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ZIKA VIRUS
ANP MODEL
DECISION MAKING IN A COMPLEX ENVIRONMENT

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Abstract

In 2015, the Zika Virus made headlines around the world when it was linked to **microcephaly**.

Although the virus was first discovered in 1947, several factors helped to elevate the significance of contracting the disease:

1. The definitive link to an irreversible, debilitating disease in fetuses – microcephaly – of women who contract the Zika virus while pregnant, according to the World Health Organization (WHO). Microcephaly causes the fetus' head to grow to be much smaller than a healthy size, which in turns, limits the brain's growth, as well.
2. The possible link to premature birth, eye problems and other neurological conditions in babies born to mothers who were infected while pregnant.
3. The virus does not have a medicinal cure or developed vaccine for prevention
4. It can be spread through Aedes aegypti mosquitos, which can now be found as far north as San Francisco and New York, and, most recently confirmed, through sexual transmission
5. The virus only presents symptoms one in five people. The other four out of five people show no symptoms and thus carry the virus unknowingly, which means they could spread it to another person through sexual transmission or through their blood.
6. Beyond affecting developing fetuses, the virus has been linked to neurological diseases that attach brain cells and the spine, causing paralysis in people and other symptoms that are similar to Multiple Sclerosis (MS).

The virus is causing alarm among major health agencies such as the Centers for Disease Control and Prevention (CDC), the European Centre for Disease Prevention and Control (ECDC) and the WHO.

We're analyzing this model from the perspective of world health organizations, whose main objective is to stop the spread of disease and reduce the impact, such as cases of microcephaly and other debilitating conditions. We're looking for the best solution from a health perspective.

Introduction

As of April 17, 2016, the Zika virus has been identified in more than 40 countries. The cases of babies born with microcephaly to mothers carrying the Zika virus has increased, specifically in Brazil. Because the virus is spread through mosquitos and humans who travel, the virus has now become a multi-national problem to solve. The alternatives that will be considered as the best strategy for slowing or stopping the spread of the Zika virus will be:

1. DEET mosquito control
2. Restrict travel
3. Education (for everyone)

4. Increased access to contraception and abortion
5. Pharmaceutical option, such as a treatment or vaccine
6. Do nothing

Alternatives – Background

1. DEET Mosquito control

DEET is an insect repellent that has been found to be effective for deflecting mosquitos from human skin, and, with the increasing spread of the Zika virus, has been deemed acceptable for pregnant women to use. It is also one of the insect repellents approved by the U.S. Environmental Protection Agency (EPA).

Using DEET on large scale or excessively, such as spraying wooded areas, areas with water and other land, may make some food and river/ground water unsafe to consume. The crops, and animals who ingest food that is sprayed with DEET, would need to be regulated by each country or region, and may cause residual effects of a food shortage as well as be disruptive to the farmers and merchants who depend on sales from crops and animal meat for their economic viability.

2. Restrict travel

In the latest recommendations from WHO, updated on March 8, 2016, pregnant women, and their partners, were advised not to travel to areas of ongoing Zika virus outbreaks.

In January 2016, the CDC issued a Level 2 travel advisory, stating that women in their third trimester of pregnancy should avoid areas with the presence of the Zika virus, and advised women who are trying to get pregnant to speak with their doctors before traveling to areas where the virus is present.

On April 11, 2016, the ECDC advised pregnant women and women planning to become pregnant should consider postponing nonessential travel to affected areas until after delivery. They also advised travelers with immune disorders or severe chronic illnesses should consult their doctor before travelling, particularly on effective prevention measures. Travelers to Zika-affected areas and EU citizens residing in affected areas were advised that using condoms could reduce the risk of sexual transmission through semen.

Travel restriction may help to decrease the number of Zika cases and therefore the additional effects, such as cases of microcephaly. However, it may be disruptive to the economy of some of the countries that depend on tourism for economic sustainability.

Travel restrictions are estimated to cost Caribbean islands due to a decrease in tourism, and larger countries such as Brazil and Mexico are anticipated to lose business, growth opportunities and revenue-generating opportunities because of the virus. The current estimate for overall loss to the world economy is $3.5 billion, a large part of which is due

to recommended travel restrictions. This number will only grow larger, specifically as the Rio de Janeiro Summer Olympics approach and travelers and athletes alike will need to decide whether or not they want to visit Brazil. If it's similar to the previous 2013 dengue outbreak, the global economy could lose $8.9 billion.

3. *Education (for everyone)*

Education about the presence, risk and prevention of the Zika virus may be able to slow the spread. In Brazil, troops were deployed to educate the general population about the virus.

The risk with using solely education to slow or stop the spread of the disease is that it still leaves a whole to access for materials to apply the preventive measures. Those would include:
- Pesticides to apply to skin to deflect mosquitos
- Screens for windows, to prevent mosquitos that may be carrying the virus from entering homes and buildings
- Condoms to prevent the sexual transmission of the disease and/or pregnancies that could have poor results, such as a miscarriage or deformed or impaired child

In February 2016, President Obama's Administration requested the release of $1.8 billion in funds to aid in the slowing of the spread of the Zika virus, which will be used to educate people at risk as well as their health care providers, plus bring the needed materials to areas with the virus, such as screens for windows, netting and insect repellent.

