

Complex Systems Thinking Assignment
Vaccine Hesitancy and Refusal to Immunization
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Public Health 4000
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Vaccine hesitancy - A public health problem:

Vaccination is one of the most significant achievements of public health (Greenwood, 2014). Vaccination programs have substantially reduced the incidence and prevalence of vaccine-preventable diseases (Dube et al., 2016). However, the recent outbreaks of vaccine-preventable diseases in Canada reflect that public confidence in vaccination is declining (Dube et al., 2016). Vaccine hesitancy is a serious public health concern as vaccinations are the most effective prevention tools for infectious disease control (Omar et al., 2009). Any significant rate of vaccine refusal can pose a public health threat (Sadaf et al., 2013), as evidenced by recent outbreaks of pertussis in Southern Alberta (Liu et al., 2017). Many studies of vaccine refusal focus on individual or interpersonal factors such as the socio-demographic status of parents (Omar et al., 2009). However, vaccine refusal is a complex, worldwide issue that involves interactions between many systems and levels of influences (Dube et al., 2016). Therefore, it is essential to address it from systems thinking approach.

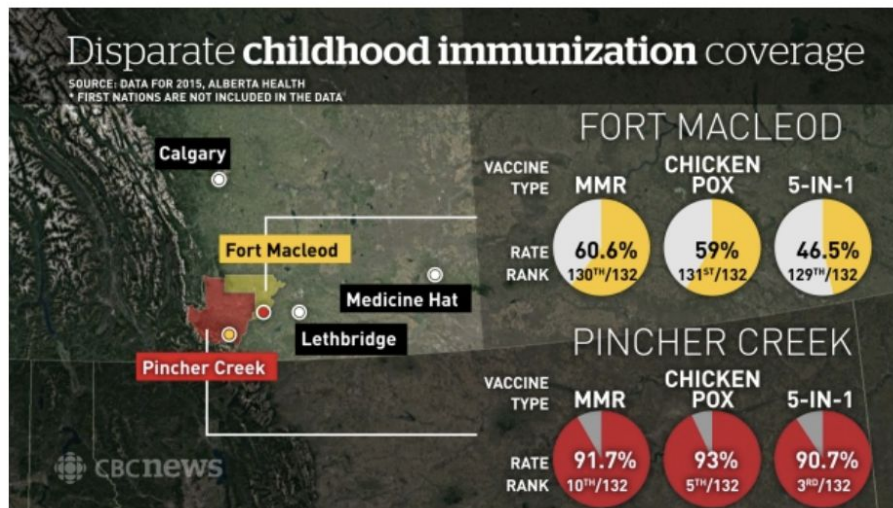
Boundaries of the problem

While vaccine refusal is a worldwide issue, for the purpose of this systems analysis, we will be looking specifically at parental refusal and hesitancy of *Bordetella pertussis* (“whooping cough”) vaccination (DTaP-IPV-Hib) in Southern Alberta. This has been selected because of recent outbreaks in the area, which suggests that refusal of this vaccine is a very pertinent public health issue (Liu et al., 2017).

Time-scale :

We will be looking at the time-scale starting from the year 2000 and ending in 2017. In this time period, there have been various outbreaks and sporadic incidences of *Bordetella pertussis*, with the most recent outbreak beginning in 2016 (Alberta Health Services, 2017; Fathima et al., 2014). In the most recent outbreak, the incidence rate of *Bordetella pertussis* has surged to 416 cases, with 90% of afflicted patients reporting no history of immunization (Alberta Health Services, 2017). Our causal loop diagram (CLD) will account for many of the factors behind this outbreak and also explore other potential determinants contributing to the low vaccine rates or hesitancy towards immunization.

Fig.1 Pincher Creek vs Fort Macleod immunization rates, Fletcher, 2017.



Identifiable variables in the system:

Parental Concerns and Personal Factors Responsible for Vaccine Refusal:

Role of Sociodemographic factor:

A crucial element of vaccine hesitancy is personal factors. This includes socioeconomic status, education and knowledge level, perceived risk levels and individual proximity to vaccine clinics and services. Socioeconomic indicators related to education, poverty, and insurance have been associated with immunization uptake across countries (Dunn et al., 2017). Anello et al. (2017) found that parents with higher formal educations who lived in highly-developed countries were more likely to be non-compliant with vaccination schedules. Additionally, those who live in rural areas are less likely to vaccinate themselves and/or their children than those who live in urban areas, mainly due to restricted proximity to medical services (Zimmerman, 2003).

