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Research Paper

The State of Vaccine Confidence 2016: Global Insights Through a 67-Country Survey

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ABSTRACT

Background: Public trust in immunization is an increasingly important global health issue. Losses in confidence in vaccines and immunization programmes can lead to vaccine reluctance and refusal, risking disease outbreaks and challenging immunization goals in high- and low-income settings. National and international immunization stakeholders have called for better monitoring of vaccine confidence to identify emerging concerns before they evolve into vaccine confidence crises.

Methods: We perform a large-scale, data-driven study on worldwide attitudes to immunizations. This survey – which we believe represents the largest survey on confidence in immunization to date – examines perceptions of vaccine importance, safety, effectiveness, and religious compatibility among 65,819 individuals across 67 countries. Hierarchical models are employed to probe relationships between individual- and country-level socio-economic factors and vaccine attitudes obtained through the four-question, Likert-scale survey.

Findings: Overall sentiment towards vaccinations is positive across all 67 countries, however there is wide variability between countries and across world regions. Vaccine-safety related sentiment is particularly negative in the European region, which has seven of the ten least confident countries, with 41% of respondents in France and 36% of respondents in Bosnia & Herzegovina reporting that they disagree that vaccines are safe (compared to a global average of 13%). The oldest age group (65+) and Roman Catholics (amongst all faiths surveyed) are associated with positive views on vaccine sentiment, while the Western Pacific region reported the highest level of religious incompatibility with vaccines. Countries with high levels of schooling and good access to health services are associated with lower rates of positive sentiment, pointing to an emerging inverse relationship between vaccine sentiments and socio-economic status.

Conclusions: Regular monitoring of vaccine attitudes – coupled with monitoring of local immunization rates – at the national and sub-national levels can identify populations with declining confidence and acceptance. These populations should be prioritized to further investigate the drivers of negative sentiment and to inform appropriate interventions to prevent adverse public health outcomes.

1. Introduction

Vaccine confidence is an increasingly important global public health issue, with decreases in confidence leading to well-documented cases of disease outbreaks, setbacks to global polio eradication as well as other immunization goals, and contentious political debates in high and low-income countries alike (Brown et al., 2010; Hanley et al., 2015;

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Khetsuriani et al., 2010; Larson et al., 2011; Yu et al., 2016). The World Health Organization's (WHO) Strategic Advisory Group of Experts (SAGE) on Immunization (WHO, 2014) as well as national immunization programmes (US Dept. Health and Human Services, 2015) have called for better monitoring of vaccine confidence and hesitancy to inform the development of communication and other interventions to address confidence gaps, to sustain confidence in vaccines and immunization programmes and to avert confidence crises and their public health consequences.

In March 2012, the SAGE Working Group on Vaccine Hesitancy convened to define "vaccine hesitancy" and to develop and standardize survey frameworks within which the scale and determinants of vaccine hesitancy and vaccine confidence can be measured (Larson et al., 2015a, 2015b). A number of studies have since investigated attitudes towards vaccines in diverse contexts, including investigation of attitudes towards immunization programmes (Dubé et al., 2016), vaccine hesitancy among general practitioners (GPs) (Verger et al., 2015), the detrimental effects of non-voluntary immunization campaigns (especially amongst those already expressing negative vaccine sentiment) (Betsch and Böhm, 2016), and social-network analyses identifying clustering of vaccine-refusing households (Onnela et al., 2016).

This latter study is particularly important in the context of vaccine refusal, since it supports a growing body of research which underscores the role of clusters of non-vaccinators in lowering herd immunity and allowing for disease outbreaks (Salathé and Bonhoeffer, 2008; Liu et al., 2015). The US Centers for Disease Control have also recognized this phenomenon, highlighting also the vulnerability of under-vaccinated groups to imported diseases, and noting a paradigm-shift away from access as the primary barrier to vaccinations and towards "philosophical objections" (CDC, 2013). It is thus worth stressing the importance of identifying and monitoring hesitant groups: small clusters of non-vaccinators can have disproportionately adverse effects on herd immunity and epidemic spread.

Our objectives in this paper are to: respond to international calls for monitoring public confidence in immunization; examine worldwide variation in attitudes, exploring the socio-economic determinants of vaccine attitudes; and, finally, interpret and discuss the results in the context of global immunization and monitoring systems. This study – in collaboration with WIN/Gallup International Association[i] – draws from the ten-question Likert survey proposed by SAGE (Larson et al., 2015a, 2015b) and comprises survey responses from 65,819 individuals across 67 countries to questions on vaccination importance, safety, effectiveness, and religious compatibility. This study builds on a five-country vaccine confidence survey conducted in collaboration with Win/Gallup International in 2014 (Larson et al., 2014a, 2014b). We believe this study to be of unprecedented scale in the vaccine confidence literature, and a potential cornerstone for monitoring of public confidence in immunization. We begin by exploring worldwide variation in attitudes to four statements investigating individuals' perceptions of the importance, safety, and effectiveness of vaccines, as well as the compatibility with their religious beliefs. We then highlight regional trends in vaccine safety perceptions and explore socio-economic determinants of vaccine sentiments using logistic hierarchical modelling.

