus Hesitancy. *J Pharm Res Int* 2021; : 108–17.
22. Prickett KC, Chapple S. Trust in Government and Covid-19 Vaccine Hesitancy. *Policy Q* 2021; **17**. DOI:10.26686/pq.v17i3.7135.
23. Jennings W, Stoker G, Bunting H, *et al.* Lack of Trust, Conspiracy Beliefs, and Social Media Use Predict COVID-19 Vaccine Hesitancy. *Vaccines* 2021; **9**: 593.
24. Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger J. Vaccine Hesitancy: An Overview. *Hum Vaccines Immunother* 2013; **9**: 1763–73.
25. Larson H. Stuck: How Vaccine Rumors Start - And Why They Don't Go Away. New York, NY: Oxford University Press, 2020.
26. Vergara RJD. Social trauma as a contributory factor in Filipino's vaccine hesitancy. *J Public Health* 2021; **43**: e745–6.
27. Brackstone K, Marzo RR, Bahari R, Head MG, Patalinghug ME, Su TT. COVID-19 vaccine hesitancy and confidence in the Philippines and Malaysia: A cross-sectional study of sociodemographic factors and digital health literacy. *PLOS Glob Public Health* 2022; **2**: e0000742.
28. Connell J. COVID-19 and Culture in Papua New Guinea. Failing to Meet the Challenges of Diversity? In: Akhtar R, ed. Coronavirus (COVID-19) Outbreaks, Vaccination, Politics and Society. Cham: Springer International Publishing, 2022: 33–44.
29. Prickett KC, Habibi H, Carr PA. COVID-19 Vaccine Hesitancy and Acceptance in a Cohort of Diverse New Zealanders. *Lancet Reg Health - West Pac* 2021; **14**: 100241.
30. Okubo R, Yoshioka T, Ohfuji S, Matsuo T, Tabuchi T. COVID-19 Vaccine Hesitancy and Its Associated Factors in Japan. *Vaccines* 2021; **9**: 662.
31. Vaccines don't save lives, vaccination does. *Lancet Reg Health - West Pac* 2021; **6**: 100099.
32. Robinson E, Jones A, Lesser I, Daly M. International estimates of intended uptake and refusal of COVID-19 vaccines: A rapid systematic review and meta-analysis of large nationally representative samples. *Vaccine* 2021; **39**: 2024–34.
33. Hagenaars JA, McCutcheon AL, editors. Applied Latent Class Analysis. Cambridge; New York: Cambridge University Press, 2002.
34. Turhan Z, Dilcen HY, Dolu İ. The mediating role of health literacy on the relationship between health care system distrust and vaccine hesitancy during COVID-19 pandemic. *Curr Psychol* 2022; **41**: 8147–56.
35. Ruscio J, Ruscio AM. Categories and Dimensions: Advancing Psychological Science Through the Study of Latent Structure. *Curr Dir Psychol Sci* 2008; **17**: 203–7.
36. Kreuter F, Yan T, Tourangeau R. Good Item or Bad—Can Latent Class Analysis Tell?: The Utility of Latent Class Analysis for the Evaluation of Survey Questions. *J R Stat Soc Ser A Stat Soc* 2008; **171**: 723–38.

