

This is an Open Access article distributed under the terms of the Creative Commons Attribution Licence, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.



## A Systems Map to Elucidate the Factors Influencing Vaccine Coverage

**Ellie Cassandra Clark,<sup>1,2\*</sup> Florian De Rop,<sup>1,3\*</sup> Iria Anne Jimenez Garcia,<sup>1,4\*</sup> Ana Nogal Macho,<sup>1,5\*</sup> Ruel Alexander Mannette,<sup>1,6\*</sup> Jorge Ricardo Nova Blanco,<sup>1,7</sup> Kaat Ramaekers<sup>7§</sup> & Corinne Vandermeulen<sup>9,10</sup>**

<sup>1</sup>KU Leuven, Honours Programme Transdisciplinary Insights, Institute for the Future, Leuven, Belgium;

<sup>2</sup>KU Leuven, Master's Student, Biology, Leuven, Belgium;

<sup>3</sup>KU Leuven, Master's Student, Bioscience Engineering, Leuven, Belgium;

<sup>4</sup>KU Leuven, Master's Student, Biomedical Sciences, Leuven, Belgium;

<sup>5</sup>KU Leuven, Master's Student, Bioinformatics, Leuven, Belgium;

<sup>6</sup>KU Leuven, Master's Student, Philosophy, Leuven, Belgium;

<sup>7</sup>KU Leuven, Department of Microbiology, Immunology & Transplantation, Rega Institute for Medical Research, Clinical and Epidemiological Virology, Leuven, Belgium;

<sup>9</sup>KU Leuven, Department of Public Health and Primary Care, Environment and Health, Leuven, Belgium;

<sup>10</sup>Leuven University Vaccinology Centre, Leuven, Belgium.

\*Authors contributed equally to the work.

§Email: [kaat.ramaekers@kuleuven.be](mailto:kaat.ramaekers@kuleuven.be)

### Abstract

This abstract is a report of the investigations by a transdisciplinary team working on the 'Vaccine Confidence' challenge (Supplement 1). Since their introduction, vaccines have been one of the most successful health interventions in medicine. Prior to vaccination programs against poliomyelitis, more than 350,000 cases of polio were reported annually worldwide, a number that decreased to just 33 reported cases in 2018<sup>1</sup>. Additionally, between 2000 and 2017, the measles vaccination program is estimated to have prevented 21.1 million deaths.<sup>2</sup> However, in 2018 more than 19 million children under one year of age did not receive the recommended WHO vaccines.<sup>3</sup> A recent rise in anti-vaccine or vaccination-hesitant mentalities has led to decreasing vaccine coverage in several Western countries. The WHO identified three C's as main determinants of vaccine hesitancy, namely Complacency, Convenience in accessing vaccines, and Confidence. However, the term 'vaccine hesitancy' tends to be interpreted as a lack of confidence in vaccines and vaccinations for various reasons. Nevertheless, the goal of vaccination is to reach herd immunity by reaching a high vaccination coverage (90–95% vaccinated) to stop the circulation of vaccine preventable diseases. We wanted to give equal attention to the three C's as they are equally important in reaching herd immunity.

Therefore, we chose to present the problem as a challenge of ‘vaccine coverage,’ rather than ‘vaccine hesitancy’ or ‘vaccine confidence’. In order to understand the complexity of the problem, we have developed a systems map which relates different global factors that impact an individual’s vaccination decision-making, as well as their likelihood of receiving vaccinations (Supplement 2). To create this map we assembled the information for the variables and connections from literature studies of peer-reviewed articles and interviews with stakeholders, kept anonymous, in the field of vaccination or healthcare (Supplements 3 & 4). This approach was selected as it provides a wide perspective that allows academics, governmental authorities, and lawmakers to better assess the various factors that affect vaccine coverage, and how they are related. The work leading to the map was presented to the public at a symposium (Supplement 5). Our map identifies essential factors such as psychology, education, economy, vaccine technology, political and environmental sphere, sources of information, and healthcare in order to understand what governs vaccination coverage. The map emphasizes how various factors and determinants are often interrelated, as opposed to the isolated factors described in previous literature. We identified important discrepancies between developed and developing countries regarding the factors that drive vaccine-related decision-making and availability. The systems map could ultimately serve as a tool to better understand the multifaceted problem of suboptimal vaccination coverage.

Vaccine hesitancy as a threat to vaccination coverage is a complex and wicked problem with many underlying contributing factors, as has been depicted in our systems map on vaccine coverage. Our systems map

allows more in-depth insights, not only into which factors are contributing, but also into the relationship between factors. Solving the decrease in vaccination coverage will require different types of solutions which can be developed by using a transdisciplinary approach.

## Key words

Vaccines, Herd Immunity, World-Map, Systems Map

## Supplements

Supplement 1: Original challenge document submitted to the ‘Institute for the Future.’

Supplement 2: Systems map of vaccine coverage using the KUMU software.

Supplement 3: Elements and connections in the systems map exported to excel.

Supplement 4: Reference list accompanying the KUMU map.

Supplement 5: Link to video recording of the presentation held at the Symposium ‘KU Leuven Facing the Future,’ May 8, 2019, Leuven, Belgium.

## References

1. Poliomyelitis. Available at: <https://www.who.int/news-room/fact-sheets/detail/poliomyelitis>. (Accessed: 16th May 2019)
2. Measles. Available at: <https://www.who.int/news-room/fact-sheets/detail/measles>. (Accessed: 16th May 2019)
3. Immunization coverage. Available at: <https://www.who.int/news-room/fact-sheets/detail/immunization-coverage>. (Accessed: 18th September 2019)

## Supplement 1: Original Challenge Submission

The challenge was taken up by a team of master's students, their coach, and stakeholders in the context of the Honours Programme 'Transdisciplinary Insights' (<https://rega.kuleuven.be/if/vaccine-hesitancy>).

### HONOURS PROGRAMME TRANSDISCIPLINARY INSIGHTS KU LEUVEN

#### ABOUT YOUR CHALLENGE

##### NAME OF THE CHALLENGE

**Understanding the impact of fake news on vaccination confidence and finding ways to reverse the negative consequences.**

(Challenge submitted by Prof. Corinne Vandermeulen)

**Could you please state a specific challenge, problem, or question?** If you have more than one challenge, please submit each challenge separately. Please be aware that if the same or a very similar challenge is submitted by multiple actors, we will pool this into a single challenge and, as a result, the challenge might diverge slightly from what you submitted.

Besides running water and hygiene, vaccines are the best preventive medical invention/intervention that worldwide have impacted morbidity and mortality significantly, and their effect can hardly be overestimated. By using vaccines systematically and globally through organized vaccination programs, about 2–3 million deaths are averted annually (WHO). The advantage of vaccines is not only that they are able to induce individual protection against disease, but a vaccinated person can, for most vaccines, not be infected anymore and will thus stop transmission of the infectious pathogen. This phenomenon made eradication of smallpox possible and the elimination of many vaccine-preventable diseases (e.g. polio, diphtheria, measles, rubella, ...) in countries with high vaccination coverage. By organizing vaccination programs where >90–95% of the population is vaccinated, circulation can be stopped and the most vulnerable children and adults, who cannot be vaccinated or do not respond to vaccination, can also be protected. This is called herd or community immunity.

Despite the overwhelming scientific evidence of the positive effect of vaccination and of herd immunity, over the last decade vaccine hesitancy has been increasing. The three Cs that define vaccine hesitancy are Convenience, Complacency, and Confidence. Where Convenience is defined by access to vaccines, Complacency and Confidence are related to knowledge about and trust in vaccines, vaccinators, governments who organize vaccination programs, and vaccine manufacturers.

The current generation of new parents is not familiar anymore with the severity and complications of vaccine-preventable infectious diseases, and parents are increasingly focused on (alleged) side effects of vaccines. This phenomenon has led to lower confidence in the effects of vaccination and increased complacency. An increasing proportion of parents are doubting and delaying vaccination or even refusing to have their child vaccinated. Even though it is the individual choice of parents not to immunize their child, that should be placed in a broader societal context. Especially over the internet and through social networks fake news on vaccines is spreading with lightning speed. Shares, likes, and tweets of emotional witnesses of alleged side effects of vaccines are spread more easily than solid scientific evidence, helped by internet bots and trolls. Parents also tend to click more on negative news when looking for information on vaccines on the internet. Additionally, search engines have features which are more advantageous for negative vaccine messages as inputs of searches are already pre-populated by search strings that are used more often. As such the anti-vaccine movement is helped by technology and is increasing vaccine hesitancy in parents. As a result more parents refuse to have their children vaccinated or delay essential vaccination to a later, mostly undefined, age.

Unfortunately, this hesitancy has led to a decrease in vaccination coverage in different countries and has given rise to new epidemics of vaccine-preventable diseases which we thought were eliminated, such as measles. This means that unprotected and often vulnerable children get ill and suffer again from complications of infectious diseases which had almost disappeared.

Even though many initiatives have already been taken to identify factors which influence vaccine hesitancy (e.g. vaccine confidence project), and many initiatives are taken to increase vaccine confidence, especially new ways on how to tackle this issue would be most welcome. It is important that this high wave of vaccine hesitancy is somehow stopped before our countries are flooded again with vaccine-preventable diseases.

**Would you like to add some objectives to that challenge?** For example, can you imagine how you want the future to be with regard to this specific challenge. Is there any specific result that you want the research group to reach?

The interdisciplinary group will be asked to think about ways to increase confidence in vaccines and reduce complacency. This will be done by case studies of vaccines which have suffered from fake news (e.g. measles, HPV) in different countries. Through conversations with specialists of different disciplines (health psychology, sociology, communication, ...) and its own literature search, the group should suggest new steps on how to address vaccine hesitancy.

**Could you please let us know the context of the challenge and why you think this challenge is relevant to a transdisciplinary research team?** Please be aware that our transdisciplinary research teams accept only challenges that have to be dealt with from different points of view.

WHO and experts around the world recognize that loss of vaccine confidence is a growing challenge for vaccination programs and undermines the efforts that have been made in the past to eliminate some of the more serious infectious diseases. Vaccine hesitancy can be present in all countries, but underlying mechanisms can be different as vaccine hesitancy is also the result of a broader societal context and should be looked at in the historical, political, and socio-cultural context in which vaccination takes place. (Dubé et al., Vaccine 2014) By bringing together people from different disciplines (health psychology, sociology, informatics, medicine, communication, new technologies, ...), insights on vaccine hesitancy from other perspectives might help to find new ways to address this growing problem.