Moreover, according to a study by Smith et al. (2011), ethnicity may also play a role. Similarly, in Southern Alberta, Lieu et al. (2017) and Kulig et al. (2002) mention that low vaccination rates have been observed in certain ethnic groups like the Dutch and Hutterites who refuse to vaccinate their children due to various child health and safety concerns. This body of evidence shows that a large number of personal factors have a

significant effect on vaccination refusal and hesitancy, especially when taken in the context of other important system factors.

Parental Attitude and Concerns towards Immunization :

Issues of trust regarding the vaccine, medical professionals, and government authority also contribute towards vaccine hesitancy (Colgrove, 2016). Parental concerns on why they refuse to vaccinate their child are; potential to experience a long term complication/adverse effect from a vaccine, short term pain or fever, current illness, do not think their child will contract the vaccine-preventable illness, a view that it is a lack of control regarding health decisions for their child, fail to believe the risk or severity of disease is warranted for vaccination, have friends using an alternative vaccination schedule, concerns that vaccines weaken the immune system, fail to believe that vaccines are effective, view there is inadequate research, and general worry (Bass, 2015; Kulig et al., 2002). Hence, for all the mentioned reasons, by many parents, vaccination is perceived as unsafe and unnecessary (Onnela et al., 2016; Kulig et al., 2002).

Role of Social Network:

An important element of the system is the influence of social networks on immunization. Many communities within the South Zone of Alberta are socially isolated from the general population in their geographical area (Matkin, Simmonds, & Suttorp, 2014). However, they are highly interconnected within their community and share unique cultural and religious beliefs. The Netherlands Reformed Congregation represent a larger part of these communities, along with the Low German-Speaking Mennonite communities, and some Hutterite colonies. Children of these communities are either privately schooled or homeschooled and participate in activities such as sports or church mainly within their tight-knit social networks (Matkin, Simmonds, & Suttorp, 2014; Kulig et al., 2002). These communities are also strongly linked to countries such as Netherlands, South America and Mexico, and traveling to related communities who also might have low immunization rates increases the risk of importing vaccine-preventable diseases to southern Alberta and hence a potential risk of outbreak (Matkin, Simmonds, & Suttorp, 2014). The people that parents know personally, including friends, families, and co-workers can have a major impact on their decisions regarding pertussis vaccination. Young couples are advised by their relatives not to immunize their children (Kulig et al., 2002). Specifically, Onnela et al.

(2016) found that vaccine-refusing homes have more ties to other vaccine-refusing homes than to vaccine-accepting households. Additionally, those who have positive social support, in the forms of family members or friends supporting vaccines, are three times more likely to accept vaccines than those who do not (Frew, Saint-Victor, Owens, & Omer, 2014).

Role of Religious Beliefs:

Another important element of social networks that must be considered is religion. While many religious leaders from a variety of faiths have espoused the benefits and permissibility of vaccines to their followers (Grabenstein, 2013), there are some religious messages that oppose vaccine (Dubé et al., 2013). Religious opposition to vaccine may occur due to a variety of features of vaccination. On a global scale, some minority religious groups have expressed political concerns that vaccinations represent masked forms of sterilization or cultural genocide (Grabenstein, 2013). More commonly, religious followers may object to the bovine, porcine or egg contents in vaccines, due to religious beliefs in vegetarianism and/or religiously sanctioned slaughter techniques (Grabenstein, 2013).

Another factor which may lead some religious groups and individuals to reject vaccines is a belief in healing through faith alone (Grabenstein, 2013). This doctrine, espoused by a small but vocal minority of North American Christian groups, contains the principle that believers should solely rely on religious and spiritual treatments such as prayer and worship, rather than seeking secular medical services such as vaccination (Pierek, 2017). This doctrine is believed to have a significant influence on the low rates of vaccinations in certain Southern Albertan Christian communities, making it very relevant to our causal loop diagram (Kulig et al., 2002).

Moreover, a common religious belief among the Dutch and Hutterite population in southern Alberta is that immunization challenges the will of God, and that if not immunized, god will take care of the children. Also, they believe that if a child contracts a communicable diseases then that is god's will, and if a child becomes handicapped from immunization, then its the parent to blame (Kulig et al., 2002).