4. *Increased access to contraception and abortion*

Because the Zika virus has been found to cause microcephaly in unborn children, the government in countries such as Brazil, Colombia, Jamaica, El Salvador and Ecuador advised women of childbearing age to avoid getting pregnant for the next two years.

While pregnancy prevention can help decrease the number of cases of children born with microcephaly to mother's carrying the Zika virus, another alternative is abortion. With 97 percent of women of childbearing age living in countries with highly restrictive abortion laws in Latin America and the Caribbean, it can be very hard for a woman who may unintentionally conceive while having Zika or being at risk for contracting to have the option to terminate the pregnancy even if the fetus demonstrates signs of the highly debilitating microcephaly. Increasing access to abortion would help to decrease the number of cases of children born with microcephaly.

Increased access to contraception, specifically condoms, would help to prevent the spread of the disease, since the Zika virus has been confirmed as able to be sexually transmitted, as well as prevent pregnancies in women who may have Zika or be at risk for contracting it.

Both access to contraception and access to abortion services have barriers in many countries, because of a variety of reasons:

- Legal – Some countries ban abortion and condoms, with legal ramifications and punishment, including going to prison, for use of the pregnancy prevention or services.
- Social – Even if abortion and/or contraception is legally allowed, some countries or areas of countries hold a strong stigma against using either, usually due to a religious reason.
- Location – There may not be funding to distribute enough condoms or other contraceptives to entire countries, including the urban centers, or to rural areas that are far (in distance) to the cities. The same applies to abortion: even if it's legal, there may not be enough doctors to serve all the women who need access to an abortion if needed to minimize the number of microcephaly cases.

5. *Pharmaceutical Option*

For the purpose of this model, and from a health organization perspective, the pharmaceutical option would be invest millions – possibly billions – of dollars into a Zika virus vaccine or cure. The monetary costs of the pharmaceutical option are high, with factors such as drug development and testing, drug manufacturing plants being built and the costs to distribute the drugs. Ultimately, the true dollar cost for developing either a Zika virus vaccine or cure is unknown.

While this may take a lot of money and time to research, develop and test, in the long-term, preventing the virus altogether will have the biggest impact on stopping the spread of the disease and the other effects it is causing such as microcephaly and other nervous system diseases.

The pharmaceutical option may also introduce possible treatments for other viruses that act in a similar manner to the Zika virus, such as targeting the nervous system. It may also introduce some vaccines for diseases that spread in a similar manner (through mosquitos) and also cause flu-like symptoms and possibly death, such as dengue and chikungunya.

6. *Do nothing*

The "do nothing" alternative refers to investing no time, money or energy into preventing the contraction of the virus, the spread of the virus or managing the other medical and health conditions associated with the Zika virus. This has proven to be effective in the past, when the virus was found on Yap Island in Micronesia. In this population, a natural immunization occurred, so that after the first season, many women were immunized against the virus and so were their children if they were conceived and birthed after the mother contracted the virus, and did not develop with microcephaly.
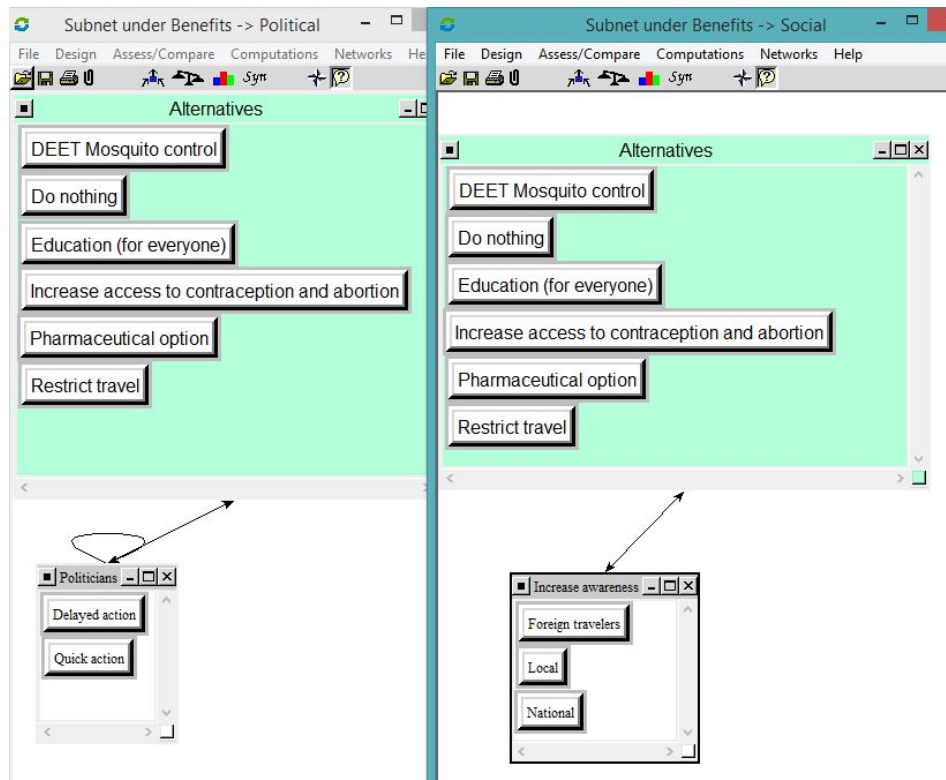
Methodology

Each alternative was be measured against the control criteria of economic, social, political and environmental on a Benefit, Opportunity, Cost and Risk (BOCR) model.