Could you indicate from which disciplines you want a researcher to address this challenge? You need to pick at least one from each domain.

**Domain of Humanities and Social Sciences:**

- Arts
- Canon Law
- Economics and Business
- Law
- Philosophy
- Psychology and Educational Sciences
- Social Sciences
- Theology and Religious Studies
- Other: \_\_\_\_\_

**Domain of Science, Engineering and Technology:**

- Architecture
- Bioscience Engineering
- Engineering Science
- Engineering Technology

- Sciences
- Other: IT, network specialists

#### Domain of Biomedicine:

- Kinesiology and Rehabilitation Sciences
- Medicine
- Pharmaceutical Sciences
- Other: \_\_\_\_\_

#### Can we contact you to get further details of your challenge?

Yes: [corinne.vandermeulen@kuleuven.be](mailto:corinne.vandermeulen@kuleuven.be)

#### Do you accept the terms and conditions for the proposition of this challenge? (See below)

- Yes
- No

#### Terms and Conditions

1. *Stakeholders (Students, University, Government, Industry, Society, and Not-for-profit Organizations) are invited to submit their challenges and also to share their insights to help address specific challenges, structured programs of analysis, and knowledge sharing to address specific questions around societal or global problems faced by people and planet based on transdisciplinary interactions. This may be in the form of Stakeholders providing background for the challenge, publishing articles, posting comments in online discussions, participating in in-person events, or in other ways sharing their expertise.*
2. *If a submitted challenge is selected for further research, the academic team could modify the submitted contents for formatting in a scientific frame*
3. *Stakeholders should ensure that they own the intellectual property rights or have secured the necessary permissions for content or ideas they share as part of a Challenge*
4. *Intellectual property rights over content shared by a Stakeholder as part of a Challenge will remain with the original owner of the intellectual property.*
5. *Stakeholders that submit or contribute to a challenge will not be entitled to any payment or reward for contributing content to a challenge.*
6. *The intellectual property rights of final Challenge outputs, such as, but not limited to, reports, papers, abstracts, videos, conferences, will belong solely to the 'Transdisciplinary Insights Course' based on the Honours programme regulated by the terms and conditions of the KU Leuven. These outputs will be made available in an open access 'Transdisciplinary Insights e-Journal'. Any other form of knowledge dissemination of the challenge output can be negotiated with the Academic team. Stakeholders agree that Challenge outputs can draw on content and ideas shared by them during the course of the Challenge, or shared on the 'Transdisciplinary Insights e-Journal' or at a 'Transdisciplinary Insights Course'-related event. Stakeholders agree to place no restrictions on the content that they share and grant permission to the 'Transdisciplinary Insights e-Journal' to draw on or reproduce or publish this content, with appropriate attribution, in producing the Challenge outputs.*
7. *Challenges are funded by supporters. Supporters' names and/or logos will be acknowledged by the 'Transdisciplinary Insights e-Journal'*
8. *'Transdisciplinary Insights Course' reserves the right to change or update these T&Cs from time to time without prior notice to you.*



## Supplement 2: Systems Map of Vaccine Coverage using the Kumu Software

Available at: <https://embed.kumu.io/05b50ce938a9b9028afc41c6533f4ea7>

The following introductory text accompanies the map:

### Vaccine Hesitancy and Vaccine Coverage

The idea of finding a solution to vaccine hesitancy and increasing vaccine coverage appears simple when first considered. However, after considerable research one would learn about the countless influences and factors that can have an impact on vaccine coverage in different populations. As researchers, we were able to illustrate the interconnected nature of elements impacting vaccine coverage, which helped clarify our initial confusion surrounding vaccine hesitancy. Ultimately, the goal of the project became to distill the complexity of the problem into an easily navigable map, and in this way our work can serve to inform the reader of the situation's complexity. We believe that before any solution can be found, one must first understand the subtleties of the problem they intend to solve.

When navigating this map, one might explore a single factor affecting vaccine coverage and soon find it affecting or being affected by several others. As the Greek historian, Thucydides, says, 'The worst thing is to rush into action before the consequences have been properly debated.' It is our hope that with this uniquely different approach we may provide a suitable place and insight for others to develop solutions to increase vaccine coverage themselves.

To understand this map:

- The legend includes the subdisciplines, such as individual and social psychology, which are uniquely involved in this wicked problem.
- Green arrows connecting the elements represent a positive relationship. For example, when there is an increase in 'vaccine confidence' there will also be an increase in 'vaccine coverage'.
- Red arrows connecting the elements represent a negative relationship. For example, when there is an increase in 'belief in delaying vaccinations' there will also be a subsequent decrease in 'adherence to vaccination programs'.
- The map is fluidly structured from bottom to top. Societal/herd factors situated near the bottom of the map influence individual decision making, culminating in the final vaccination decision at the apex of the map.

These connections do not imply direct causality, and may vary from region to region.

To read sources and information about the relationships between elements click on the connecting line. The information included in this map was compiled from various sources including an in-depth literature study of peer-reviewed articles, several interviews with (anonymous) stakeholders in the field of vaccination or healthcare. In some cases, logical reasoning steps are made in place of a direct literature citation, e.g. an increase in Vaccine Coverage will lead to a decrease in the Incidence of Vaccine-Preventable Diseases.

This map was compiled by an interdisciplinary team of 5 students:

Ellie Cassandra Clark (Biology/Psychology)  
Florian De Rop (Bioscience Engineering)  
Iria Anne Jimenez Garcia (Biomedical Science)  
Ana Nogal Macho (Bio-informatics)  
Ruel Alexander Mannette (Philosophy)  
Kaat Ramaekers (Supervisor)  
Prof. Corinne Vandermeulen (Supervising Professor)





## Supplement 3: Elements and Connections in the Systems Map Exported to Excel

Label	Type	Description
Amount of anti-vaccine religious beliefs	Individual Psychology	
Individuals range of Rebelliousness	Individual Psychology	
Trust in primary care physicians	Healthcare and Health	
Access to Vaccines	Healthcare and Health	
Quality of logistics infrastructure	Economics	
Length of Vaccine Tender	Economics	
Availability of alternative methods of vaccination	Vaccine Technology	
Level of Education of Society	Education	
Individual Nation-States Vaccine Budget	Economics	
Desire to be a good parent	Individual Psychology	Shui I, Kennedy A, Wooten K, Schwartz B, Gust D. Factors influencing African-American mothers' concerns about immunization safety: a summary of focus group findings. <i>J Natl Med Assoc</i> 2005; 97:657–66; PMID:15926642
Quality of Vaccination Registry	Healthcare and Health	
Number of vaccinations	Healthcare and Health	
Presence of Vaccine-related Infrastructure	Healthcare and Health	
Number of vaccines per needle	Vaccine Technology	
Vaccine Literacy of Society	Education	
Vaccine Coverage	Goal	
Rural Births	Healthcare and Health	Minor effect
Vaccine Convenience	Core Principles	Vaccination convenience is affected by: 1) Physical availability 2) Affordability/willingness-to-pay 3) Geographical accessibility 4) Ability to understand (language and health literacy) 5) Appeal of immunization services 6) The quality of the service (real and/or perceived) and 7) Degree to which vaccination services are delivered at a time and place and in a cultural context that is convenient and comfortable

Personal vaccination complications	Healthcare and Health	
Hostility of the Climate	Political and Environmental Sphere	
Experience with primary care physicians	Healthcare and Health	
Demand for Vaccines	Healthcare and Health	
Influence of Anti-vaccine Movement	Sources of Information	
Price of Vaccine	Economics	
Concerns for child well-being	Individual Psychology	
Number of shots per visit	Vaccine Technology	
Confidence in Omission Bias	Individual Psychology	<p>The concern of the consequences of doing something, (vaccine side effects), over the concern of not doing something, (vaccination).</p> <p>Benin AL, Wisler-Scher DJ, Colson E, Shapiro ED, Holmboe ES. Qualitative analysis of mothers' decisionmaking about vaccines for infants: the importance of trust. <i>Pediatrics</i> 2006; 117:1532–41; PMID:16651306; <a href="http://dx.doi.org/10.1542/peds.2005-1728">http://dx.doi.org/10.1542/peds.2005-1728</a></p> <p>Brown KF, Kroll JS, Hudson MJ, Ramsay M, Green J, Vincent CA, et al. Omission bias and vaccine rejection by parents of healthy children: implications for the influenza A/H1N1 vaccination programme. <i>Vaccine</i> 2010; 28:4181–5; PMID:20412878; <a href="http://dx.doi.org/10.1016/j.vaccine.2010.04.012">http://dx.doi.org/10.1016/j.vaccine.2010.04.012</a></p>
Confidence in Big Pharma	Sources of Information	
Privatization of Clinics	Economics	
Economic Prosperity	Economics	Per nation/region
Vaccine literacy of Parents	Education	
Vaccine Complacency	Core Principles	<p>Vaccination complacency is affected by:</p> <ol style="list-style-type: none"> <li>1) Vaccination is not deemed a necessary preventive action (due to low incidence of vaccine preventable disease)</li> <li>2) other life/health responsibilities that may be seen to be more important at that point in time.</li> <li>3) Immunization programme success may, paradoxically, result in complacency</li> <li>4) Individuals weigh risks of vaccination with a particular vaccine against risks of the disease the vaccine prevents that disease is no longer common.</li> <li>5) Self-efficacy (the self-perceived or real ability of an individual to take action to be vaccinated)</li> </ol>