Interestingly, however, in a qualitative study, Vandenberg and Kulig (2015) found that healthcare professionals tended to attach more importance to religion as a contributing factor to vaccine refusal than did vaccine-refusing mothers themselves. These mothers more often mentioned distrust of the medical system as their reason for dissent, as well as emotional and social factors (Vandenberg & Kulig, 2015). While this study suggests that the role of religion in Southern Alberta immunization refusal should not be overstated, religion does remain an important factor in the overall system of vaccine refusal, due to the factors outlined above.

Role of Media in Vaccine Hesitancy:

Vaccine refusal is influenced by many factors, including open information on the internet or other sources of media. People may not have the time to cross check this information or look for evidence-based information, especially considering that parents are a population with significant time conflicts and constraint. Moreover, at times people may not have the knowledge or concept to formulate the information that is widely available through mass media (Wang, Baras & Bутtenheim, 2015). The unbalanced portrayal or negative image of vaccine by media weakens the confidence in vaccines contributing to the low vaccination rates (Powell et al., 2016).

The News Media:

The news media plays a crucial role in public beliefs, attitudes and opinions regarding vaccines (Ackerman, Chapman & Leask, 2004; Powell et al., 2016). Ackerman, Chapman and Leask (2004) found that Australian newspaper articles that purported adverse effects of vaccines were more likely to be published and linked to medical conspiracy theories than articles that presented vaccines in a positive light.

The Positive Role of Media:

However, media does not only influence vaccine uptake negatively. Specifically, one potential positive effect that the media can have is the communication of outbreak information, which can then lead people to perceive a heightened threat of disease and thus seek vaccination, as Colgrave (2016) reported can happen through public health messages of persuasion and coercion. Rahul, Ries and Caulfield (2011) found that during the H1N1 pandemic in 2011, many media representations of vaccines were positive and

included explicit recommendations for individuals to obtain the vaccination. When paired with emotionally-charged and dramatic coverage of the potential dangers of H1N1, this media coverage may have encouraged people to get vaccinated (Rahul, Ries & Caulfield, 2011).

Role of Medical Sector and Infrastructure in Immunization:

Role of Health Professionals:

Another element of the system is the medical sector. It is through the medical sector that the actual administration of vaccines will take place. Thus, doctors, nurses and other healthcare professionals play an important role in informing parents of the importance of childhood vaccinations. Interestingly, Bass (2015) has found that pediatricians often have more time to have conversations regarding vaccines compared to general physicians, which could have an important influence on vaccine uptake.

Vaccine Center Accessibility:

Another important element of the medical sector is the availability of vaccine clinics. Under-vaccination is often more common in rural areas, due to a lack of visibility and/or availability of vaccine clinics, especially for those who do not have access to automobile transportation (Zimmerman et al., 2003).

Role of Research Sector:

The next element, which is quite closely connected to the medical sector is the research sector. It is important for the research sector to not only continue to work to find safe and effective vaccines, but to also widely publicize and disseminate this information to medical professionals and the general public (Salisbury, Beverley, & Miller, 2002). The research sector has had a significant negative impact on public perceptions of vaccines in the past through the publication of Wakefield's fraudulent data. This demonstrates that the research sector does indeed have power over personal perceptions and could perhaps have a positive effect on perceptions in the future if they wielded their communication with the media, patients and medical professionals, to focus on the positives of vaccines (Rao & Andrade, 2011).

Building a Causal loop Diagram:

The system of vaccine refusal is very open. As detailed above in this paper, there is an interaction between many different elements, including the medical sector, health promotion efforts, media coverage of vaccinations, personal factors such as sociodemographic status and education level, perceived behavioural risks and access to vaccination clinics. All of these elements are interconnected in various ways, as shown in our causal loop diagram (Fig:8, Page 15). The main loops we identified were medical sector, parental beliefs, social network and perceived risk.

Parental attitudes are the main drivers in our cycle (Fig. 2). Parental attitudes on vaccine can be influenced by a variety of factors, including the media, levels of outbreaks, social networks, and religion. It is for this reason that we decided to form it as the main seed structure of our diagram. The parental belief loop is a reinforcing loop as the health practitioners and family and friends influence the parental belief against immunization by providing a negative image of immunization and suggesting alternative vaccine options.