37. Jung T, Wickrama KAS. An Introduction to Latent Class Growth Analysis and Growth Mixture Modeling: Latent Trajectory Classes. *Soc Personal Psychol Compass* 2008; **2**: 302–17.
38. Nylund-Gibson K, Choi AY. Ten Frequently Asked Questions About Latent Class Analysis. *Transl Issues Psychol Sci* 2018; **4**: 440–61.
39. OECD. Enhancing public trust in COVID-19 vaccination: The role of governments. 2021 https://www.oecd.org/coronavirus/policy-responses/enhancing-public-trust-in-covid-19-vaccination-the-role-of-governments-eae0ec5a/#contactinfo-d7e4201.
40. Tanaka Y, Ueda Y, Yoshino K, Kimura T. History repeats itself in Japan: Failure to learn from rubella epidemic leads to failure to provide the HPV vaccine. *Hum Vaccines Immunother* 2017; **13**: 1859–60.
41. Waring ME, Pagoto SL, Rudin LR, *et al.* Factors Associated with Mothers' Hesitancy to Receive a COVID-19 Vaccine. *J Behav Med* 2022; published online Jan 4. DOI:10.1007/s10865-021-00268-0.
42. Horiuchi S, Sakamoto H, Abe SK, *et al.* Factors of Parental COVID-19 Vaccine Hesitancy: A Cross Sectional Study in Japan. *PLOS ONE* 2021; **16**: e0261121.
43. Thapar R, Kumar N, Surendran P, *et al.* Vaccine Hesitancy Among Mothers of Under-Five Children in Coastal South India: A Facility-Based Cross-Sectional Study. *F1000Research* 2021; **10**: 186.
44. Argyris YA, Kim Y, Roscizewski A, Song W. The Mediating Role of Vaccine Hesitancy Between Maternal Engagement with Anti- and Pro-Vaccine Social Media Posts and Adolescent HPV-Vaccine Uptake Rates in the US: The Perspective of Loss Aversion in Emotion-Laden Decision Circumstances. *Soc Sci Med* 2021; **282**: 114043.
45. The New York Times. Covid-19 Vaccine Tracker: Latest Updates. 2022. https://www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html (accessed July 12, 2022).

Figures

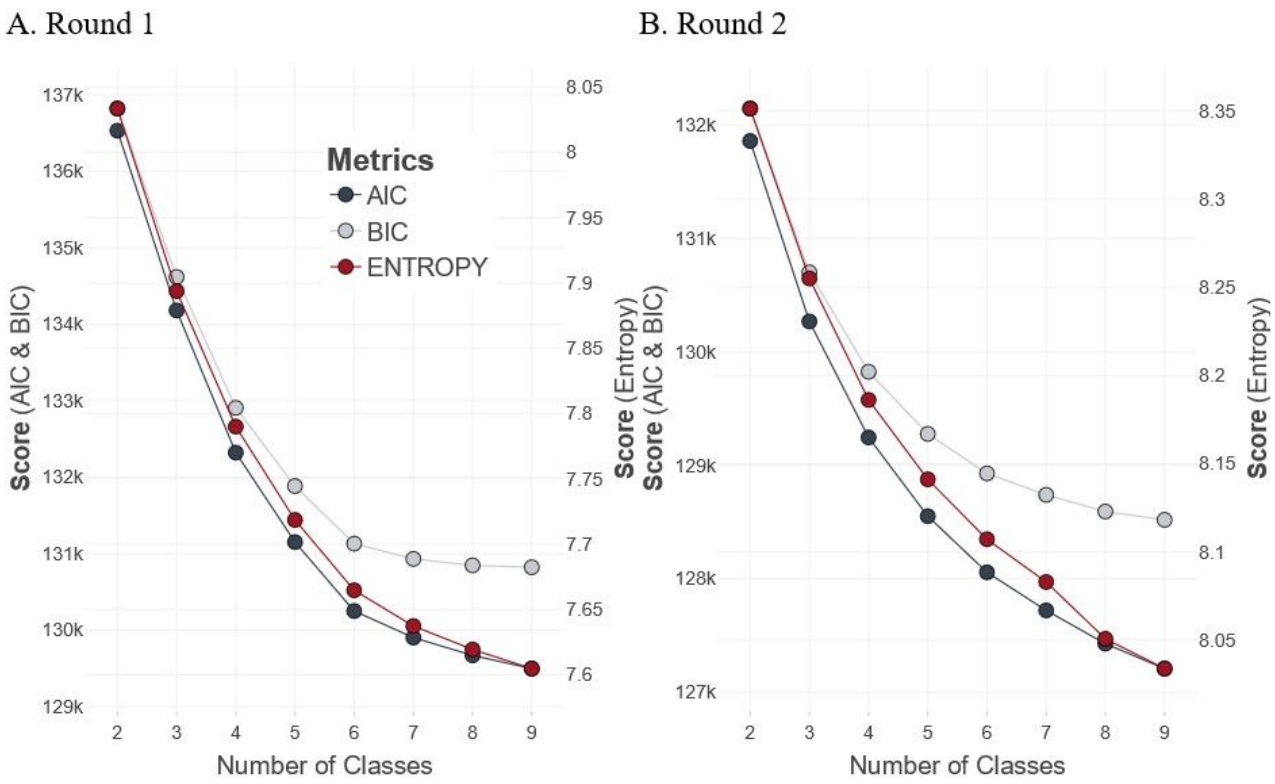

Figure 1

Scree Plots of Latent Class Analysis.