Incidence of vaccine stockouts	Healthcare and Health	
Valuation of Personal Health	Individual Psychology	
Acceptance of vaccination social norms	Social Psychology	
Confidence in Government	Sources of Information	
Level of Education of Parents	Education	
Accuracy of the News	Sources of Information	
Ability to determine validity of vaccine information	Sources of Information	
Vaccine literacy of Healthcare Workers	Education	
Rate of Vaccine Completion	Healthcare and Health	
Degree of belief in Natural Holism	Individual Psychology	Degree of belief in Natural Holism represents the degree in which an individual ascribes to an inviolability of nature, whether philosophical or religious. Lower belief in natural holism represents a predilection to 'natural' products, practices and food while a higher belief represents a conception of natural sanctity (pantheistic) and omnipotence in which only 'natural cures' can work. It can overlap with various other religious and philosophical outlooks.
Adherence to Vaccination Programme	Healthcare and Health	
Local Experience with Pandemics	Healthcare and Health	
Range of Moral Sphere	Individual Psychology	The range of who you consider within your ethical sphere. The lowest is egoism, the mid-range is family or nationality the further extreme is all animal life and the farthest extreme is pantheism. This is meant as purely descriptive and not intended to bias one range over another. If you don't consider certain people within your moral sphere then appeals for their health are irrelevant for the individual.
Degree of Belief in Pseudoscience or Biased science	Sources of Information	
Trust in Health Care Workers	Healthcare and Health	
Susceptibility to conspiracies	Individual Psychology	
Localized Clinical Costs	Economics	
Quality of information on the internet	Sources of Information	

Influence of High profile Individuals	Social Psychology	
Quality of vaccine storage	Vaccine Technology	
Vaccine Confidence	Core Principles	Confidence is defined as trust in: (i) the effectiveness and safety of vaccines (ii) the system that delivers them, including the reliability and competence of the health services and health professionals (iii) the motivations of policy-makers who decide on the needed vaccines.
Passive Vaccination	Individual Psychology	“The biggest threat is not that 30% don’t vaccinate, but the threat is that people passively vaccinate – they do it because everyone else does it. They don’t really understand how it works. This is great if everyone vaccinates, but when you get a rumour, you get a wave effect because people just copy each other. People realise you have to invest in peace time, otherwise you don’t get resilience.”  *Robb Butler (in an interviewed by the students on 29/04/2019)*
Quality of Health Care Infrastructure	Healthcare and Health	
Level of Religiosity	Individual Psychology	Level of religiosity represents the degree in which an individual practices common religious activities, personally ascribes to religious beliefs and operates actively in a religious community or otherwise spiritually associated collective.
Predictability of Vaccine Demand	Healthcare and Health	
Indirect costs of Vaccines	Economics	
Short-term political Goals	Political and Environmental Sphere	**You saw that people vaccinate without thinking, do you think therefore that enhancing literacy is the way to go? **  “Yes, we have to put more emphasis on longer term return on investment. We need a long term objective in investing in parents before they become parents, in healthcare workers at the start of their curriculum, and better relationships with the media. All three aspects are important. My children already know a lot about smoking, traffic, reproduction, ... But not immunisation. What politicians want is something that pays off within their tenure. That’s something we have to try and get over. Immunisation is the corner stone of primary health care. There is no universal care unless you reach every child. If you have outbreaks and the inability to respond to outbreaks, then vaccine-preventable diseases should be the centre of your program. Medical practitioners have only 40 minutes on vaccinology. There’s something wrong with how we’re equipping our medical health care workers.”  *Robb Butler (in an interviewed by the students on 29/04/2019)*

Socio-Economic Status of Individual	Economics	
Health of individual	Healthcare and Health	
Confidence of Alternative Therapies	Alternatives to Vaccination	
Concern about side effects	Individual Psychology	
Incidence of Vaccine-preventable Disease	Healthcare and Health	
Influence of Peer Group	Social Psychology	
Parental Hesitancy	Individual Psychology	
Emergency Migrations	Political and Environmental Sphere	
Belief in delaying vaccinations	Individual Psychology	
Presence of Health Concepts in Media	Social Psychology	
Opportunity Cost for family seeking Vaccination	Economics	
Access to Healthcare	Healthcare and Health	
Wait Time for Vaccination	Economics	
Socio-cultural Morality Scale	Social Psychology	<p>This is ranging from high number on the scale which is extremely tight knit and collectivity focused to a low number on the scale which is extremely individualistic. This is following the psychologists Johnathan Haidt’s moral reasoning and its relationship to culture. Below is the paper on disgust and its cultural contingency.</p> <p>Haidt, Jonathan, Paul Rozin, Clark Mccauley, and Sumio Imada. “Body, Psyche, and Culture: The Relationship between Disgust and Morality.” <i>Psychology &amp; Developing Societies</i> 9, no. 1 (1997): 107–31.</p>
Stability of Government	Political and Environmental Sphere	

From	To	Type	Description
Access to Healthcare	Health of individual		Logical step. If there is no healthcare available, then the health of individuals would be affected.
Vaccine Confidence	Influence of Anti-vaccine Movement	Opposite	Hussain H, Omer SB, Manganello JA, Kromm EE, Carter TC, Kan L, et al. Immunization safety in US print media, 1995–2005. <i>Pediatrics</i> 2011; 127(Suppl 1):S100–6; PMID:21502237; <a href="http://dx.doi.org/10.1542/peds.2010-17220">http://dx.doi.org/10.1542/peds.2010-17220</a>  Kennedy A, Lavail K, Nowak G, Basket M, Landry S. Confidence about vaccines in the United States: understanding parents’ perceptions. <i>Health Aff (Millwood)</i> 2011; 30:1151–9; PMID:21653969; <a href="http://dx.doi.org/10.1377/hlthaff.2011.0396">http://dx.doi.org/10.1377/hlthaff.2011.0396</a>  Davies P, Chapman S, Leask J. Antivaccination activists on the world wide web. <i>Arch Dis Child</i> 2002; 87:22–5; PMID:12089115; <a href="http://dx.doi.org/10.1136/adc.87.1.22">http://dx.doi.org/10.1136/adc.87.1.22</a>  Kata, A. (2010). A postmodern Pandora’s box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i> , 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a>
Influence of Anti-vaccine Movement	Degree of Belief in Pseudoscience or Biased science		Kata, A. (2010). A postmodern Pandora’s box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i> , 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a>
Level of Religiosity	Range of Moral Sphere		Kahn, Peter A. “Bioethics, Religion, and Public Policy: Intersections, Interactions, and Solutions.” <i>Journal of Religion and Health</i> 55, no. 5 (2016): 1546–560.
Level of Religiosity	Degree of belief in Natural Holism		Increase in religiosity as an increased adherence to religious practices from any of the major world religions or belief systems and coinciding with a belief in the predominance of religious explanations for events in reality. This increase in a religious explanation for events in reality then will coincide with a preconception that nature functions either: seamlessly, along-a preordained plan, or that ‘nature’ represents a sacred whole that functions properly. This conception of nature as an unadulterated whole that functions holistically outside of human development is natural holism. The connection between the increase in religiosity is that religious explanations regarding nature are more likely tend to be totalizing of nature as it functions rather than viewing nature as ad hoc or fallible.
Hostility of the Climate	Emergency Migrations		Tacoli, C. (2009). Crisis or adaptation? migration and climate change in a context of high mobility. <i>Environment and Urbanization</i> , 21(2), 513–525. doi:10.1177/0956247809342182

Socio-cultural Morality Scale	Concerns for child well-being		<p>Based on the definition of socio-cultural morality scale, someone who scores highly in socio-cultural morality would be collectively focused on a community and would therefore also have an increased concern for child well being, as children are seen as being a part of said community. A decrease in socio-cultural morality would lead to more individualistic beliefs and tendencies, leading also to a decrease in concern for child well-being.</p> <p>Socio-cultural morality scale: This is ranging from high number on the scale which is extremely tight-knit and collectivity focused to a low number on the scale which is extremely individualistic. This is following the psychologists Johnathan Haidt's moral reasoning and its relationship to culture. Below is the paper on disgust and its cultural contingency.</p> <p>Haidt, Jonathan, Paul Rozin, Clark Mccauley, and Sumio Imada. "Body, Psyche, and Culture: The Relationship between Disgust and Morality." <i>Psychology &amp; Developing Societies</i> 9, no. 1 (1997): 107–31.</p>
Concern about side effects	Belief in delaying vaccinations		Gowda C, Dempsey AF. The rise (and fall?) of parental vaccine hesitancy. <i>Human Vaccines &amp; Immunotherapeutics</i> . 2013 Aug 8;9(8):1755–62.
Privatization of Clinics	Wait Time for Vaccination	Opposite	From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Parental Hesitancy	Vaccine Confidence	Opposite	Wheeler M, Bутtenheim AM. Parental vaccine concerns, information source, and choice of alternative immunization schedules. <i>Hum Vaccin Immunother</i> . 2013 Aug 1;9(8):1782–9.
Valuation of Personal Health	Vaccine Complacency		Logical step. A person who has an interest in their own personal health would be more likely to also be complacent with vaccinations.
Quality of Health Care Infrastructure	Localized Clinical Costs		From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Quality of vaccine storage	Incidence of vaccine stockouts	Opposite	Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Amount of anti-vaccine religious beliefs	Degree of Belief in Pseudoscience or Biased science		Julie Milstien, P. David Griffin & J-W. Lee (1995) Damage to immunisation programmes from misinformation on contraceptive vaccines, <i>Reproductive Health Matters</i> , 3:6, 24–28, DOI: 10.1016/0968-8080(95)90155-8

Desire to be a good parent	Range of Moral Sphere	Opposite	<p>Consider that an individual with a small moral sphere is more concerned about the well-being of those closest to them than any other living being or belief. It would logically follow that someone who desires to be a good parent would also be more concerned about the well-being of their child than most other things. Thus, the desire to be a good parent leads to a decrease in their moral-sphere. Based on the definition of moral sphere.</p> <p>Moral sphere: The range of who you consider within your ethical sphere. The lowest is egoism, the mid-range is family or nationality the further extreme is all animal life and the farthest extreme is pantheism. This is meant as purely descriptive and not intended to bias one range over another. If you do not consider certain people within your moral sphere then appeals for their health are irrelevant for the individual.</p>
Economic Prosperity	Quality of logistics infrastructure		Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Degree of Belief in Pseudoscience or Biased science	Vaccine Confidence	Opposite	Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i> , 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a>
Quality of information on the internet	Vaccine Confidence	Same	<p>As the quality of information on the internet regarding vaccines increases, or becomes more accessible and attractive, it would follow that those who subscribe to the information would become more confident in the safety of vaccines.</p> <p>Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A. Increasing Vaccination: Putting Psychological Science Into Action. <i>Psychological Science in the Public Interest</i>. 2017 Dec;18(3):149–207.</p>
Access to Vaccines	Adherence to Vaccination Programme		Direct relationship. It would make sense that if an individual has access to vaccines they would be more likely to adhere to a vaccine program.
Vaccine literacy of Healthcare Workers	Vaccine Literacy of Society		Gust DA, Kennedy A, Shui I, Smith PJ, Nowak G, Pickering LK. Parent attitudes toward immunizations and healthcare providers the role of information. <i>Am J Prev Med</i> 2005; 29:105–12; PMID:16005806; <a href="http://dx.doi.org/10.1016/j.amepre.2005.04.010">http://dx.doi.org/10.1016/j.amepre.2005.04.010</a>
Acceptance of vaccination social norms	Adherence to Vaccination Programme		<p>Shui I, Kennedy A, Wooten K, Schwartz B, Gust D. Factors influencing African-American mothers' concerns about immunization safety: a summary of focus group findings. <i>J Natl Med Assoc</i> 2005; 97:657–66; PMID:15926642</p> <p>Liu, Jiming. "A Computational Approach to Characterizing the Impact of Social Influence on Individuals' Vaccination Decision Making." <i>PLoS One</i> 8, no. 4 (2013): E60373.</p>