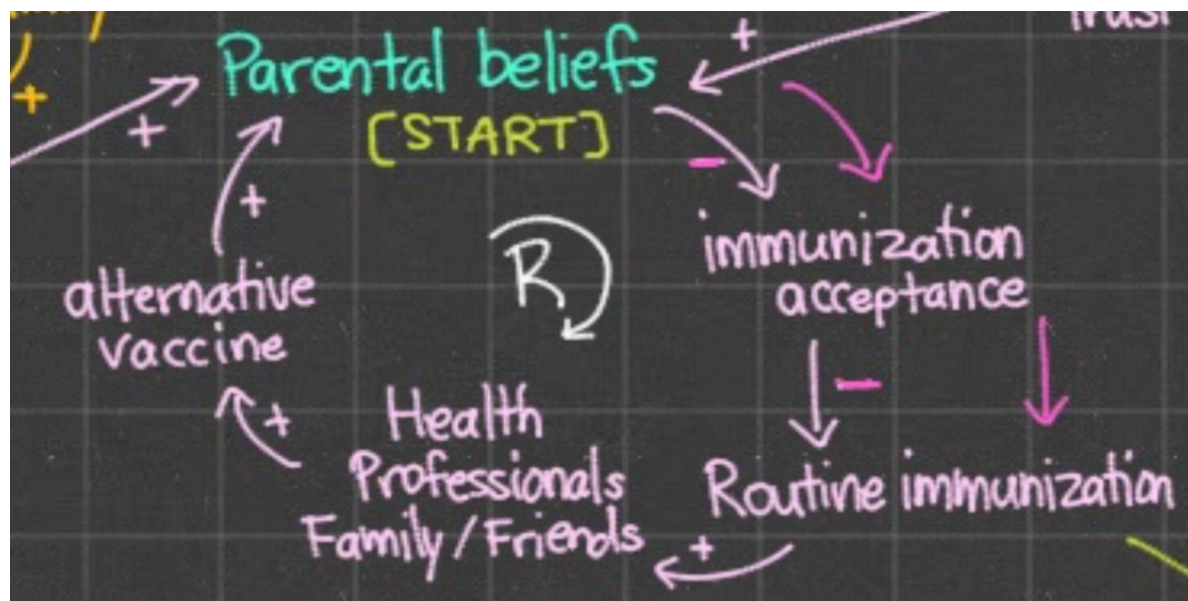


Fig. 2, Parental belief loop

Another contributing factor is negative vaccine information (Fig. 2.2), including information that vaccines will cause pain, fever and adverse side effects. All of this

information, some of which comes from reliable sources and some of which do not, which can further increase parental attitudes against vaccination. Negative vaccine information can feed into myths, while myths can also feedback to negative vaccine information. Finally, alternative vaccine schedules may be the result of myths about vaccines.