Note. Markers indicate the scores of fit indices. The Y-axis on the left maps out the AIC and BIC scores, while the other is for the entropy score.

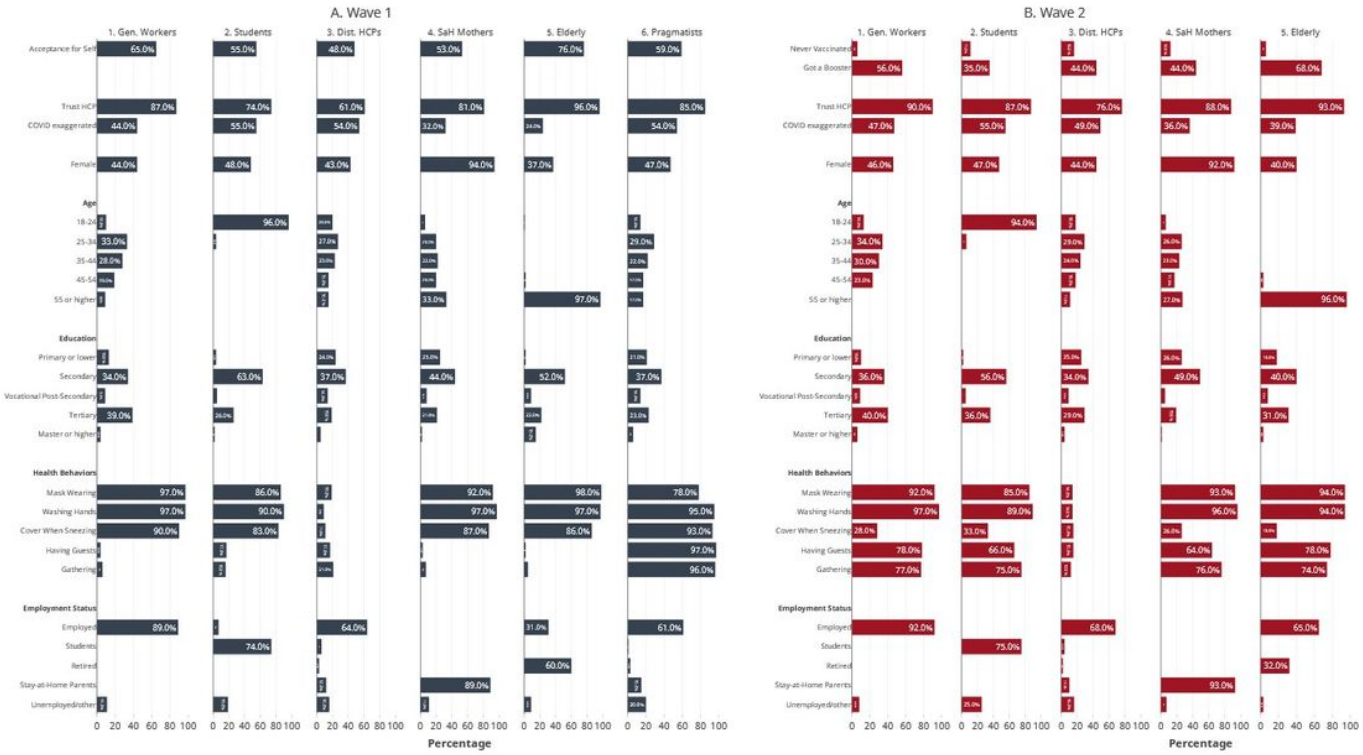

Figure 2

Sample Characteristics by Latent Class and by Survey Round.