Desire to be a good parent	Concerns for child well-being	Same	Shui I, Kennedy A, Wooten K, Schwartz B, Gust D. Factors influencing African-American mothers' concerns about immunization safety: a summary of focus group findings. <i>J Natl Med Assoc</i> 2005; 97:657–66; PMID:15926642
Accuracy of the News	Degree of Belief in Pseudoscience or Biased science	Opposite	Articles most likely to be shared contain information that is an easily identifiable 'gist'. Articles of these types tend to be 'click-bait' and are known to misrepresent data. The misrepresented data can be used to reinforce individuals belief in biased or pseudoscience science. Therefore, the accuracy of the news would an effect on the degree of belief in biased or pseudoscience.  Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A. Increasing Vaccination: Putting Psychological Science Into Action. <i>Psychological Science in the Public Interest</i> . 2017 Dec;18(3):176.
Incidence of Vaccine-preventable Disease	Health of individual	Opposite	MacDonald, N. E., Eskola, J., Liang, X., Chaudhuri, M., Dube, E., Gellin, B., ... Schuster, M. (2015). Vaccine hesitancy: Definition, scope and determinants. <i>Vaccine</i> , 33(34), 4161–4164. doi:10.1016/j.vaccine.2015.04.036
Personal vaccination complications	Concern about side effects		Logical step. Complications from vaccines can include health risks, such as developing a fever- which can increase individual concern about the side effects of other vaccinations as well.
Experience with primary care physicans	Trust in primary care physicians	Opposite	Bardenheier BH, Yusuf HR, Rosenthal J, Santoli JM, Shefer AM, Rickert DL, et al. Factors associated with underimmunization at 3 months of age in four medically underserved areas. <i>Public Health Rep</i> 2004; 119:479–85; PMID:15313111; <a href="http://dx.doi.org/10.1016/j.phr.2004.07.005">http://dx.doi.org/10.1016/j.phr.2004.07.005</a>
Quality of logistics infrastructure	Incidence of vaccine stockouts	Opposite	Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Desire to be a good parent	Belief in delaying vaccinations		Among vaccine-hesitant parents, it is a common belief that delaying vaccines is healthier for their children as it allows the child's immune system to mature, as opposed to the normal schedule that many feels are too much of a demand on their children. Therefore, these parents are acting in a manner that seeks the best interests of their children and would consider themselves good parents for doing so.  Gowda C, Dempsey AF. The rise (and fall?) of parental vaccine hesitancy. <i>Human Vaccines &amp; Immunotherapeutics</i> . 2013 Aug 8;9(8):1755–62.
Vaccine Literacy of Society	Passive Vaccination	Opposite	From an interview with a social scientist specializing in public health interventions and social safeguards, former head of national NGO.

Stability of Government	Economic Prosperity		La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (1999). The quality of government. <i>Journal of Law, Economics, and Organization</i> , 15(1), 222–279.
Degree of Belief in Pseudoscience or Biased science	Confidence in Big Pharma	Opposite	Based on an interview with a single male in his mid-twenties who is vaccine-hesitant.
Concerns for child well-being	Desire to be a good parent		Logical step. A parent that is concerned for their child's well being is typically intrinsically motivated to be a good parent as well.
Economic Prosperity	Emergency Migrations	Opposite	From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Personal vaccination complications	Parental Hesitancy		Gowda C, Dempsey AF. The rise (and fall?) of parental vaccine hesitancy. <i>Human Vaccines &amp; Immunotherapeutics</i> . 2013 Aug 8;9(8):1755–62.
Presence of Vaccine-related Infrastructure	Vaccine Confidence		From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Influence of High profile Individuals	Parental Hesitancy	Opposite	Scherer LD, Shaffer VA, Patel N, Zikmund-Fisher BJ. Can the vaccine adverse event reporting system be used to increase vaccine acceptance and trust? <i>Vaccine</i> . 2016;34:2424–9.
Vaccine Coverage	Incidence of Vaccine-preventable Disease	Opposite	Logical step. An increase in vaccine coverage would lead to a decrease in vaccine-preventable diseases among the general population.  MacDonald, N. E., Eskola, J., Liang, X., Chaudhuri, M., Dube, E., Gellin, B., ... Schuster, M. (2015). Vaccine hesitancy: Definition, scope and determinants. <i>Vaccine</i> , 33(34), 4161–4164. doi:10.1016/j.vaccine.2015.04.036
Quality of Health Care Infrastructure	Price of Vaccine	Opposite	From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Quality of information on the internet	Degree of Belief in Pseudoscience or Biased science	Opposite	The quality of information on the internet is affected by the increasing popularity of vaccine-hesitant websites that provide incorrect or biased science that is often supported by so-called “whistle-blowers” in positions of power- Andrew Wakefield. Therefore, as the quality of the information on the internet changes, for example, decreases in quality, the degree of belief in pseudoscience or biased science would fluctuate in response, in this case, increase.  Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A. Increasing Vaccination: Putting Psychological Science Into Action. <i>Psychological Science in the Public Interest</i> . 2017 Dec;18(3):157
Number of vaccines per needle	Number of shots per visit	Opposite	Logical Step: if the number of vaccines able to be delivered per needle were to increase the number of shots required per visit to achieve the recommended vaccinations would decrease.

Concerns for child well-being	Concern about side effects		Logical step. A parent who is concerned about their child’s well being would also be likely to be concerned about any possible side effects that may arise from a vaccination.
Economic Prosperity	Stability of Government		From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Vaccine Convenience	Vaccine Coverage		MacDonald, N. E., Eskola, J., Liang, X., Chaudhuri, M., Dube, E., Gellin, B., ... Schuster, M. (2015). Vaccine hesitancy: Definition, scope and determinants. <i>Vaccine</i> , 33(34), 4161–4164. doi:10.1016/j.vaccine.2015.04.036
Trust in Health Care Workers	Influence of Peer Group	Opposite	Bardenheier BH, Yusuf HR, Rosenthal J, Santoli JM, Shefer AM, Rickert DL, et al. Factors associated with underimmunization at 3 months of age in four medically underserved areas. <i>Public Health Rep</i> 2004; 119:479–85; PMID:15313111; <a href="http://dx.doi.org/10.1016/j.phr.2004.07.005">http://dx.doi.org/10.1016/j.phr.2004.07.005</a>
Accuracy of the News	Vaccine Confidence		Articles most likely to be shared contain information that is an easily identifiable ‘gist’. Articles of these types tend to be ‘click-bait’ and are known to misrepresent data. The misrepresented data can be used to decrease the individual’s confidence in vaccines. Therefore, the accuracy of the news would affect vaccine confidence.  Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A. Increasing Vaccination: Putting Psychological Science Into Action. <i>Psychological Science in the Public Interest</i> . 2017 Dec;18(3):176.
Quality of Vaccination Registry	Rate of Vaccine Completion		Hill, D. R., Ericsson, C. D., Pearson, R. D., Keystone, J. S., Freedman, D. O., Kozarsky, P. E., ... Ryan, E. T. (2006). The practice of travel medicine: Guidelines by the infectious diseases society of america. <i>Clinical Infectious Diseases</i> , 43(12), 1499–1539. doi:10.1086/508782
Influence of Anti-vaccine Movement	Parental Hesitancy		Davies P, Chapman S, Leask J. Antivaccination activists on the world wide web. <i>Arch Dis Child</i> 2002; 87:22–5; PMID:12089115; <a href="http://dx.doi.org/10.1136/adc.87.1.22">http://dx.doi.org/10.1136/adc.87.1.22</a>
Indirect costs of Vaccines	Adherence to Vaccination Programme	Opposite	From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Range of Moral Sphere	Vaccine Complacency		Someone with a high moral sphere, who might consider all living beings as being ethically important to them, would also be highly likely to be vaccine complacent in order to prevent vaccine-preventable illnesses and to contribute to herd immunity. Someone with a smaller moral sphere might be less likely to be vaccine complacent as they would be more likely to succumb to concerns about vaccine side effects or may not be personally interested in vaccinating themselves. Based on the definition of the moral sphere.

			Moral sphere: The range of who you consider within your ethical sphere. The lowest is egoism, the mid-range is family or nationality the further extreme is all animal life and the furthest extreme is pantheism. This is meant as purely descriptive and not intended to bias one range over another. If one does not consider certain people within their moral sphere then appeals for the health of other people are irrelevant for the individual.
Individual Nation-States Vaccine Budget	Privatization of Clinics	Opposite	From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Concern about side effects	Confidence in Omission Bias		Benin AL, Wisler-Scher DJ, Colson E, Shapiro ED, Holmboe ES. Qualitative analysis of mothers' decision-making about vaccines for infants: the importance of trust. <i>Pediatrics</i> 2006; 117:1532–41; PMID:16651306; <a href="http://dx.doi.org/10.1542/peds.2005-1728">http://dx.doi.org/10.1542/peds.2005-1728</a>  Brown KF, Kroll JS, Hudson MJ, Ramsay M, Green J, Vincent CA, et al. Omission bias and vaccine rejection by parents of healthy children: implications for the influenza A/H1N1 vaccination programme. <i>Vaccine</i> 2010; 28:4181–5; PMID:20412878; <a href="http://dx.doi.org/10.1016/j.vaccine.2010.04.012">http://dx.doi.org/10.1016/j.vaccine.2010.04.012</a>
Quality of logistics infrastructure	Quality of Health Care Infrastructure		From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Valuation of Personal Health	Vaccine Complacency		Logical step, someone who highly values their personal health would be more likely to also comply with vaccinations. Thus, when the valuation of their personal health increases, so does their likelihood to also be vaccine complacent.
Length of Vaccine Tender	Price of Vaccine	Opposite	From an interview with a professor of vaccinology at Katholieke Universiteit Leuven.
Stability of Government	Quality of logistics infrastructure		From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Predictability of Vaccine Demand	Incidence of vaccine stockouts	Opposite	From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Access to Vaccines	Vaccine Convenience		Logical Step: Insofar as Vaccine convenience is defined by the degree in which vaccines are accessible in a given locale (i.e. convenient when accessible inconvenient when inaccessible) it only follows that the access to vaccines would directly impact this.