The strategic criteria are health and welfare, security, environmental impact and economic stability.

Under the Benefits, we considered the following subnet:
Figure 1:

The Benefits focused largely on political and social, where there would be short-term, immediate actions to achieve the goal of slowing or stopping the spread of the Zika virus and its impact.

From a political perspective, if a politician demonstrated quick action – even without knowing long-term consequences – it may be perceived as a better solution than waiting and allowing the virus to continue to spread. The benefits for the individuals in the affected areas, in turn, would also be much quicker in respect to slowing the spread of the disease and its impacts.

We considered economic benefits such as an undisrupted economy because of the ability of people to prevent the disease (and thus continue to be productive). This benefit seemed disconnected from the actual goal of stopping the spread of the disease and limiting its impact, so we removed it.

There seemed to be limited environmental benefits from stopping the spread of the disease and its impact based on the alternatives, so we removed that.

Figure 2: Opportunities subnet
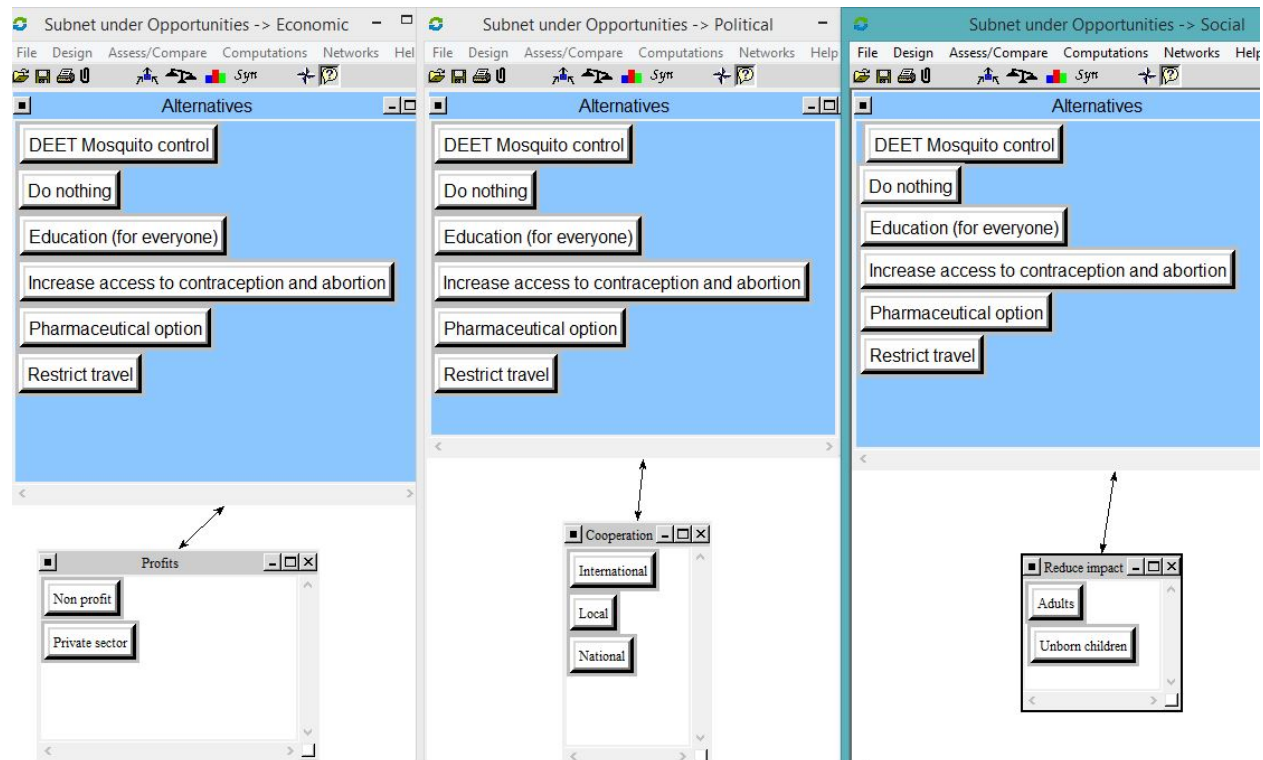
In the Opportunities, which we considered for long-term gains or benefits, we included the economic, political and social subnets. Each had an area that could reap a benefit long-term, worth considering; for economic, there's the possible growth from a pharmaceutical option being developed and eliminating or significantly reducing the risk of the disease and, for the public sectors' perspective, growth in that there would be less strain on public hospitals, welfare and health care payers.