2. Methods

2.1. Data

Individual-level vaccine-sentiment and socio-economic data in this study was collected through a WIN/Gallup International Association survey. The WIN/GIA Annual Survey has been conducted annually since 1977. In 2015, in collaboration with the Vaccine Confidence Project at the London School of Hygiene & Tropical Medicine,[ii] WIN-Gallup International extended their annual 14-question survey conducted in 67 countries to include four questions related to attitudes towards vaccines. A total of 65,819 persons were interviewed globally,[iii] with a sample of around 500 men and 500 women interviewed either face-to-face (28 countries, $n = 30{,}230$), via telephone (16 countries, $n = 13{,}062$), or online (23 countries, $n = 22{,}527$). Algeria reported the fewest respondents (398), whilst Afghanistan reported the most (2080). The fieldwork was conducted between September 2015 and December 2015. The interview method selected in each country was largely determined by the availability of the internet and the phone. In those countries where the internet is widely used (e.g. Europe) the majority of fieldwork was carried out via online panels. In those countries where phone penetration is sufficiently high a random digit dial telephone methodology was used. In those countries with poor internet and landline phone coverage (e.g. Pakistan) interviews were carried out face-to-face following a multi stage random probability methodology. In each country only one mode of interviewing was used.

Each respondent was asked to rate – on the five-point Likert scale: strongly agree, tend to agree, do not know, tend to disagree, strongly disagree – the extent to which they agreed with four statements pertaining to vaccination: "vaccines are important for children to have"; "overall I think vaccines are safe"; "overall I think vaccines are effective"; and "vaccines are compatible with my religious beliefs". In addition to these survey responses, individual respondents' sex, age, income level, religion, work status, and educational level were recorded. The overall missing data fraction is 6.4%, however, this varies substantially by country and covariate: sex, age, work status, and education have ~1% missing data, whereas religion and income have ~11% missing values. Missing responses are present within the question response data though their prevalence is difficult to establish since "no response" and "do not know" are coded collectively. The number of "do not know/no response" to each of the four questions is 3%, 5%, 4%, and 12% respectively, suggesting 3% as a likely upper threshold for those providing no response.

To allow the statistical investigation into socio-economic factors that affect country-wide variation in response data, country-level data was also collected from a variety of sources including the World Health Organization, the World Bank, and the United Nations Development Programme. This set of socio-economic factors – which includes GDP, births attended by skilled health staff, child mortality, access to sanitation, access to water, total health spending, and mean years in school – allows variation of country-level variables with response to be investigated in addition to the individual-level factors.

2.2. Statistical Analysis

A hierarchical logistic model is used to probe the ties between individual- and country-level variables and attitudes to vaccines. The responses to each question are dichotomized into positive versus non-positive (including don't know or no response), with partial pooling between countries via a combination of random effects and regression on country level factors. There are a total of 18 missing data points (out of a total of 469) for the country-level factors, which are imputed using mean-imputation. Odds ratios (with 95% confidence intervals) are derived for risk factors. Full details of the model are provided in the Supplementary materials. R 3.3.0 is used for all analyses and stargazer is used to create Table 1 (R, 2016; Hlavac, 2013).

[i] Disclaimer: Gallup International Association or its members are not related to Gallup Inc., headquartered in Washington D.C which is no longer a member of Gallup International Association. Gallup International Association does not accept responsibility for opinion polling other than its own. We require that our surveys be credited fully as Gallup International (not Gallup or Gallup Poll).For further details see website: www.Gallup-international.com.

[ii] www.vaccineconfidence.org

[iii] http://www.wingia.com/web/files/richeditor/filemanager/Methosheet_Global.pdf

3. Results

Immunization-response data is renormalized after removing "do not know/no response" responses. An overall summary by question and country (stratified by world region as defined by the World Health Organization) is shown in Fig. 1 using weighted responses, which are adjustments to account for over- or under-represented individuals within the population. (World regions are categorized by WHO region according to the definitions at www.who.int/about/regions/en (accessed 08/07/2016): AFR (Africa region); AMR (Americas region); EMR (Eastern Mediterranean region); EUR (European region); SEAR (South-East Asia region); and WPR (Western Pacific region).) Overall differences in responses between the six WHO regions are again shown as Likert responses in Fig. 2A and worldwide vaccine attitudes to vaccine safety are mapped in Fig. 2C (South, 2011).