Socio-cultural Morality Scale	Acceptance of vaccination social norms		<p>Socio-cultural morality scale: This is ranging from high number on the scale which is extremely tight-knit and collectivity focused to a low number on the scale which is extremely individualistic. This is following the psychologists Johnathan Haidt’s moral reasoning and its relationship to culture. Below is the paper on disgust and its cultural contingency.</p> <p>Based on this definition, as an individual’s socio-cultural morality scale increases and they become more focused on the collective well being of those surrounding them, it would be logical that these people are more likely to accept the vaccination social norms of those around them. These vaccination social norms would include the population’s beliefs towards vaccinations at that point in time, which would generally be positive towards vaccinations but could also be negative. Thus, as an individual becomes more concerned about the well being of the collective, they would also be more likely to adhere to the beliefs about vaccines around them.</p>
Quality of Health Care Infrastructure	Vaccine Convenience		From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Price of Vaccine	Access to Vaccines	Opposite	From an interview with a professor of health economics at Katholieke Universiteit Leuven.
Access to Healthcare	Wait Time for Vaccination	Opposite	From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Vaccine Confidence	Confidence in Omission Bias	Opposite	<p>Logical step. If an individual becomes more confident in the efficacy of vaccines, they will be less likely to rely on omission bias. Omission bias occurs when an individual is more likely to avoid a certain action due to the possibility of negative consequences regardless of the possible consequences that would be a result of doing nothing.</p> <p>Benin AL, Wisler-Scher DJ, Colson E, Shapiro ED, Holmboe ES. Qualitative analysis of mothers’ decisionmaking about vaccines for infants: the importance of trust. <i>Pediatrics</i> 2006; 117:1532–41; PMID:16651306; <a href="http://dx.doi.org/10.1542/peds.2005-1728">http://dx.doi.org/10.1542/peds.2005-1728</a></p> <p>Brown KF, Kroll JS, Hudson MJ, Ramsay M, Green J, Vincent CA, et al. Omission bias and vaccine rejection by parents of healthy children: implications for the influenza A/H1N1 vaccination programme. <i>Vaccine</i> 2010; 28:4181–5; PMID:20412878; <a href="http://dx.doi.org/10.1016/j.vaccine.2010.04.012">http://dx.doi.org/10.1016/j.vaccine.2010.04.012</a></p>

Socio-Economic Status of Individual	Health of individual	Same	Krieger, N., Williams, D. R., & Moss, N. E. (1997). Measuring social class in us public health research: Concepts, methodologies, and guidelines doi:10.1146/annurev.publhealth.18.1.341  Bloom, D. E., Canning, D., & Sevilla, J. (2004). The effect of health on economic growth: A production function approach. <i>World Development</i> , 32(1), 1–13. doi:10.1016/j.worlddev.2003.07.002
Number of vaccinations	Vaccine Complacency	Opposite	Logical Step: The number of vaccines decreases the prevalence of vaccine preventable diseases in a given population (herd immunity). In addition, a lack vaccine preventable diseases in a given population is a precondition for complacency. (There must be no/limited diseases for a group to not worry about them). Furthermore, Vaccination is the most likely way for this lack to occur. Therefore, Vaccination is the most likely way to achieve the precondition for complacency.
Influence of Anti-vaccine Movement	Confidence in Big Pharma	Opposite	Smith, T. C. Vaccine Rejection and Hesitancy: A Review and Call to Action. <i>Open Forum Infect. Dis.</i> 4, (2017).
Number of vaccinations	Adherence to Vaccination Programme		From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa, a global health advisor for European Commission Humanitarian Aid Office, as well as a professor of health economics at Katholieke Universiteit Leuven.
Confidence in Omission Bias	Parental Hesitancy	Same	Benin AL, Wisler-Scher DJ, Colson E, Shapiro ED, Holmboe ES. Qualitative analysis of mothers' decision-making about vaccines for infants: the importance of trust. <i>Pediatrics</i> 2006; 117:1532–41; PMID:16651306; <a href="http://dx.doi.org/10.1542/peds.2005-1728">http://dx.doi.org/10.1542/peds.2005-1728</a>  Brown KF, Kroll JS, Hudson MJ, Ramsay M, Green J, Vincent CA, et al. Omission bias and vaccine rejection by parents of healthy children: implications for the influenza A/H1N1 vaccination programme. <i>Vaccine</i> 2010; 28:4181–5; PMID:20412878; <a href="http://dx.doi.org/10.1016/j.vaccine.2010.04.012">http://dx.doi.org/10.1016/j.vaccine.2010.04.012</a>
Amount of anti-vaccine religious beliefs	Vaccine Confidence	Opposite	Those who follow religions that either place restrictions on not receiving vaccines or the beliefs are against them would also be more likely to not be confident in the efficacy of vaccines. Therefore, as the more an individual adheres to religions that deter vaccinations the less likely the individual would be confident in getting vaccines.
Influence of High profile Individuals	Influence of Anti-vaccine Movement		Scherer LD, Shaffer VA, Patel N, Zikmund-Fisher BJ. Can the vaccine adverse event reporting system be used to increase vaccine acceptance and trust? <i>Vaccine</i> . 2016;34:2424–9.

Acceptance of vaccination social norms	Parental Hesitancy		<p>Kennedy A, Lavail K, Nowak G, Basket M, Landry S. Confidence about vaccines in the United States: understanding parents' perceptions. <i>Health Aff (Millwood)</i> 2011; 30:1151–9; PMID:21653969; <a href="http://dx.doi.org/10.1377/hlthaff.2011.0396">http://dx.doi.org/10.1377/hlthaff.2011.0396</a></p> <p>Liu, Jiming. "A Computational Approach to Characterizing the Impact of Social Influence on Individuals' Vaccination Decision Making." <i>PLoS One</i> 8, no. 4 (2013): E60373.</p>
Emergency Migrations	Economic Prosperity	Opposite	<p>Akanbi, Olusegun Ayodele. <i>International Journal of Social Economics</i> 44, no. 5 (2017): 683–95.</p> <p>Cooper, Richard. "Recent Books on International Relations: Economic, Social, and Environmental: Diaspora, Development, and Democracy: The Domestic Impact of International Migration From India." <i>Foreign Affairs</i> 90, no. 1 (2011): 175.</p>
Vaccine literacy of Parents	Trust in Health Care Workers	Opposite	<p>Opel DJ, Taylor JA, Mangione-Smith R, Solomon C, Zhao C, Catz S, et al. Validity and reliability of a survey to identify vaccine-hesitant parents. <i>Vaccine</i> 2011; 29:6598–605; PMID:21763384; <a href="http://dx.doi.org/10.1016/j.vaccine.2011.06.115">http://dx.doi.org/10.1016/j.vaccine.2011.06.115</a></p>
Desire to be a good parent	Vaccine Confidence		<p>Shui I, Kennedy A, Wooten K, Schwartz B, Gust D. Factors influencing African-American mothers' concerns about immunization safety: a summary of focus group findings. <i>J Natl Med Assoc</i> 2005; 97:657–66; PMID:15926642</p>
Economic Prosperity	Quality of Vaccination Registry		<p>From an interview with a professor of health economics at Katholieke Universiteit Leuven.</p>
Influence of Anti-vaccine Movement	Acceptance of vaccination social norms	Opposite	<p>Navin, Mark (2013) Disgust, Contamination, and Vaccine Refusal. In: [2013] 3rd Annual Values in Medicine, Science, and Technology Conference (Dallas; 22–24 May 2013) <a href="http://philsci-archive.pitt.edu/view/confandvol/confandvol2013avmstcdallas2224may2013.html">http://philsci-archive.pitt.edu/view/confandvol/confandvol2013avmstcdallas2224may2013.html</a>. URL: <a href="http://philsci-archive.pitt.edu/id/eprint/9767">http://philsci-archive.pitt.edu/id/eprint/9767</a> (accessed 2019–02–07).</p>
Access to Healthcare	Access to Vaccines		<p>Logical step.</p> <p>Health infrastructure is required for the ordering and delivery of vaccines.</p>
Confidence of Alternative Therapies	Vaccine Confidence	Opposite	<p>Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i>, 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a></p>
Experience with primary care physicians	Trust in Health Care Workers	Opposite	<p>Experiences with primary care physicians had a direct impact on the trust individuals place in health care workers in general. People who had positive experiences were more likely to have trust in health care workers.</p> <p>Gowda C, Dempsey AF. The rise (and fall?) of parental vaccine hesitancy. <i>Human Vaccines &amp; Immunotherapeutics</i>. 2013 Aug 8;9(8):1755–62.</p>

Socio-cultural Morality Scale	Individuals range of Rebelliousness	Opposite	Sobo, ELISA J. "THEORIZING (VACCINE) REFUSAL: Through the Looking Glass." <i>Cultural Anthropology</i> 31, no. 3 (2016): 342–50.
Stability of Government	Emergency Migrations	Opposite	Calderón, Irene Rivera. (2017, May 5). Migration: Causes, Conflict, and Policy Solutions. Retrieved from <a href="http://www.saisjournal.org/posts/migration">http://www.saisjournal.org/posts/migration</a> .  Zieseimer, Thomas H. W. H. "Developing Countries' Net-migration: The Impact of Economic Opportunities, Disasters, Conflicts, and Political Instability." <i>International Economic Journal</i> 25, no. 3 (2011): 373–86.
Rural Births	Predictability of Vaccine Demand	Opposite	From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Presence of Vaccine-related Infrastructure	Quality of Vaccination Registry		Hill, D. R., Ericsson, C. D., Pearson, R. D., Keystone, J. S., Freedman, D. O., Kozarsky, P. E., ... Ryan, E. T. (2006). The practice of travel medicine: Guidelines by the infectious diseases society of america. <i>Clinical Infectious Diseases</i> , 43(12), 1499–1539. doi:10.1086/508782
Passive Vaccination	Vaccine Complacency		From an interview with a social scientist specializing in public health interventions and social safeguards, former head of national NGO.
Socio-cultural Morality Scale	Range of Moral Sphere		Socio-cultural Morality Scale being a range from individualist to communal socio-cultural patterns. So seeing communal as high and individualist as low.  Range of moral sphere being: a large moral sphere means a larger group of assumed moral actors while a smaller moral sphere entails a smaller group of assumed moral actors. An example: A very large moral sphere including all humans, plants, and animals a very small moral sphere being only a select group of humans worthy as moral actors. (e.g. Aristotle's specific rational wealthy males). This scale is assumed value-neutral as to which range would be better or worse and is instead meant as an empirical evaluation of the ranges of morals for individuals. It is assumed that these examples are extreme and the exact range of beings people assume are moral agents. This moral sphere can also contain internal hierarchies where ones family or religion may be valued above others but the individual may still consider all of humanity for instance as moral actors. Egoism as the lowest pantheism as the highest.