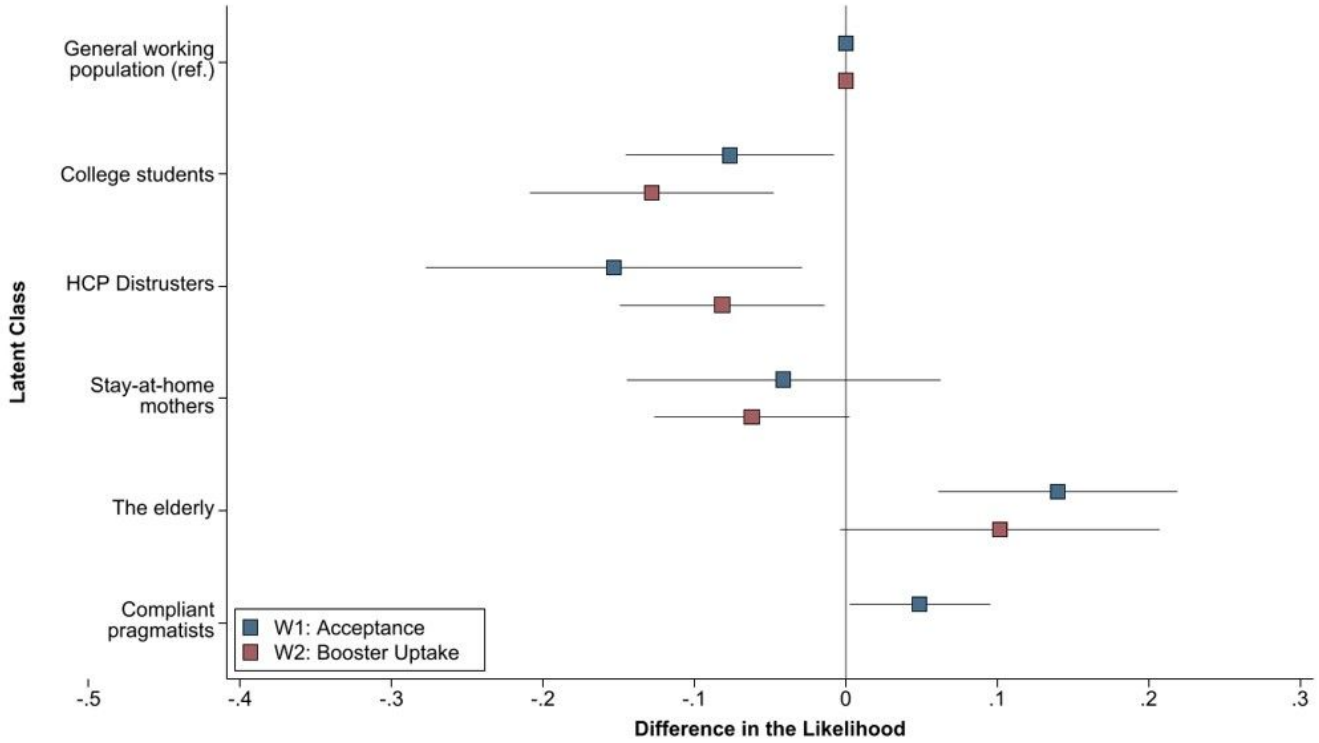

Figure 3

COVID-19 Vaccine Acceptance and Booster Uptake by Subgroup.

Note. Markers indicate OLS coefficients. The latent class of general working population is the reference category. Horizontal lines around the markers indicate 95% CIs. Unobserved country-level variations were fixed. Standard errors were clustered at the country level.