Variability in vaccine sentiment across countries and WHO regions is investigated by considering the fraction of respondents who either agree or disagree with the four statements on immunization (Fig. 1). The EUR region reports the highest mean-averaged (across all countries in the region) negative responses for vaccine importance, safety, and effectiveness (8.0%, 17.0%, and 11.3%, respectively) and seven of the ten most negatively-reporting countries to vaccine safety are in EUR. Pairwise *t*-tests between regional means demonstrate that EUR has more importance- and safety-related skepticism than AFR, AMR, EMR, and SEAR (at $p = 0.05$), and that WPR has more safety-related skepticism than SEAR. EUR has more effectiveness-related skepticism than AMR. SEAR and WPR report the most religious incompatibility (25.7% and 24.3% respectively): pairwise *t*-tests reveal significance at $p = 0.05$ between these two regions and the four others, but none between them.

In Fig. 1, countries are ranked by the percentage of (normalized) negative sentiment expressed towards a given question. (All figures quoted are normalized responses.) Respondents from Bangladesh (0.3%), Ecuador (0.4%), and Iran (0.5%) report the lowest levels of importance-related skepticism, whilst respondents from Russia (17.1%), Azerbaijan (15.7%), and Italy (15.4%) report the highest (the global average is 5.8%). With regard to vaccine safety, Bangladesh (0.2%), Saudi Arabia (1.2%), and Argentina (1.3%) report the lowest levels of skepticism, whilst respondents from France (45.2%), Bosnia & Herzegovina (38.3%), and Japan (31.0%) have the highest (the global average is 13.0%). Argentina (1.3%), Ethiopia (2.1%), and Ecuador (2.2%) have the lowest levels of effectiveness-related doubts, whilst Bosnia & Herzegovina (27.3%), Russia (20.1%), and Italy (18.7%) have the highest (global average 9.1%). With regard to religious compatibility, Saudi Arabia (2.3%), Finland (2.6%), and Brazil (3.2%) have the lowest levels of reported incompatibility, whilst Mongolia (50.5%), Thailand (44.4%), and Vietnam (31.8%) have the highest (global average 15.4%).