Politically, a viable Zika solution has the potential to strengthen political relationships at all levels; an opportunity to collaborate to reach a universal goal together, regardless of political affiliations or divisions. From a social perspective, slowing or stopping the spread of the Zika virus would impact people differently depending on their age/stage of growth as a person.

Environmental was not included here because long-term, the environment would not improve in any capacity because of the reduction of cases of the Zika virus.

Figure 3: Cost subnet
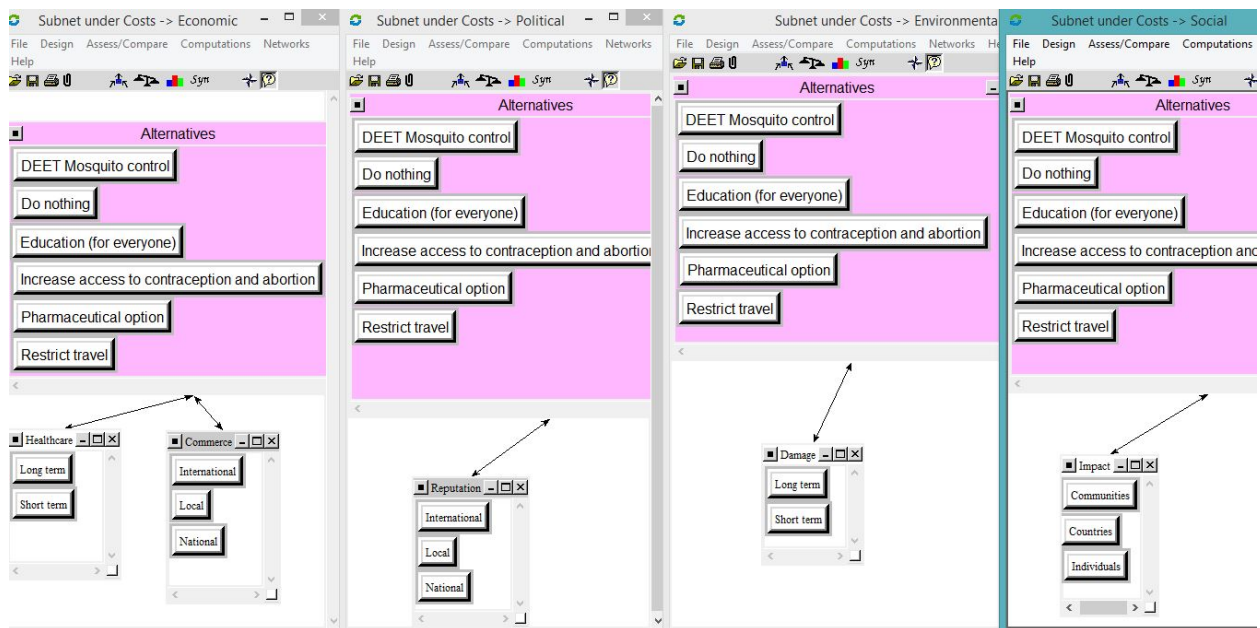
For the Costs subnet, we considered the economic (monetary), environmental, political (relationships on all levels of politics) and social (cultural, religious) levels. For most of the alternatives, there's the potential cost of something – be it money, respect, collaborative relationships, crops/livestock or disruption of small communities and individual identities – being reduced or lost altogether.

Figure 4: Risk subnet
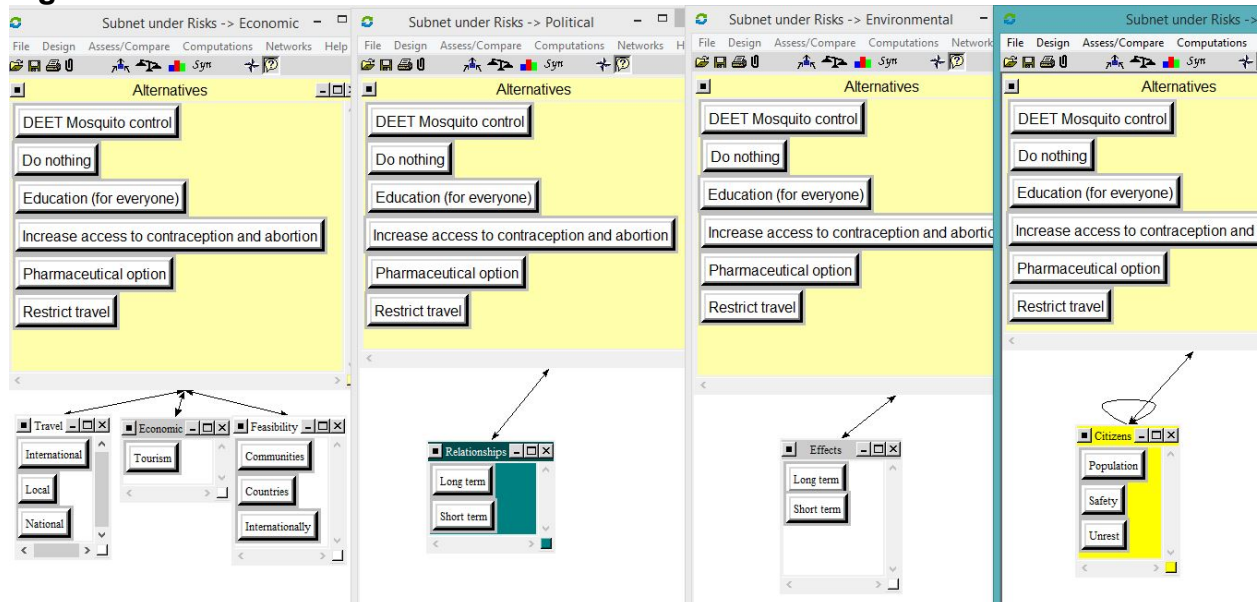
The Risk subnet had similar considerations as the cost subnet, with both tangibles (money) and intangibles (culture) being considered at risk. We considered the long-term