			Based on these definitions we can see that a social-cultural morality scale that is more individualist would lead to a decrease in range of moral sphere assuming that the range of the moral sphere is impacted by the broader socio-cultural morality scale. We are not assuming that this connection is deterministic and necessarily follows. Rather, that the social pressures of the socio-cultural morality will more often be mimicked in the individuals own moral sphere.
Confidence in Omission Bias	Vaccine Confidence	Opposite	Based on an interview with a single male in his mid-twenties who is vaccine-hesitant.
Belief in delaying vaccinations	Adherence to Vaccination Programme	Opposite	Based on an interview with a single male in his mid-twenties who is vaccine-hesitant.
Economic Prosperity	Socio-Economic Status of Individual		General relation between wealth of society and wealth of the individual  Horton, R. (2000). The health and wealth of nations. <i>Science</i> , 287(5456), 1207–1209. doi:10.1126/science.287.5456.1207
Adherence to Vaccination Programme	Vaccine Coverage		Logical step. If more people adhere to vaccination schedules, vaccine coverage then increases as well.
Vaccine Complacency	Vaccine Coverage		MacDonald, N. E., Eskola, J., Liang, X., Chaudhuri, M., Dube, E., Gellin, B., ... Schuster, M. (2015). Vaccine hesitancy: Definition, scope and determinants. <i>Vaccine</i> , 33(34), 4161–4164. doi:10.1016/j.vaccine.2015.04.036
Short-term political Goals	Vaccine Literacy of Society		From an interview with a social scientist specializing in public health interventions and social safeguards, former head of national NGO.
Level of Education of Parents	Vaccine literacy of Parents	Opposite	Gust DA, Kennedy A, Shui I, Smith PJ, Nowak G, Pickering LK. Parent attitudes toward immunizations and healthcare providers the role of information. <i>Am J Prev Med</i> 2005; 29:105–12; PMID:16005806; <a href="http://dx.doi.org/10.1016/j.amepre.2005.04.010">http://dx.doi.org/10.1016/j.amepre.2005.04.010</a>
Incidence of vaccine stockouts	Vaccine Convenience	Opposite	Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Quality of logistics infrastructure	Access to Health-care		Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Availability of alternative methods of vaccination	Number of shots per visit	Opposite	Based on an interview with a single male in his mid-twenties who is vaccine-hesitant and a professor of health economics at Katholieke Universiteit Leuven.

Localized Clinical Costs	Indirect costs of Vaccines		From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Number of shots per visit	Concern about side effects		From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Individual Nation-States Vaccine Budget	Length of Vaccine Tender		From an interview with a professor of vaccinology at Katholieke Universiteit Leuven.
Degree of belief in Natural Holism	Confidence of Alternative Therapies		Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i> , 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a>
Quality of Health Care Infrastructure	Economic Prosperity		Piabuo, S. M. & Tieguhong, J. C. Health expenditure and economic growth - a review of the literature and an analysis between the economic community for central African states (CEMAC) and selected African countries. <i>Health Econ. Rev.</i> 7, (2017).
Individuals range of Rebelliousness	Vaccine Complacency		Sobo, ELISA J. "THEORIZING (VACCINE) REFUSAL: Through the Looking Glass." <i>Cultural Anthropology</i> 31, no. 3 (2016): 342–50.
Degree of Belief in Pseudoscience or Biased science	Influence of Anti-vaccine Movement		Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i> , 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a>
Incidence of vaccine stockouts	Adherence to Vaccination Programme	Opposite	Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Incidence of vaccine stockouts	Access to Vaccines	Opposite	Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Level of Religiosity	Amount of anti-vaccine religious beliefs		Khan, Muhammad, Umair Ahmad, Akram Salman, Saad Ayub, Maria Aqeel, Talieha Haq, and Noman-ul Saleem. "Muslim Scholars' Knowledge, Attitudes and Perceived Barriers Towards Polio Immunization in Pakistan." <i>Journal of Religion and Health</i> 56, no. 2 (2017): 635–48.  Grabenstein, John D. "What the World's Religions Teach, Applied to Vaccines and Immune Globulins." <i>Vaccine</i> 31, no. 16 (2013): 2011–023.

Level of Education of Society	Economic Prosperity		Gylfason, T. (2001). Natural resources, education, and economic development. <i>European Economic Review</i> , 45(4–6), 847–859. doi:10.1016/S0014-2921(01)00127-1
Wait Time for Vaccination	Opportunity Cost for family seeking Vaccination		From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Belief in delaying vaccinations	Vaccine Confidence	Opposite	Gowda C, Dempsey AF. The rise (and fall?) of parental vaccine hesitancy. <i>Human Vaccines &amp; Immunotherapeutics</i> . 2013 Aug 8;9(8):1755–62.
Opportunity Cost for family seeking Vaccination	Indirect costs of Vaccines		From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Degree of belief in Natural Holism	Amount of anti-vaccine religious beliefs		Grabenstein, John D. “What the World’s Religions Teach, Applied to Vaccines and Immune Globulins.” <i>Vaccine</i> 31, no. 16 (2013): 2011–023.
Degree of belief in Natural Holism	Parental Hesitancy	Same	Kata, A. (2010). A postmodern Pandora’s box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i> , 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a>
Opportunity Cost for family seeking Vaccination	Adherence to Vaccination Programme	Opposite	From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Susceptibility to conspiracies	Confidence in Big Pharma	Opposite	Based on an interview with a single male in his mid-twenties who is vaccine-hesitant.
Level of Education of Parents	Concern about side effects		Opel DJ, Taylor JA, Mangione-Smith R, Solomon C, Zhao C, Catz S, et al. Validity and reliability of a survey to identify vaccine-hesitant parents. <i>Vaccine</i> 2011; 29:6598–605; PMID:21763384; <a href="http://dx.doi.org/10.1016/j.vaccine.2011.06.115">http://dx.doi.org/10.1016/j.vaccine.2011.06.115</a>
Level of Education of Parents	Level of Education of Society		Logical step. If we consider that the parents are individual actors within a society, it would follow that the level of education the parents obtain would have an influence not only on the education of their child but would also contribute to the education level of their society.
Confidence in Big Pharma	Vaccine Confidence		Based on an interview with a single male in his mid-twenties who is vaccine-hesitant.
Economic Prosperity	Access to Healthcare		Krieger, N., Williams, D. R., & Moss, N. E. (1997). Measuring social class in us public health research: Concepts, methodologies, and guidelines doi:10.1146/annurev.publhealth.18.1.341 Retrieved from <a href="http://www.scopus.com">www.scopus.com</a>

Ability to determine validity of vaccine information	Vaccine literacy of Parents		Gust DA, Kennedy A, Shui I, Smith PJ, Nowak G, Pickering LK. Parent attitudes toward immunizations and healthcare providers the role of information. <i>Am J Prev Med</i> 2005; 29:105–12; PMID:16005806; <a href="http://dx.doi.org/10.1016/j.amepre.2005.04.010">http://dx.doi.org/10.1016/j.amepre.2005.04.010</a>
Level of Education of Parents	Ability to determine validity of vaccine information		Gust DA, Kennedy A, Shui I, Smith PJ, Nowak G, Pickering LK. Parent attitudes toward immunizations and healthcare providers the role of information. <i>Am J Prev Med</i> 2005; 29:105–12; PMID:16005806; <a href="http://dx.doi.org/10.1016/j.amepre.2005.04.010">http://dx.doi.org/10.1016/j.amepre.2005.04.010</a>
Access to Health-care	Adherence to Vaccination Programme		From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Confidence in Omission Bias	Parental Hesitancy		Benin AL, Wisler-Scher DJ, Colson E, Shapiro ED, Holmboe ES. Qualitative analysis of mothers’ decision-making about vaccines for infants: the importance of trust. <i>Pediatrics</i> 2006; 117:1532–41; PMID:16651306; <a href="http://dx.doi.org/10.1542/peds.2005-1728">http://dx.doi.org/10.1542/peds.2005-1728</a>  Brown KF, Kroll JS, Hudson MJ, Ramsay M, Green J, Vincent CA, et al. Omission bias and vaccine rejection by parents of healthy children: implications for the influenza A/H1N1 vaccination programme. <i>Vaccine</i> 2010; 28:4181–5; PMID:20412878; <a href="http://dx.doi.org/10.1016/j.vaccine.2010.04.012">http://dx.doi.org/10.1016/j.vaccine.2010.04.012</a>
Vaccine literacy of Parents	Adherence to Vaccination Programme	Opposite	Opel DJ, Taylor JA, Mangione-Smith R, Solomon C, Zhao C, Catz S, et al. Validity and reliability of a survey to identify vaccine-hesitant parents. <i>Vaccine</i> 2011; 29:6598–605; PMID:21763384; <a href="http://dx.doi.org/10.1016/j.vaccine.2011.06.115">http://dx.doi.org/10.1016/j.vaccine.2011.06.115</a>
Degree of belief in Natural Holism	Degree of Belief in Pseudoscience or Biased science		“In addition, these parents were not convinced that vaccines worked, stating ‘there is no evidence proving vaccine’s effectiveness [as a way to prevent disease]’ and, ‘If immunizations worked, you wouldn’t have epidemics.’ Rather, relying on natural immunity was a motivation for some parents who believed as this parent wrote that, ‘All diseases can be prevented and cured using safe natural means, without resorting to manufactured chemical processes.’ Parents also believed that if they used natural methods for boosting the child’s immune system, vaccinations were not needed. As stated by several parents, ‘... I believe [the] body can heal itself’ and, ‘I know there are other options to prevent disease. I work at a natural health clinic’ and, ‘I use homeopathic methods to build up my child’s immune system (a natural alternative).”