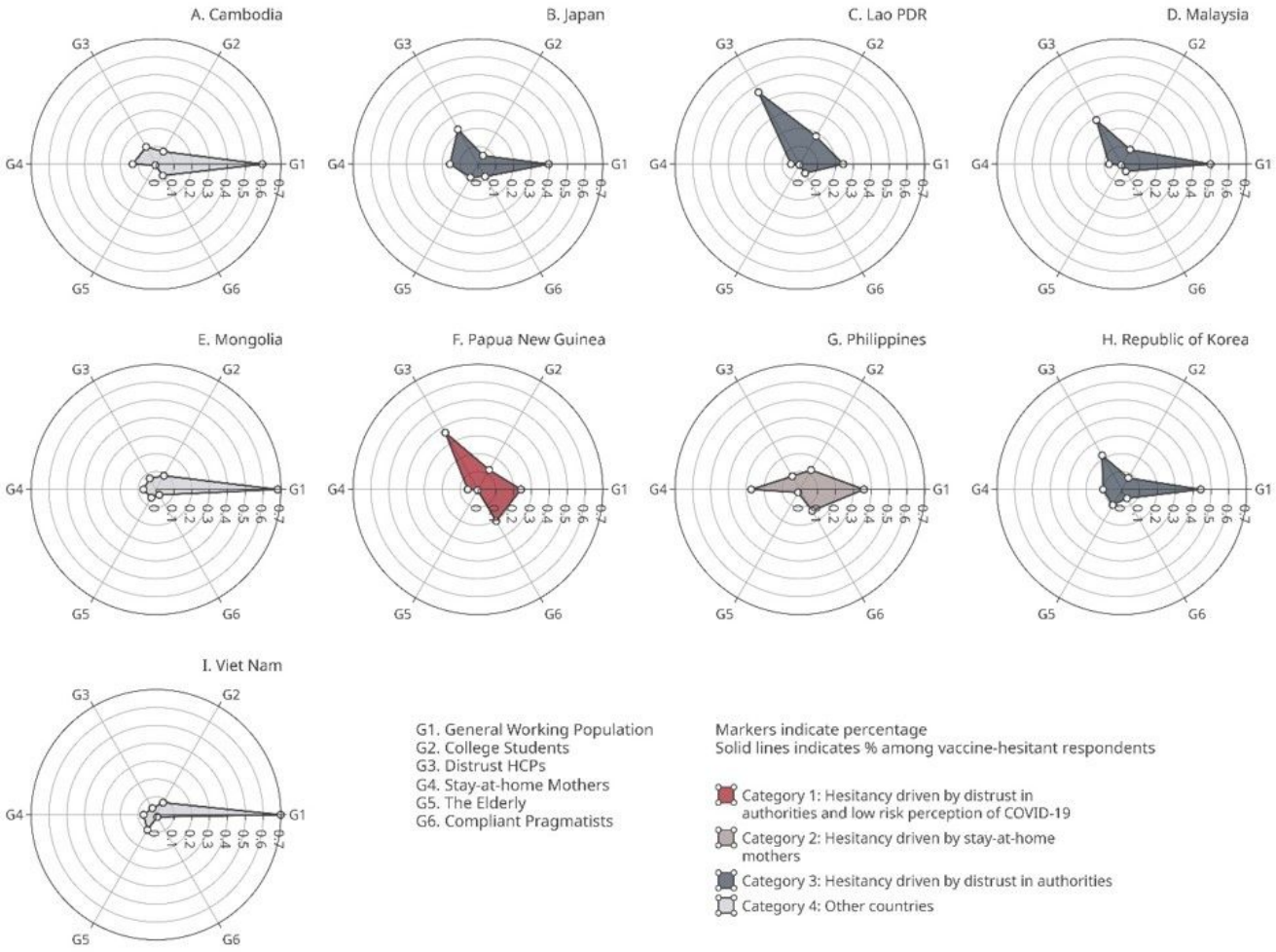

Figure 4

Latent Class Distributions among Vaccine-hesitant and Other Respondents by Country (June – August, 2021).

Note. Markers indicate percentages. Colors represent the country category identified by the authors: Category 1 – PNG; Category 2 – the Philippines; Category 3 – Japan, Lao PDR, Malaysia, and the ROK; Category 4 – Cambodia, Mongolia, and Viet Nam. Dotted lines indicate all respondents. Solid lines indicate respondents who are hesitant to get vaccinated.