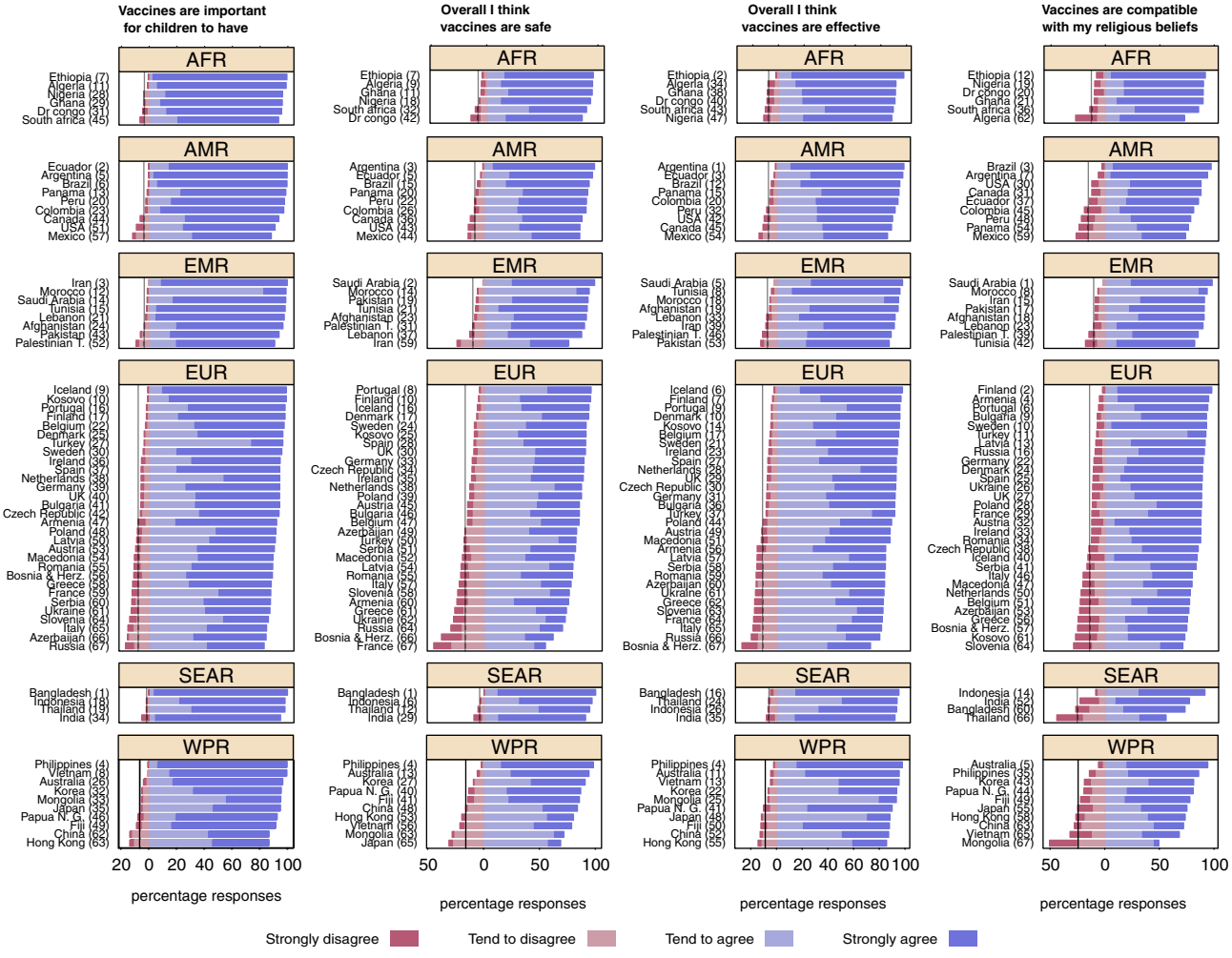

Fig. 1. Weighted responses to survey questions by country and WHO region Renormalized Likert responses by country and world region across the four survey statements, with mean-averaged (across all countries within a region) negative sentiment displayed (vertical grey lines). Within each statement countries are ranked by the percentage of negative responses. The European region performs poorly for vaccine importance, safety, and effectiveness-related skepticism, with Southern and Eastern European countries performing notably poorly for vaccine safety, though France and Italy are notable exceptions. The South East Asian and Western Pacific Region have high levels of religious-based vaccine incompatibility, notably in Mongolia, Vietnam, and Thailand.