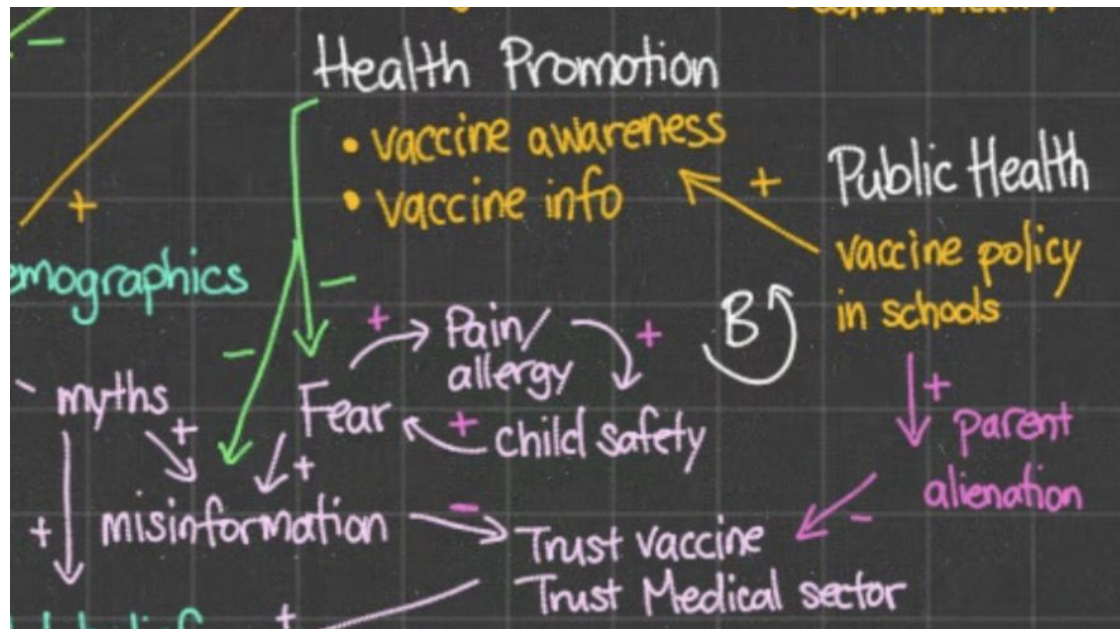


Fig. 2.2, Contributing factors in negative vaccine information

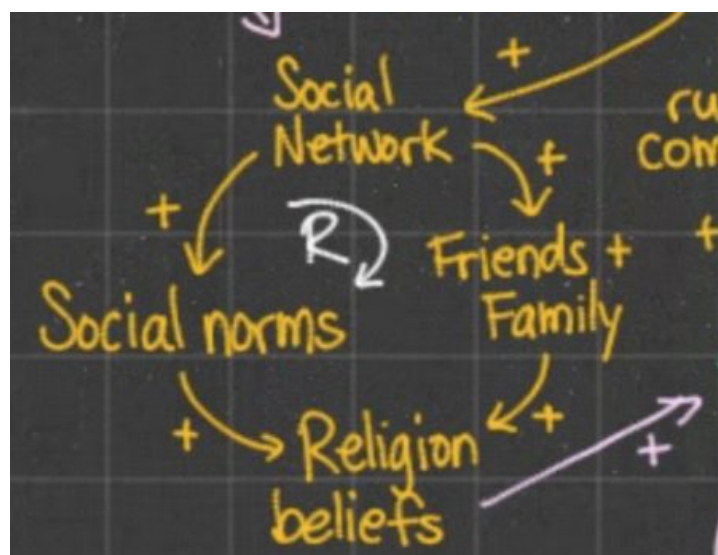


Fig. 3, Social network loop

The next loop, which directly impacts alternative vaccine schedules, as well as our seed loop of parental beliefs, is that of the **social network** (Fig.3). Specifically, family and friends may be responsible for spreading information about alternative vaccine schedules and negative vaccine information in general. The social network also involves social norms and religion, which can play a significant role in discouraging vaccine uptake as outlined earlier in this paper. Hence, all these variables are responsible for the vaccine hesitancy observed in parents and thus leading to refusal to immunization, making it a reinforcing loop.