			Luthy, Karlen E, Renea L Beckstrand, Lynn C Callister, and Spencer Cahoon. "Reasons Parents Exempt Children From Receiving Immunizations." <i>The Journal of School Nursing</i> 28, no. 2 (2012): 153–60.
Vaccine Confidence	Confidence of Alternative Therapies	Opposite	Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i> , 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a>
Degree of belief in Natural Holism	Confidence in Omission Bias		Natural holism as conception of nature as an unadulterated whole that functions holistically outside of human development.  Omission bias, in this case, being the assumption that avoiding something (vaccines) that has known side effects is inherently safer. This misses the possibility that the results of not doing anything could potentially be worse.  So if you assume nature functions ideally or perfectly without human interaction this allows people to more confidently assume that their omission of the dangers potentially associated with side effects of vaccine will therefore be safer. Natural holism provides an increase in confidence for omission bias. (Conclusions drawn based off of an interview with vaccine hesitant individual )
Degree of belief in Natural Holism	Vaccine Confidence	Opposite	Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. <i>Vaccine</i> , 28(7), 1709–1716. <a href="https://doi.org/10.1016/j.vaccine.2009.12.022">https://doi.org/10.1016/j.vaccine.2009.12.022</a>
Level of Education of Society	Vaccine Literacy of Society		Van der Heide, I. et al. The relationship between health, education, and health literacy: results from the Dutch Adult Literacy and Life Skills Survey. <i>J. Health Commun.</i> 18 Suppl 1, 172–184 (2013).
Influence of Anti-vaccine Movement	Vaccine Confidence	Opposite	Direct relationship. Vaccine confidence is lowered by increasing influence of the anti-vaccine movement.  Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A. Increasing Vaccination: Putting Psychological Science Into Action. <i>Psychological Science in the Public Interest.</i> 2017 Dec;18(3):149–207.
Vaccine Confidence	Vaccine Coverage		MacDonald, N. E., Eskola, J., Liang, X., Chaudhuri, M., Dube, E., Gellin, B., ... Schuster, M. (2015). Vaccine hesitancy: Definition, scope and determinants. <i>Vaccine</i> , 33(34), 4161–4164. doi:10.1016/j.vaccine.2015.04.036
Rate of Vaccine Completion	Vaccine Coverage		Direct relationship. It would make sense that vaccine completion would lead to an increase in vaccine coverage as well.
Quality of Vaccination Registry	Predictability of Vaccine Demand		Logical Step. While no study inherently states that the quality of vaccine registration impacts the forecasting of vaccine demand. It can be gathered that as this information is key in predicting demand, having a higher quality vaccine registry will improve the accuracy of vaccine demand.

			<p>From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.</p> <p>Chiu, R., Chang, C. &amp; Chang, Y. A Forecasting Model for Deciding Annual Vaccine Demand. in 2008 Fourth International Conference on Natural Computation 7, 107–111 (2008).</p>
Trust in primary care physicians	Concern about side effects		<p>Gust DA, Woodruff R, Kennedy A, Brown C, Sheedy K, Hibbs B. Parental perceptions surrounding risks and benefits of immunization. <i>Semin Pediatr Infect Dis</i> 2003; 14:207–12; PMID:12913833; <a href="http://dx.doi.org/10.1016/S1045-1870(03)00035-9">http://dx.doi.org/10.1016/S1045-1870(03)00035-9</a></p>
Trust in Health Care Workers	Vaccine Confidence		<p>Gust DA, Woodruff R, Kennedy A, Brown C, Sheedy K, Hibbs B. Parental perceptions surrounding risks and benefits of immunization. <i>Semin Pediatr Infect Dis</i> 2003; 14:207–12; PMID:12913833; <a href="http://dx.doi.org/10.1016/S1045-1870(03)00035-9">http://dx.doi.org/10.1016/S1045-1870(03)00035-9</a></p>
Socio-Economic Status of Individual	Concern about side effects		<p>Opel DJ, Taylor JA, Mangione-Smith R, Solomon C, Zhao C, Catz S, et al. Validity and reliability of a survey to identify vaccine-hesitant parents. <i>Vaccine</i> 2011; 29:6598–605; PMID:21763384; <a href="http://dx.doi.org/10.1016/j.vaccine.2011.06.115">http://dx.doi.org/10.1016/j.vaccine.2011.06.115</a></p>
Vaccine Complacency	Adherence to Vaccination Programme		<p>Logical step. Vaccine complacency leads to an adherence in vaccination programme.</p>
Economic Prosperity	Individual Nation-States Vaccine Budget		<p>Logical step. A nations GDP and government structure impacts the way budgets are distributed and therefore how the individual nations vaccine budget.</p>
Incidence of Vaccine-preventable Disease	Economic Prosperity	Opposite	<p>Fonkwo, P. N. (2008). Pricing infectious disease. the economic and health implications of infectious diseases. <i>EMBO Reports</i>, 9(SUPPL. 1), S13-S17. doi:10.1038/embo.2008.110</p> <p>Ozawa, S. et al. Estimated economic impact of vaccinations in 73 low- and middle-income countries, 2001–2020. <i>Bull. World Health Organ.</i> 95, 629–638 (2017).</p>
Short-term political Goals	Vaccine literacy of Healthcare Workers		<p>From an interview with a social scientist specializing in public health interventions and social safeguards, former head of national NGO.</p>
Confidence in Government	Stability of Government		<p>Government at a glance 2013. OECD 2013</p>
Quality of Vaccination Registry	Demand for Vaccines		<p>From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.</p>

			Chiu, R., Chang, C. & Chang, Y. A Forecasting Model for Deciding Annual Vaccine Demand. in 2008 Fourth International Conference on Natural Computation 7, 107–111 (2008).
Indirect costs of Vaccines	Access to Vaccines	Opposite	From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Emergency Migrations	Predictability of Vaccine Demand	Opposite	From an interview with a professor of operations management and operations research, the logistics coordinator for Southern, Central, Eastern Africa and the Indian Ocean, a researcher of sustainable innovation and customization working on a project in Africa and a global health advisor for European Commission Humanitarian Aid Office.
Belief in delaying vaccinations	Vaccine Complacency		Belief in delaying vaccinations decreases self-efficacy which affects vaccine complacency.
Incidence of vaccine stockouts	Rate of Vaccine Completion	Opposite	Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Local Experience with Pandemics	Incidence of vaccine stockouts	Opposite	Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. <i>Influenza and Other Respiratory Viruses</i> , 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
Presence of Health Concepts in Media	Valuation of Personal Health		Hodgetts, Darrin, Bruce Bolam, and Christine Stephens. "Mediation and the Construction of Contemporary Understandings of Health and Lifestyle." <i>Journal of Health Psychology</i> 10, no. 1 (2005): 123–36.
Number of vaccinations	Concern about side effects	Opposite	Gowda C, Dempsey AF. The rise (and fall?) of parental vaccine hesitancy. <i>Human Vaccines &amp; Immunotherapeutics</i> . 2013 Aug 8;9(8):1755–62.
Degree of belief in Natural Holism	Range of Moral Sphere		Logical Step: If we have defined Natural Holism as a degree in which nature is seen to be valued and interconnected. The highest degree equalling everything in the universe while the lowest degree a monadistic isolationist conception of no interconnectedness. Meanwhile range of moral sphere was defined as high moral sphere being also broadly encompassing while the lowest moral sphere being associated with egoism. Therefore it follows that the higher degree you would consider things interconnected and valuable in themselves the more you would consider them to fall within your moral sphere. Meanwhile the inverse would also be true the less you consider things as interconnected and mutually valuable in themselves the less you would consider within your moral sphere. Further explanation: If 'A' considers 1–50 as = to 'A' therefore A will value them all at the same level as moral agents.

			<p>If 'B' Considers only 1–10 as equally valuable to itself than only 1–10 could be considered as moral agents. If 'C' considers 1 and not 2–50 as equally valuable to itself only 1 could be a moral agent. These statements are intended as purely descriptive based on the two concepts as have been defined.</p>
Vaccine Literacy of Society	Vaccine Confidence		<p>Johri, M. et al. Association between maternal health literacy and child vaccination in India: a cross-sectional study. <i>J. Epidemiol. Community Health</i> 69, 849–857 (2015).</p> <p>Lee, H. Y. et al. Disparities in Human Papillomavirus Vaccine Literacy and Vaccine Completion Among Asian American Pacific Islander Undergraduates: Implications for Cancer Health Equity. <i>J. Am. Coll. Health J ACH</i> 63, 316–323 (2015).</p>