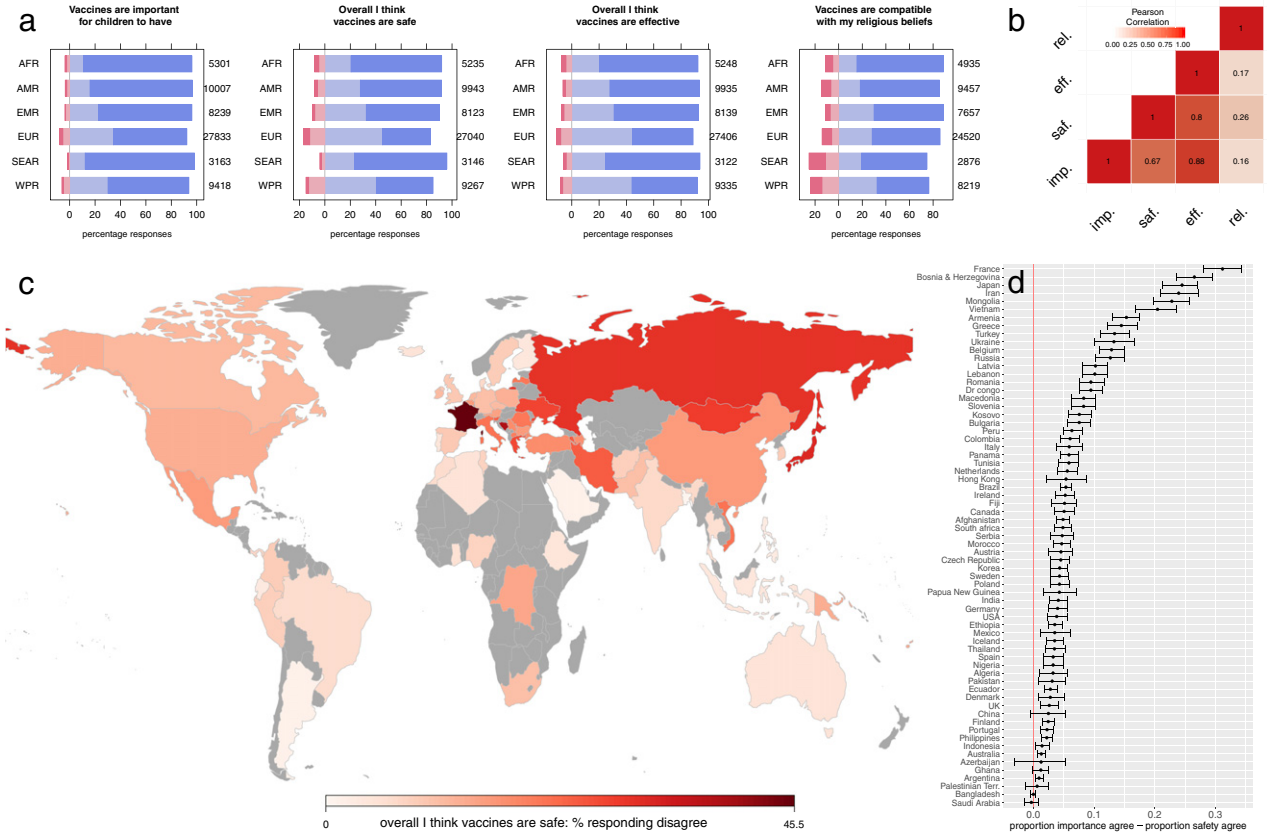

Fig. 2. Vaccine confidence by world region and differences between perceived safety and importance. (A) Summary of Likert Responses by world region. (B) Pearson correlations between percentage of respondents across all countries agreeing ("strongly agree" or "tend to agree") with each statement. (C) Vaccine World map of percentage negative ("tend to disagree" or "strongly agree") survey responses to the statement "overall I think vaccines are safe". (D) Differences in the proportion of people responding that they believe vaccines are important but unsafe (with 95% confidence intervals).

In EUR, vaccine safety and importance are concerns, though there is relatively little reported religious incompatibility. In WPR, however, great concerns are expressed about safety, importance, and religious compatibility (Fig. 2A). Pearson correlations between the fractions of negative responses (across countries) between questions reveals that responses are more consistent among vaccine importance, safety, and effectiveness than with religious compatibility (Fig. 2B). A notable trend is the observation that the number of respondents who report more positive sentiment for vaccine importance is larger than that for vaccine safety. The striking consistency in this trend across most of the countries surveyed is clear in Fig. 2C. This suggests that vaccination intent could be buffered by perceived importance, suggesting that people are willing to take a risk given an effective guard against disease. As suggested by the correlation in responses of vaccine importance and vaccine safety, individual responses between vaccine effectiveness and vaccine safety are very similar (see Supplementary material), though we note a higher fraction of countries with no significant difference and some countries with a higher fraction of respondents reporting that vaccines are safe then effective (Nigeria, Ghana, Pakistan, Indonesia, and Bangladesh).

Worldwide levels of vaccine-safety skepticism are mapped in Fig. 2C. With the notable exceptions of France and Italy – which have high levels of safety-based vaccine skepticism – Western and Northern European countries express less concern about vaccine safety than Eastern and Southern European countries. Spatial contiguity is not limited to Europe: USA, Canada, and Mexico have higher levels of safety concerns than countries in South America; and China, Mongolia, Japan, Hong Kong, and Vietnam all have high fractions of negative responses.

Results of the logistic hierarchical model employed to investigate the link between both individual- and country-level predictors, and attitudes towards immunizations are shown in Table 1. To compare data on different scales, country-level factors have been z-scored so that a unit increase in country-level factor is associated with the reported odds ratios. Parameters with *p*-values lower than 0.05 are considered.

Males are less likely to think vaccines are important than females (odds ratio [OR] 0.86, 95% confidence interval [CI] 0.80 to 0.94), but there are no significant differences between the sexes for vaccine safety, effectiveness, or religious compatibility. Those aged 25–34 are less likely to believe vaccines are safe compared to 18–24 year olds (OR 0.88, CI 0.77–1.00); over 65 s are both more likely to report that vaccines are effective (OR 1.39, CI 1.11–1.76) and to express religious incompatibilities (OR 1.27, CI 1.05–1.53). Any level of education elevates positive views towards immunizations for vaccine importance, effectiveness, and religious compatibility; yet, notably, not for vaccine safety. Masters/PhD – the highest educational level – is not associated with more positive views on vaccine importance and effectiveness than those with no education. The fifth income quintile is associated with less positive vaccine sentiment across all four statements than higher income bands. Those unemployed are more likely to hold negative sentiment for vaccine safety (OR 0.77, CI 0.67–0.90) and effectiveness (OR 0.79, CI 0.67–0.92) than the baseline group. Compared to Roman Catholics, religious groups – including atheists/agnostics and with possible exceptions of Hindus and Jews – are less likely to hold positive vaccine sentiment for vaccine importance and vaccine safety. Other Christians and atheists/agnostics are more likely to have religious compatibility issues; however, it should be noted that it is unclear whether atheists/agnostics could have reasonably answered this question, since the phrasing assumed that the respondent's religiosity.