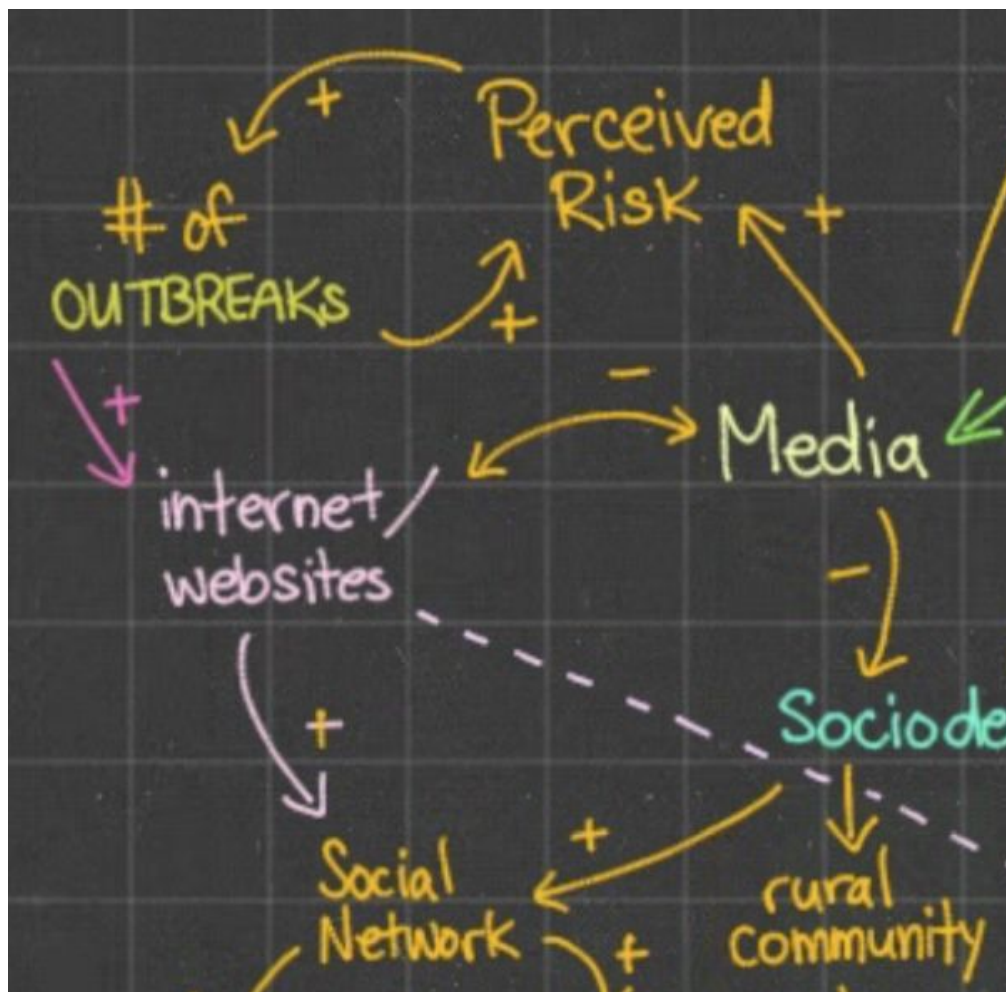


Fig. 4, Sociodemographics and media loop

The next important factor is sociodemographics. **Sociodemographics** loop (Fig. 4) is tied to parental beliefs loop, and also to the social networks loop. An individual's economic status and educational level influence what social networks one is a part of (Zimmerman, 2003).

The sociodemographic status also affects what type of media one is exposed to, and media has a significant impact on vaccination status.

As mentioned earlier in our paper, **media** can have a positive role but is mostly negative for this health issue, as seen by the proliferation of false information about vaccination, which can then be disseminated into the social network as pictured in our diagram. It is for this reason, that we consider the media to increase vaccine hesitancy within our diagram. Media is also connected to myths and misinformation, which can then lead to distrust in the vaccines. Many facets of the media are contributing to distrust of the medical and pharmaceutical sector, and in turn, distrust of this sector will contribute to lower vaccination rates. The media loop connects to the perceived risk loop, which relates to the number of outbreaks. Outbreaks will increase perceived risk and ultimately vaccination rates, although unintended consequences can arise from media reporting on outbreaks, as will be described below.