and short-term, since the alternatives have varying degrees of impact when it comes to length of time. These encompassed the unknown and potential problems, as opposed to costs, where a general knowledge of the cost was known.

Analysis

After performing pairwise comparisons for each subnet, the following was revealed. The best options for each merit node is highlighted (the highest ideal for Benefits and Opportunities, the lowest ideal for Costs and Risks):

Figure 5: Benefits synthesis

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Subnet under Benefits

Name	Graphic	Ideals	Normals	Raw
DEET Mosquito control		0.370889	0.105405	0.297750
Do nothing		0.183963	0.052281	0.147686
Education (for everyone)		1.000000	0.284194	0.802802
Increase access to contraception and aborti~		0.447649	0.127219	0.359374
Pharmaceutical option		0.679662	0.193156	0.545634
Restrict travel		0.836555	0.237744	0.671589

Figure 6: Opportunities synthesis

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Subnet under 2.Opportunities

Name	Graphic	Ideals	Normals	Raw
DEET Mosquito control		0.433907	0.132513	0.272545
Do nothing		0.115861	0.035383	0.072775
Education (for everyone)		0.997912	0.304757	0.626807
Increase access to contraception and aborti~		0.475042	0.145075	0.298383
Pharmaceutical option		1.000000	0.305395	0.628119
Restrict travel		0.251729	0.076877	0.158116

Figure 7: Cost synthesis

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Subnet under Costs

Name	Graphic	Ideals	Normals	Raw
DEET Mosquito control		0.728584	0.162724	0.570545
Do nothing		0.658361	0.147040	0.515554
Education (for everyone)		0.479906	0.107183	0.375808
Increase access to contraception and aborti~		1.000000	0.223343	0.783087
Pharmaceutical option		0.765136	0.170888	0.599168
Restrict travel		0.845439	0.188822	0.662052

Figure 8: Risk synthesis

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Subnet under Risks

Name	Graphic	Ideals	Normals	Raw
DEET Mosquito control		0.617387	0.166789	0.500503
Do nothing		1.000000	0.270154	0.810679
Education (for everyone)		0.349224	0.094344	0.283109
Increase access to contraception and aborti~		0.532752	0.143925	0.431891
Pharmaceutical option		0.461999	0.124811	0.374533
Restrict travel		0.740231	0.199976	0.600090

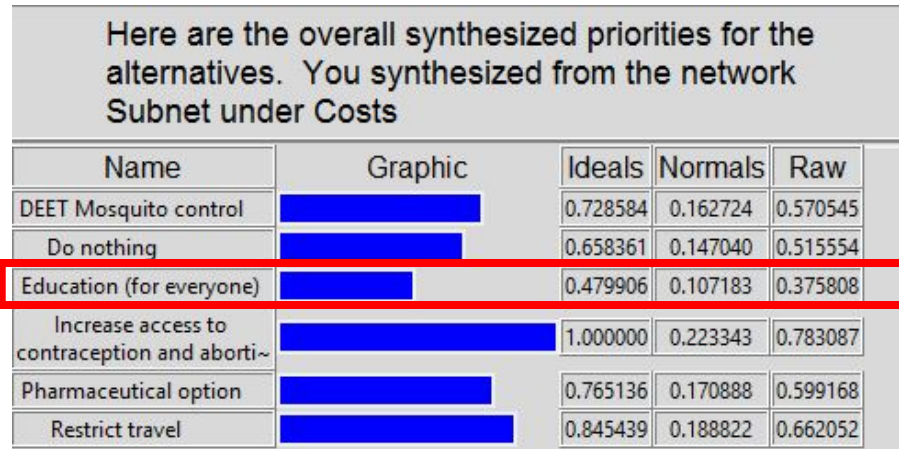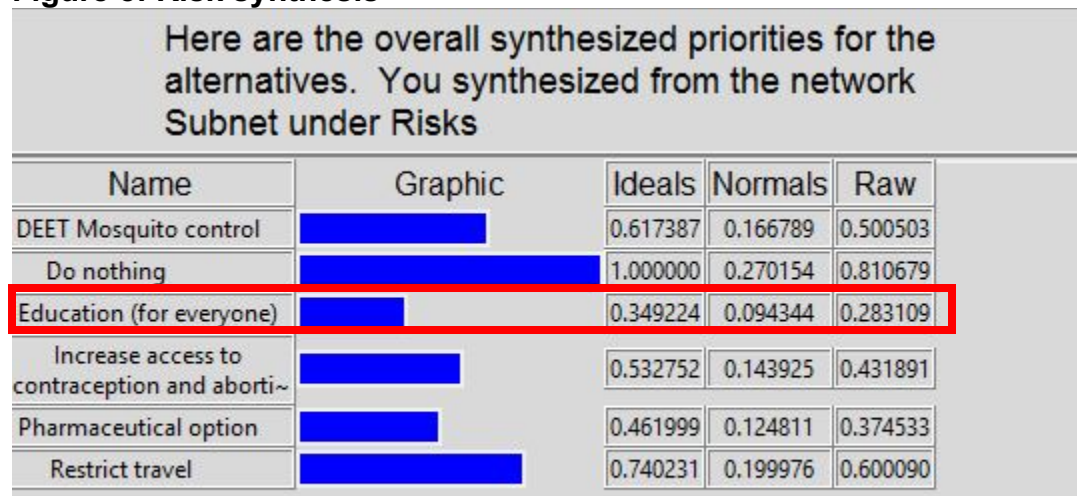**Ratings**