For vaccine importance, countries with higher levels of births attended by skilled health staff (OR 0.66, CI 0.49–0.88) and schooling (OR 0.56, CI 0.43–0.72) are associated with less positive responses,

Table 1
Results of the logistic hierarchical regression.
Odds ratios and 95% confidence intervals for the fixed effects in the logistic hierarchical model (see Supplementary materials). Survey responses are dichotomized so that odds ratios greater than one (for example) represent an association between explanatory variable and positive vaccine sentiment. Males are less likely to think vaccines are important than females. Any level of education elevates pro-vaccine views for importance, efficacy, and religious compatibility but not for vaccine safety. Over 65 s are both more likely to report that vaccines are effective (OR 1.39, CI 1.11–1.76) and to express religious incompatibilities. Countries with higher levels of education and a higher fraction of births attended by skilled health staff are associated with decreased odds of pro-vaccination attitudes.

	Importance	Safety	Effectiveness	Religious compatibility
Individual-level				
Sex				
female (baseline)				
male	0.86 (0.80–0.94)***	1.01 (0.94–1.09)	0.96 (0.89–1.03)	0.96 (0.90–1.02)
Age				
18–24 (baseline)				
25–34	0.89 (0.77–1.04)	0.88 (0.77–1.00)**	0.97 (0.86–1.10)	0.94 (0.85–1.05)
35–44	0.99 (0.84–1.17)	0.95 (0.83–1.07)	1.02 (0.89–1.16)	1.06 (0.94–1.20)
45–54	0.99 (0.83–1.19)	0.97 (0.85–1.12)	1.16 (1.00–1.34)*	1.05 (0.93–1.20)
55–64	0.99 (0.80–1.23)	0.98 (0.84–1.13)	1.07 (0.90–1.28)	1.14 (0.98–1.32)*
65 +	0.94 (0.69–1.27)	1.07 (0.88–1.31)	1.39 (1.11–1.76)***	1.27 (1.05–1.53)**
Education				
No education (baseline)				
Primary	1.46 (1.08–1.97)**	0.90 (0.71–1.15)	1.20 (0.99–1.46)*	1.12 (0.94–1.35)
Secondary	1.39 (1.05–1.83)**	0.95 (0.74–1.22)	1.31 (1.08–1.57)***	1.19 (0.97–1.44)*
University	1.44 (1.09–1.92)**	0.98 (0.76–1.26)	1.39 (1.15–1.68)***	1.35 (1.08–1.68)***
Masters/PhD	1.33 (0.94–1.89)	0.98 (0.73–1.33)	1.33 (1.05–1.70)**	1.43 (1.12–1.83)***
Income				
First quintile (low) (baseline)				
Second quintile	1.19 (1.04–1.38)**	1.17 (1.04–1.31)***	1.21 (1.07–1.36)***	1.08 (0.98–1.20)
Third quintile	1.36 (1.16–1.58)***	1.25 (1.10–1.43)***	1.31 (1.13–1.50)***	1.16 (1.04–1.29)***
Fourth quintile	1.53 (1.26–1.85)***	1.32 (1.15–1.53)***	1.43 (1.22–1.68)***	1.19 (1.05–1.36)***
Fifth quintile (high)	1.43 (1.21–1.70)***	1.28 (1.10–1.48)***	1.33 (1.14–1.55)***	1.12 (0.96–1.30)
Work type				
Housewife (baseline)				
Retired/disabled	1.13 (0.88–1.45)	0.96 (0.81–1.14)	0.91 (0.77–1.08)	1.00 (0.87–1.15)
Student	0.99 (0.77–1.27)	0.96 (0.80–1.15)	1.04 (0.85–1.26)	1.00 (0.86–1.17)
Unemployed	0.95 (0.77–1.17)	0.77 (0.67–0.90)***	0.79 (0.67–0.92)***	0.90 (0.78–1.05)
Part-time	0.86 (0.70–1.07)	0.89 (0.75–1.06)	0.91 (0.77–1.07)	0.91 (0.78–1.06)
Full-time	1.03 (0.86–1.25)	1.01 (0.88–1.16)	1.00 (0.88–1.15)	0.98 (0.87–1.11)
Religion				
Roman Catholic (baseline)				
Protestant	0.57 (0.43–0.77)***	0.72 (0.58–0.90)***	0.83 (0.67–1.02)*	1.04 (0.85–1.26)
Russian/Eastern-Orth	0.41 (0.30–0.57)***	0.56 (0.46–0.70)***	0.64 (0.51–0.82)***	0.87 (0.71–1.07)
Other Christian	0.52 (0.41–0.67)***	0.74 (0.61–0.90)***	0.72 (0.58–0.89)***	0.81 (0.68–0.97)**
Muslim	0.63 (0.43–0.91)**	0.72 (0.55–0.96)**	0.67 (0.51–0.89)***	0.82 (0.62–1.08)
Jewish	1.48 (0.50–4.39)	0.64 (0.34–1.20)	2.43 (0.74–7.98)	0.97 (0.45–2.06)
Buddhist	0.30 (0.17–0.51)***	0.48 (0.32–0.71)***	0.55 (0.35–0.87)**	0.83 (0.55–1.26)
Hindu	0.55 (0.28–1.08)*	1.40 (0.66–2.97)	0.69 (0.41–1.16)	1.07 (0.61–1.88)
Other	0.29 (0.21–0.38)***	0.45 (0.35–0.58)***	0.44 (0.34–0.57)***	0.47 (0.38–0.59)***
Atheist/agnostic	0.49 (0.38–0.64)***	0.73 (0.61–0.86)***	0.75 (0.63–0.91)***	0.45 (0.38–0.54)***
Country-level				
Health expenditure (% of GDP)	0.89 (0.74–1.08)	0.71 (0.60–0.85)***	0.81 (0.70–0.93)***	1.00 (0.87–1.14)
Births attended (% of total)	0.66 (0.49–0.88)***	0.55 (0.44–0.68)***	0.75 (0.62–0.91)***	0.79 (0.65–0.96)**
GDP per capita (US$)	1.56 (1.25–1.95)***	1.67 (1.38–2.02)***	1.68 (1.43–1.97)***	0.99 (0.86–1.15)
U5 mort. rate (per 1000 births)	0.76 (0.55–1.06)	0.93 (0.71–1.23)	0.94 (0.75–1.18)	1.16 (0.93–1.45)
Sanitation access (% with access)	0.82 (0.58–1.17)	1.35 (1.00–1.82)**	1.21 (0.96–1.54)	1.29 (1.01–1.65)**
Water access (% with access)	1.31 (0.99–1.75)*	1.23 (0.98–1.54)*	0.94 (0.78–1.14)	1.05 (0.88–1.26)
Schooling (years)	0.56 (0.43–0.72)***	0.73 (0.60–0.93)***	0.63 (0.52–0.75)***	0.80 (0.66–0.97)**