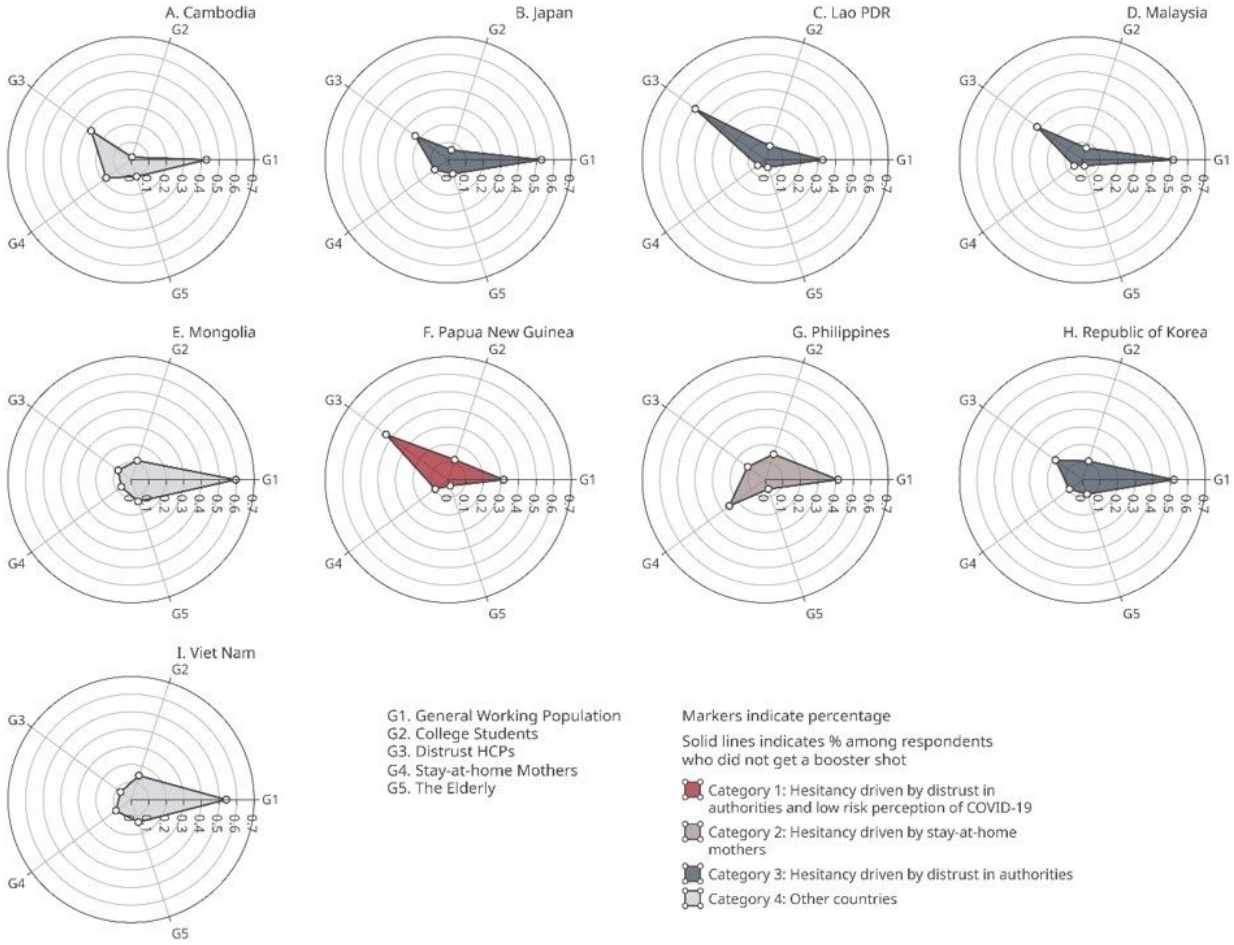

Figure 5

Latent Class Distributions among People with a Booster Vaccination and Other Respondents by Country (May – June, 2022).

Note. Markers indicate percentages. Colors represent the country category identified by the authors: Category 1 – PNG; Category 2 – the Philippines; Category 3 – Japan, Lao PDR, Malaysia, and the ROK; Category 4 – Cambodia, Mongolia, and Viet Nam. Dotted lines indicate all respondents. Solid lines indicate respondents who are hesitant to get vaccinated.

Supplementary Files

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