As part of our analysis, we also included the ratings, comparing the merit nodes with the strategic criteria. The following ratings resulted, revealing that the opportunities merit held the highest priority in the ratings, and the health and welfare strategic criterion was the highest strategic criterion:

Figure 9: Ratings

Super Decisions Ratings

	Priorities	Totals	Economic Stability 0.237151	Environmental Impact 0.091358	Health & Welfare 0.530916	Security 0.140575
Benefits	0.223809	0.474191	Medium	Low	Medium High	Low
Opportunities	0.345919	0.732912	Medium High	Low	Very High	Low
Costs	0.170336	0.360898	Medium	Medium	Medium	Low
Risks	0.259936	0.550736	Medium High	Low	Medium High	Medium

Sensitivity Graphs

Sensitivity graphs were also analyzed. Below are the sensitivity analysis graphs giving priority to each of the four merit nodes.

Figure 10: Sensitivity - Benefits
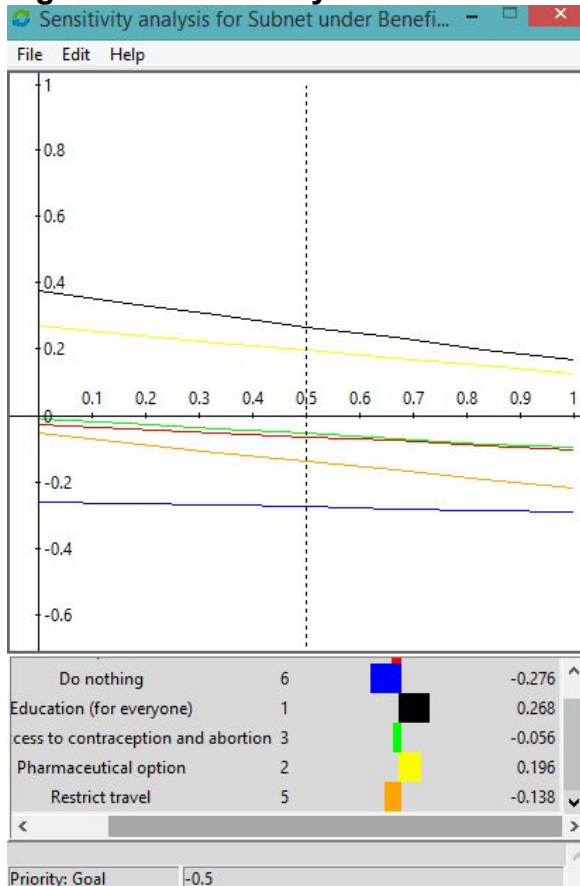
With the Benefits, education is consistently at the top, while Do nothing is at the bottom. Little interaction on this graph demonstrates the node's stability.

Figure 11: Sensitivity – Opportunities
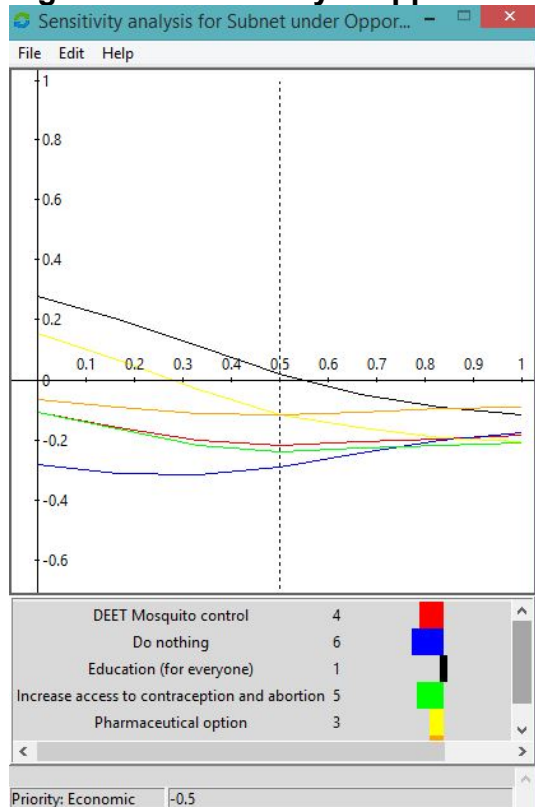
With the Opportunities, education is for the most part, the top alternative, while Do nothing is at the bottom. The interaction begins around 85%.