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

whilst countries with high GDP per capita (OR 1.56, CI 1.25–1.95) are associated with more positive responses. For vaccine safety and effectiveness, the results are similar, except health expenditure is associated with negative responses, and sanitation access is associated with positive responses (for vaccine effectiveness only). Higher levels of births attended by skilled health staff (OR 0.79, CI 0.65–0.96) and schooling (OR 0.80, CI 0.66–0.97) are associated with anti-vaccine sentiment for religious compatibility, whilst higher levels of sanitation access (OR 1.29, CI 1.01–1.65) are associated with pro-vaccine sentiment.

4. Discussion

We have performed a large-scale, data-driven study into worldwide variations in attitudes to vaccines. We find that vaccine safety sentiment is more negative in the European and the Western Pacific regions, where nine of the ten least confident countries are located (France, Bosnia & Herzegovina, Russia, Ukraine, Greece, Armenia, Slovenia, Japan, and Mongolia). Conversely, vaccines are perceived to be safe across countries surveyed in the South East Asian region (Bangladesh, Indonesia, Thailand, and India). The more negative vaccine-safety perceptions in the European region is striking, particularly given widespread access to vaccines. Our research thus stresses the emerging shift away from access to vaccines as the primary barrier to vaccination in many countries, a finding supported by other European studies, such as a recent review which finds vaccine side-effects and vaccine safety as the most commonly-cited reservation amongst the public (Yaqub et al., 2014). The extreme negative sentiment around vaccine safety reported in France builds upon multiple strands of vaccine controversies and

distrust that have evolved in France over the past two decades. These include controversies relating to side effects of the hepatitis B vaccine (Marshall, 1998); physician-led petitions disputing the hexavalent vaccine for infants and the HPV vaccine (Collange et al., 2016); and hesitancy amongst general practitioners with nearly one in four GPs responding that some vaccines recommended by the French public health authorities are not useful (Verger et al., 2015), and many reporting doubt in immunization programmes (Raude et al., 2016). Although the highest levels of vaccine skepticism were reported in Europe, the longer term global impacts should not be underestimated as reported in separate research on transnational influences of vaccine sentiment (Larson et al., 2014a, 2014b).