## Supplement 4: Reference List Accompanying the Kumu Map

1. Akanbi, Olusegun Ayodele. (2017). *International Journal of Social Economics* 44, no. 5: 683–95.
2. Bardenheier B. H., Yusuf H. R., Rosenthal J., Santoli J. M., Shefer A. M., Rickert D. L., et al. (2004). Factors associated with underimmunization at 3 months of age in four medically underserved areas. *Public Health Rep* 119:479–85; PMID:15313111; <http://dx.doi.org/10.1016/j.phr.2004.07.005>
3. Benin A. L., Wisler-Scher D. J., Colson E., Shapiro E. D., Holmboe E. S. (2006). Qualitative analysis of mothers' decisionmaking about vaccines for infants: the importance of trust. *Pediatrics* 117: 1532–41; PMID:16651306; <http://dx.doi.org/10.1542/peds.2005-1728>
4. Bloom, D. E., Canning, D., & Sevilla, J. (2004). The effect of health on economic growth: A production function approach. *World Development*, 32(1), 1–13. doi:10.1016/j.worlddev.2003.07.002
5. Brewer N. T., Chapman G. B., Rothman A. J., Leask J., Kempe A. (2017). Increasing Vaccination: Putting Psychological Science Into Action. *Psychological Science in the Public Interest*. Dec;18(3):176.
6. Brown K. F., Kroll J. S., Hudson M. J., Ramsay M., Green J., Vincent C. A., et al. (2010). Omission bias and vaccine rejection by parents of healthy children: implications for the influenza A/H1N1 vaccination programme. *Vaccine* 28:4181–5; PMID:20412878; <http://dx.doi.org/10.1016/j.vaccine.2010.04.012>
7. Calderón, Irene Rivera. (2017, May 5). Migration: Causes, Conflict, and Policy Solutions. Retrieved from <http://www.saisjournal.org/posts/migration>.
8. Chiu, R., Chang, C., & Chang, Y. (2008). A Forecasting Model for Deciding Annual Vaccine Demand. in 2008 Fourth International Conference on Natural Computation 7, 107–111.
9. Cooper, Richard. (2011). *Recent Books on International Relations: Economic, Social, and Environmental: Diaspora, Development, and Democracy: The Domestic Impact of International Migration From India*. *Foreign Affairs* 90, no. 1: 175
10. Davies P., Chapman S., Leask J. (2002). Anti-vaccination activists on the world wide web. *Arch Dis Child* 87:22–5; PMID:12089115; <http://dx.doi.org/10.1136/adc.87.1.22>
11. Fonkwo, P. N. (2008). Pricing infectious disease. the economic and health implications of infectious diseases. *EMBO Reports*, 9(SUPPL. 1), S13–S17. doi:10.1038/embor.2008.110
12. Government at a glance 2013. (2013). OECD
13. Gowda C., Dempsey A. F. (2013). The rise (and fall?) of parental vaccine hesitancy. *Human Vaccines & Immunotherapeutics*. Aug 8;9(8):1755–62.
14. Grabenstein, John D. (2013). What the World's Religions Teach, Applied to Vaccines and Immune Globulins. *Vaccine* 31, no. 16: 2011–023.
15. Gust D. A., Kennedy A., Shui I., Smith P. J., Nowak G., Pickering L. K. (2005). Parent attitudes toward immunizations and healthcare providers the role of information. *Am J Prev Med* 29:105–12; PMID:16005806; <http://dx.doi.org/10.1016/j.amepre.2005.04.010>
16. Gylfason, T. (2001). Natural resources, education, and economic development. *European Economic Review*, 45(4–6), 847–859. doi:10.1016/S0014-2921(01)00127-1
17. Haidt, Jonathan, Paul Rozin, Clark Mccauley, and Sumio Imada. (1997). Body, Psyche, and Culture: The Relationship between Disgust and Morality. *Psychology & Developing Societies* 9, no. 1: 107–31.
18. Hessel, L. (2009). Pandemic influenza vaccines: Meeting the supply, distribution and deployment challenges. *Influenza and Other Respiratory Viruses*, 3(4), 165–170. doi:10.1111/j.1750-2659.2009.00085.x
19. Hill, D. R., Ericsson, C. D., Pearson, R. D., Keystone, J. S., Freedman, D. O., Kozarsky, P. E., et al. (2006). The practice of travel medicine: Guidelines by the infectious diseases society of america. *Clinical Infectious Diseases*, 43(12), 1499–1539. doi:10.1086/508782
20. Hodgetts, Darrin, Bruce Bolam, and Christine Stephens. (2005). Mediation and the Construction of Contemporary Understandings of Health and Lifestyle. *Journal of Health Psychology* 10, no. 1: 123–36.
21. Horton, R. (2000). The health and wealth of nations. *Science*, 287(5456), 1207–1209. doi:10.1126/science.287.5456.1207
22. Hussain H., Omer S. B., Manganello J. A., Kromm E. E., Carter T. C., Kan L., et al. (2011). Immunization safety in US print media, 1995–2005. *Pediatrics* 127(Suppl 1):S100–6; PMID:21502237; <http://dx.doi.org/10.1542/peds.2010-1722O>
23. Interview with a professor of health economics at Katholieke Universiteit Leuven.
24. Interview with a professor of vaccinology at Katholieke Universiteit Leuven.
25. Interview with a single male in his mid-twenties who is vaccine-hesitant.
26. Interview with a social scientist specializing in public health interventions and social safeguards, former head of national NGO.

27. Johri, M. et al. (2015). Association between maternal health literacy and child vaccination in India: a cross-sectional study. *J. Epidemiol. Community Health* 69, 849–857.
28. Joint interview with a Professor of Operations Management and Operations Research, Logistics Coordinator for Southern, Central, Eastern Africa and the Indian Ocean and a Global Health Advisor for European Commission Humanitarian Aid Office
29. Julie Milstien, P. David Griffin & J.-W. Lee. (1995). Damage to immunisation programmes from misinformation on contraceptive vaccines, *Reproductive Health Matters*, 3:6, 24–28, DOI: 10.1016/0968-8080(95)90155-8
30. Kahn, Peter A. (2016) Bioethics, Religion, and Public Policy: Intersections, Interactions, and Solutions. *Journal of Religion and Health* 55, no. 5: 1546–560.
31. Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. *Vaccine*, 28(7), 1709–1716. <https://doi.org/10.1016/j.vaccine.2009.12.022>
32. Kennedy A., Lavail K., Nowak G., Basket M., Landry S. (2011). Confidence about vaccines in the United States: understanding parents' perceptions. *Health Aff (Millwood)* 30:1151–9; PMID:21653969; <http://dx.doi.org/10.1377/hlthaff.2011.0396>
33. Khan, Muhammad, Umair Ahmad, Akram Salman, Saad Ayub, Maria Aqeel, Talieha Haq, and Noman-ul Saleem. (2017). Muslim Scholars' Knowledge, Attitudes and Perceived Barriers Towards Polio Immunization in Pakistan. *Journal of Religion and Health* 56, no. 2: 635–48.
34. Krieger, N., Williams, D. R., & Moss, N. E. (1997). Measuring social class in us public health research: Concepts, methodologies, and guidelines doi:10.1146/annurev.publhealth.18.1.341 Retrieved from [www.scopus.com](http://www.scopus.com)
35. La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (1999). The quality of government. *Journal of Law, Economics, and Organization*, 15(1), 222–279.
36. Lee, H. Y. et al. (2015). Disparities in Human Papillomavirus Vaccine Literacy and Vaccine Completion Among Asian American Pacific Islander Undergraduates: Implications for Cancer Health Equity. *J. Am. Coll. Health JACH* 63, 316–323.
37. Liu, Jiming. (2013). A Computational Approach to Characterizing the Impact of Social Influence on Individuals' Vaccination Decision Making. *PLoS One* 8, no. 4: E60373.
38. Luthy, Karlen E., Renea L. Beckstrand, Lynn C. Callister, and Spencer Cahoon. (2012). Reasons Parents Exempt Children From Receiving Immunizations. *The Journal of School Nursing* 28, no. 2: 153–60.
39. MacDonald, N. E., Eskola, J., Liang, X., Chaudhuri, M., Dube, E., Gellin, B., et.al. (2015). Vaccine hesitancy: Definition, scope and determinants. *Vaccine*, 33(34), 4161–4164. doi:10.1016/j.vaccine.2015.04.036
40. Navin, Mark. (2013). Disgust, Contamination, and Vaccine Refusal. In: [2013] 3rd Annual Values in Medicine, Science, and Technology Conference (Dallas; May 22–24, 2013) <http://philsci-archive.pitt.edu/view/confandvol/confandvol2013avmstcdallas2224may2013.html>. URL: <http://philsci-archive.pitt.edu/id/eprint/9767> (accessed 2019–02–07).
41. Opel D. J., Taylor J. A., Mangione-Smith R., Solomon C., Zhao C., Catz S., et al. (2011). Validity and reliability of a survey to identify vaccine-hesitant parents. *Vaccine* 29:6598–605; PMID:21763384; <http://dx.doi.org/10.1016/j.vaccine.2011.06.115>
42. Ozawa, S. et al. (2017). Estimated economic impact of vaccinations in 73 low- and middle-income countries, 2001–2020. *Bull. World Health Organ.* 95, 629–638
43. Piabuo, S. M. & Tieguhong, J. C. (2017). Health expenditure and economic growth – a review of the literature and an analysis between the economic community for central African states (CEMAC) and selected African countries. *Health Econ. Rev.* 7
44. Scherer L. D., Shaffer V. A., Patel N., Zikmund-Fisher B. J. (2016). Can the vaccine adverse event reporting system be used to increase vaccine acceptance and trust? *Vaccine* 34:2424–9.
45. Shui I., Kennedy A., Wooten K., Schwartz B., and Gust D. (2005). Factors influencing African-American mothers' concerns about immunization safety: a summary of focus group findings. *J Natl Med Assoc* 97:657–66; PMID:15926642
46. Smith, T. C. (2017). Vaccine Rejection and Hesitancy: A Review and Call to Action. *Open Forum Infect. Dis.* 4
47. Sobo, Elisa J. (2016). THEORIZING (VACCINE) REFUSAL: Through the Looking Glass. *Cultural Anthropology* 31, no. 3: 342–50
48. Tacoli, C. (2009). Crisis or adaptation? migration and climate change in a context of high mobility. *Environment and Urbanization*, 21(2), 513–525. doi:10.1177/0956247809342182
49. Van der Heide, I. et al. (2013). The relationship between health, education, and health literacy: results from the Dutch Adult Literacy and Life Skills Survey. *J. Health Commun.* 18 Suppl 1, 172–184

50. Wheeler M., Buttenheim A. M. (2013). Parental vaccine concerns, information source, and choice of alternative immunization schedules. *Hum Vaccin Immunother.* Aug 1;9(8):1782–9.
51. Zieseimer, Thomas H. W. H. (2011). Developing Countries' Net-migration: The Impact of Economic Opportunities, Disasters, Conflicts, and Political Instability. *International Economic Journal* 25, no. 3: 373–86.

## Supplement 5: Video Recording

Link to the video recording of presentation held at the Symposium 'KU Leuven Facing the Future', May 8, 2019, Leuven, Belgium: [available here](#).