Figure 12: Sensitivity – Costs
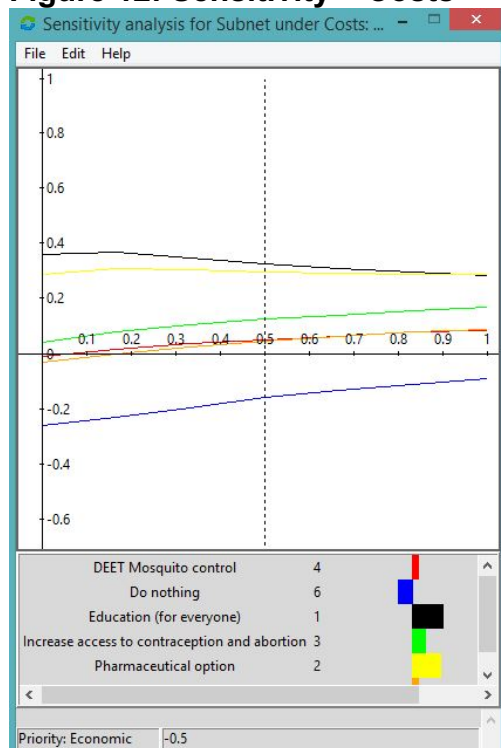
With the Costs, education is at the top for the most part, while do nothing is at the bottom. The interaction between education and the pharmaceutical option begins around 80%.

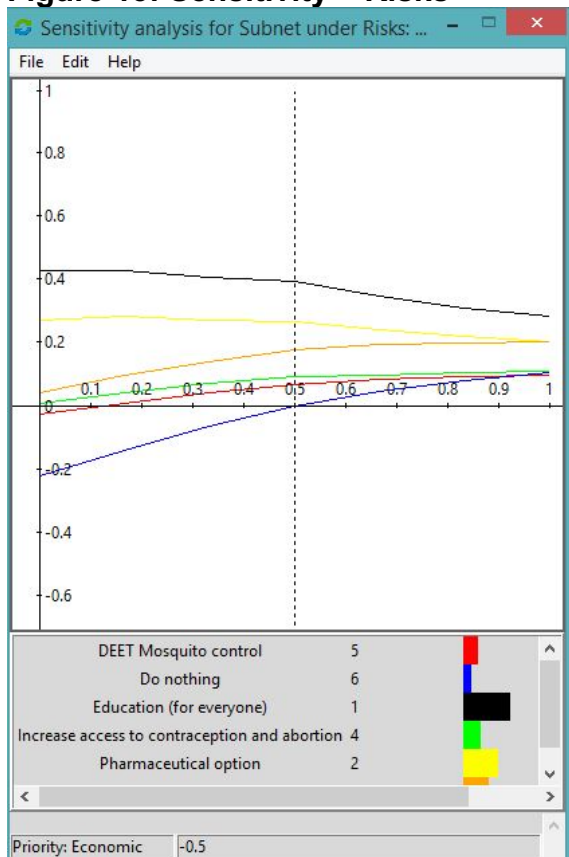**Figure 13: Sensitivity – Risks**

With the Risks, education is for the most part, the top alternative, while Do nothing is at the bottom. The interaction begins around 90%.

Overall Synthesis

The overall synthesis revealed the best alternative for the goal set forth. Both the additive (best long-term solution) and multiplicative (best short-term solution) revealed education as the top choice:

Figure 14: Additive Synthesis

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Super Decisions Main Window: ZikaSolution2.sdmod: formulaic: ratings

Name	Graphic	Ideals	Normals	Raw
DEET Mosquito control		-0.077523	-0.029058	-0.025491
Do nothing		-0.698830	-0.261942	-0.229786
Education (for everyone)		1.000000	0.374829	0.328815
Increase access to contraception and aborti~		-0.028430	-0.010657	-0.009348
Pharmaceutical option		0.716518	0.268572	0.235602
Restrict travel		-0.146584	-0.054944	-0.048199

Figure 15: Multiplicative Synthesis

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Super Decisions Main Window: ZikaSolution2.sdmod: formulaic: ratings

Name	Graphic	Ideals	Normals	Raw
DEET Mosquito control		0.065132	0.041912	0.407387
Do nothing		0.005831	0.003752	0.036471
Education (for everyone)		1.000000	0.643490	6.254744
Increase access to contraception and aborti~		0.076551	0.049259	0.478804
Pharmaceutical option		0.351627	0.226268	2.199336
Restrict travel		0.054886	0.035318	0.343295

Matrix – Synthesizing the Values for the Alternatives across Merit Nodes

Opportunities had the highest influence when considering the goal of stopping the spread of the Zika virus and its impacts on health. Overall, the economic strategic criterion was the most influential across the merit priorities.