We find that a larger proportion of respondents report more positively on vaccine importance than vaccine safety, suggesting that perceptions of vaccine importance may mitigate losses in vaccination uptake (with similar results for the difference between vaccine effectiveness and vaccine safety, though noticeable exceptions for Nigeria, Ghana, Pakistan, Indonesia, and Bangladesh – see Supplementary material). Many countries are found to have strong faith-compatibility issues, most notably in Thailand and Mongolia. In addition to investigating the relationship between vaccine importance, vaccine safety and vaccination intent, there is also a pressing need to clarify the vaccination intent of individuals who think that vaccines are incompatible with their faith. Religious fundamentalism has been cited as a major factor of polio refusal in Afghanistan, Nigeria, and Pakistan (Ahmed et al., 2013; Warraich, 2009) which have moderate religious objection rates within the Muslims sampled (3%, 12% and 14% respectively); however, faith type alone is not linked to vaccination issues and interacts with other national factors: Saudi Arabia – a country with 100% Muslim respondents – has a very low religious objection rate (2%). As Grabenstein notes in a review of religious teachings and vaccination (Grabenstein, 2013), there are few religious groups, with the exception of Christian Scientists, whose official religious texts explicitly reject immunization. Grabenstein's review found that most vaccine reluctance and refusal, sometimes attributed to religious beliefs, is more related to vaccine safety or other personal beliefs that are shared across a social network within a religious congregation. Political, cultural, and historical context modifies the effect of religion rather than being specifically tied to theological beliefs. Our survey findings – showing varying views within one religious group – also suggest that different political, cultural, and historical contexts can additionally influence vaccine opinion.

The results of the hierarchical regression suggest that countries with higher mean years of schooling are less likely to report positive vaccine sentiment, however within a country those with some education hold more positive views on vaccine importance, effectiveness, and religious compatibility (though markedly not safety) than those without. There is evidence in the recent literature to suggest that more highly educated elites in the Netherlands (Hak et al., 2005), the United States (Gilkey et al., 2014; Jones et al., 2010), and Canada (Foty et al., 2010) hold vaccine skeptic views, which is in keeping with the highest level of education of surveyed respondents (masters/PhD) having the same vaccine importance sentiment as those with no or little education. Further systematic reviews have highlighted the variability of correlations found between education and vaccine confidence, with no clear pattern except to show that education does not always imply confidence (Brown et al., 2010; Larson et al., 2014a, 2014b). Other individuals with low income and the unemployed also exhibit less positive vaccine views.

The results of this study provide valuable insights on public opinion of vaccines which can help enable policymakers and stakeholders to identify countries of particular concern with respect to the four surveyed areas of vaccine hesitancy. This study can hence be used as a baseline with which to compare future surveys on vaccine hesitancy (thus monitoring the evolution of vaccine-hesitancy) and with which future surveys can be tailored to identify hesitancies toward particular vaccinations and investigate local drivers of hesitancy. The findings herein, coupled with the recent literature on vaccine confidence, point to the importance of continued worldwide monitoring of confidence in vaccines, so that policymakers can monitor the effects of their interventions on immunization attitudes and acceptance and more effectively allocate resources to address hesitancy issues and build confidence.

A limitation of this survey is its generality of the survey which does not reveal whether the attitudes are related to specific vaccine(s) which an individual may have concerns about. A study of repeated surveys of vaccination attitudes in France (Peretti-Watel et al., 2013) also considers general vaccine-skepticism, finding a link between children unvaccinated against MMR and unfavorable attitudes towards vaccines as a whole. The ability to investigate the effect of skepticism towards a particular vaccine on other vaccines and would help understand how skepticism towards a particular vaccine can drive other harmful vaccination behaviors. To address these issues, we propose an extension to the five-point Likert scale questions to include statements on immunization intent for specific vaccines.

A further limitation is the inability in the present study to track temporal changes of immunization attitude. Repeated surveys allow for a better understanding of the complex interplay between socio-economic, political, and religious characteristics, vaccine sentiment, immunization intent, and immunization rates (de Figeiredo et al., 2016). Monitoring systems can be developed to track confidence, forecast areas of concern, and lessen hesitancy through targeted intervention.

We believe this research has far-reaching public health implications, and is particularly important in light of the variable progress in reaching the Millennium Development Goals and implications for moving forward in the context of new Sustainable Development Goals. The interconnectivity of vaccine confidence, confidence in the health system, public trust in government more broadly, and socio-economic status alongside the influences of religious and philosophical beliefs, suggest that measuring vaccine confidence can be a valuable window on bigger issues at play in the evolving health and development landscape.

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Author contributions

All authors contributed to data interpretation and contributed to writing the manuscript. AdF, ARC, and XZ, IGJ and NJ all performed the data analyses, whilst AdF created the figures. HJL, WSS, PV, and AdF performed the literature search.

Disclosure

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ebiom.2016.08.042.

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