Figure 16:

Merit Priorities	Alternatives	Ideal Vectors from Bottom Decision Subnets				Raw Vector
		Political (.333)		Social (.666)		Raw
Benefits (.223)	A1	0.327		0.282		0.298
	A2	0.19		0.126		0.148
	A3	0.408		1		0.803
	A4	0.577		0.25		0.359
	A5	1		0.318		0.546
	A6	0.419		0.797		0.672
Opportunities (.345)		Economic	Political	Social		Raw
		0.493	0.195	0.31		
	A1	0.524	0.381	0.184		0.391
	A2	0.126	0.09	0.073		0.103

		Economic	Environmental	Political	Social	Raw
	A3	0.901	1	0.605		0.829
	A4	0.626	0.301	0.265		0.451
	A5	1	0.512	1		0.905
	A6	0.175	0.222	0.233		0.203
		Economic	**Environmental**	**Political**	**Social**	**Raw**
		0.422	**0.174**	**0.137**	**0.265**	
Costs (.17)	A1	0.513	1	0.439	0.447	0.571
	A2	0.158	0.289	1	0.982	0.516
	A3	0.438	0.281	0.152	0.45	0.376
	A4	1	0.306	0.301	1	0.783
	A5	0.809	0.284	0.176	0.688	0.599
	A6	0.616	0.154	0.875	0.957	0.662
		Economic	**Environmental**	**Political**	**Social**	**Raw**
		0.39	**0.276**	**0.138**	**0.195**	
Risks (.259)	A1	0.376	0.926	0.204	0.356	0.5
	A2	0.914	0.435	1	1	0.81
	A3	0.357	0.317	0.204	0.141	0.283
	A4	0.422	0.647	0.38	0.182	0.431
	A5	0.17	1	0.087	0.101	0.374
	A6	1	0.289	0.422	0.35	0.6

Conclusion

Education was found to be the overall best option for slowing or stopping the spread of the Zika virus and minimizing its impact.

A variety of factors influenced this result:
- Fiscal cost – low compared to pharmaceutical option
- Social cost – low compared to increased access to contraception or abortion
- Opportunities – high for long-term, sustained prevention of the spread of the disease; not dependent upon high-cost research (for a vaccine or new drug, for example)
- Benefits – Actionable ways for people in the regions effective to take steps toward prevention almost immediately; also gives people the chance to delay or avoid travel to areas where the virus has been found, and avoid it altogether

Future Research

Education as a solution may be influenced from country to country, and even from region to region within each country. Research to consider if education is the best solution would need to address:

- How is the education being deployed? Would its effectiveness be dependent on literacy levels of a population?
- With the education, do all populations have access to the materials needed to follow the actions (e.g. screens for windows, insect repellent)?
- For people who do not live in areas affected by Zika, but choose to travel there, is the education approach considered ineffective? Are there benefits to being educated and willingly entering an area where the virus lives?
- What were some effective means of education in slowing and stopping the spread of other viruses, such as HIV, influenza, bird flu, etc.?

References

http://www.cdc.gov/zika/pregnancy/question-answers.html

http://www.cnn.com/2016/04/11/health/zika-virus-scarier-than-first-thought/

http://www.usatoday.com/story/news/politics/2016/04/11/scarier-than-we-initially-thought-cdc-sounds-warning-zika-virus/82894878/

https://www.rt.com/usa/332217-zika-virus-usa-miscarriages/

http://time.com/4245352/microcephaly-zika-cases-brazil-increase/

http://www.nytimes.com/2016/04/05/health/zika-virus-deet-pregant-women-safety.html

https://www.ag.ndsu.edu/cpr/weeds/deet-as-an-herbicide-07-30-15

http://www.nature.com/scitable/blog/green-science/the_dangers_of_pesticides

http://www.who.int/csr/disease/zika/information-for-travelers/en/

http://www.cdc.gov/media/releases/2016/s0315-zika-virus-travel.html

http://ecdc.europa.eu/en/publications/Publications/zika-virus-rapid-risk-assessment-11-april-2016.docx.pdf

http://www.icwa.in/pdfs/VP/2014/EconomicCostofZikaVirusvp16032016.pdf

http://www.bloombergview.com/articles/2016-02-05/the-economic-cost-of-zika-virus

http://www.vox.com/2016/1/27/10838286/how-to-stop-zika-virus-outbreak

http://www.nytimes.com/2014/07/03/health/Vaccine-Costs-Soaring-Paying-Till-It-Hurts.html?_r=0

http://www.cdc.gov/dengue/

https://www.guttmacher.org/pubs/IB_AWW-Latin-America.html

http://www.nytimes.com/2014/07/03/health/Vaccine-Costs-Soaring-Paying-Till-It-Hurts.html?_r=0

http://epidemi.as/?p=1644