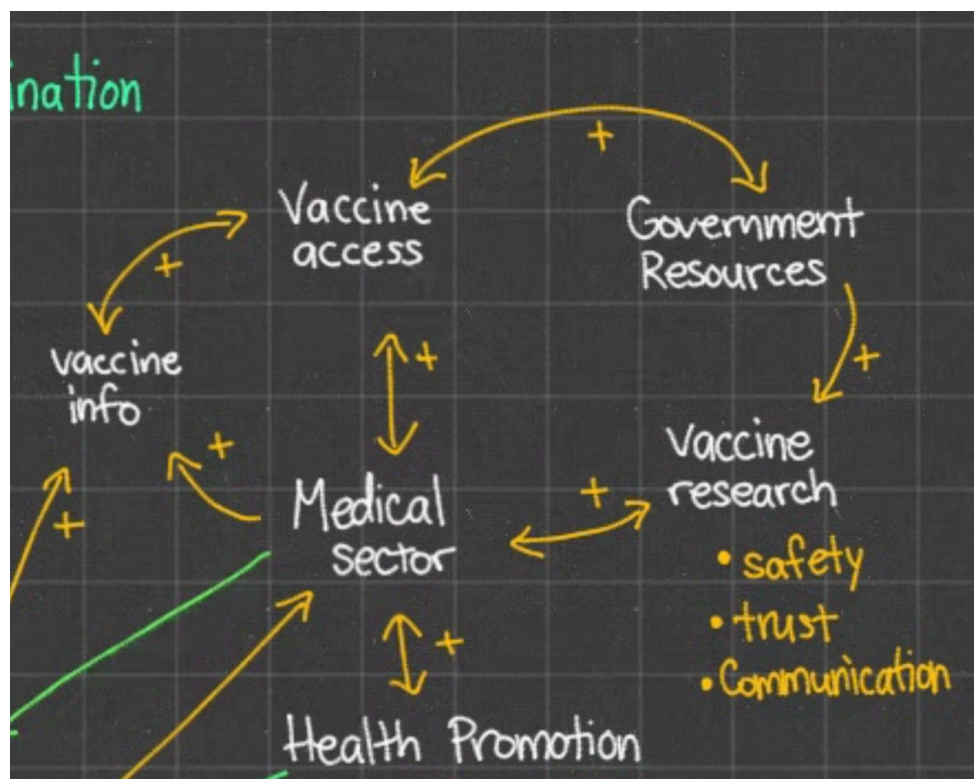


Fig. 5, Medical sector loop

The final loop we will be discussing is the **medical sector loop**, (Fig. 5). The medical sector is connected to vaccine information and access, as medical practitioners must have access to both reliable information on vaccines and access to the actual vaccines, in order to effectively intervene in vaccine hesitancy. Furthermore, vaccine access is attached to government resources, which is then tied to vaccine research. Vaccine research involves safety, trust and communication (Bouder, 2015). Vaccine research is then tied back to the medical sector because it is the responsibility of medical workers to ensure that they communicate research on vaccines with their patients and with community members (Bass, 2015). Thus, the factors of vaccine information, vaccine access, government resources, and vaccine research all form a loop in connection to the medical sector. Additionally, all of the mentioned factors are positive, which means that they will contribute to higher vaccine use.

Leverage point for intervention in the model:

Public Health no longer uses coercion or legal policies with enforcement to get people vaccinated. However, there remains persuasion tactic to be used (Colgrove, 2016). Vaccine interventions that play a role are the government laws - school immunization requirements, school and government policies for immunization exemptions, and parent immunization information or education (Sadaf, et al., 2013).

As public health practitioners, our entry point for intervention will be to identify those who are refusing vaccinations (Fig. 5). Then, we will have to dispel distrust in both vaccinations and the medical system as a whole, by promoting true messages and research on vaccination. We will have to address negative information about vaccines, working with vaccine refusers and describing which negative consequences may be real (i.e., slight pain or discomfort) and which are mostly inflated (i.e., autism risks). To address the media sector, we could put out positive media messages on vaccination or work to help increase media literacy.

Health Promotion

- vaccine awareness
- vaccine info

Demographics

myths

Fear

Pain/allergy

child safety

(B)

Unintended Consequence

One unintended consequence represented within our loop is parental alienation. This could occur if parents feel that, due to mandatory or heavily compulsory vaccine programs through the public health sector, that they do not have control over their children's health. This could then further increase distrust in the medical sector and thus eventually lead to even more vaccine refusal and a reinforcement of parental beliefs. Another unintended consequence could arise in times of outbreak (Fig. 7). In this situation, people who hear about outbreaks will then look into media about the disease and vaccination and could then be exposed to negative media about vaccines.

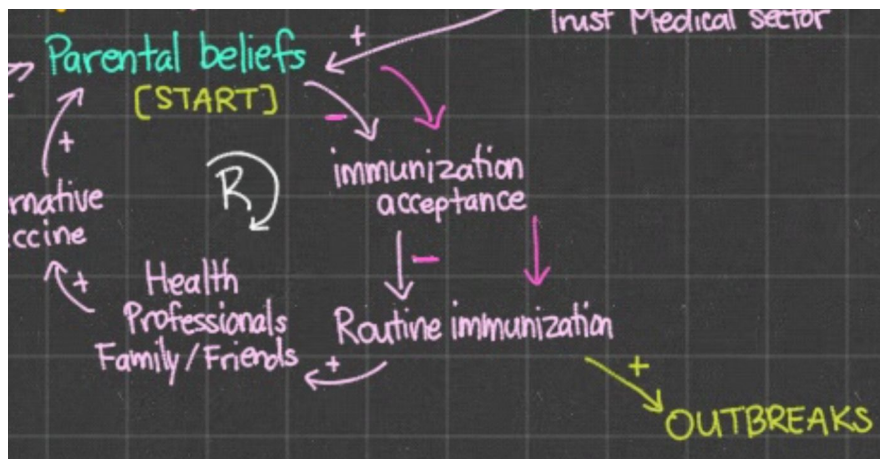


Fig. 7, Unintended consequence, reinforcement (pink colour)

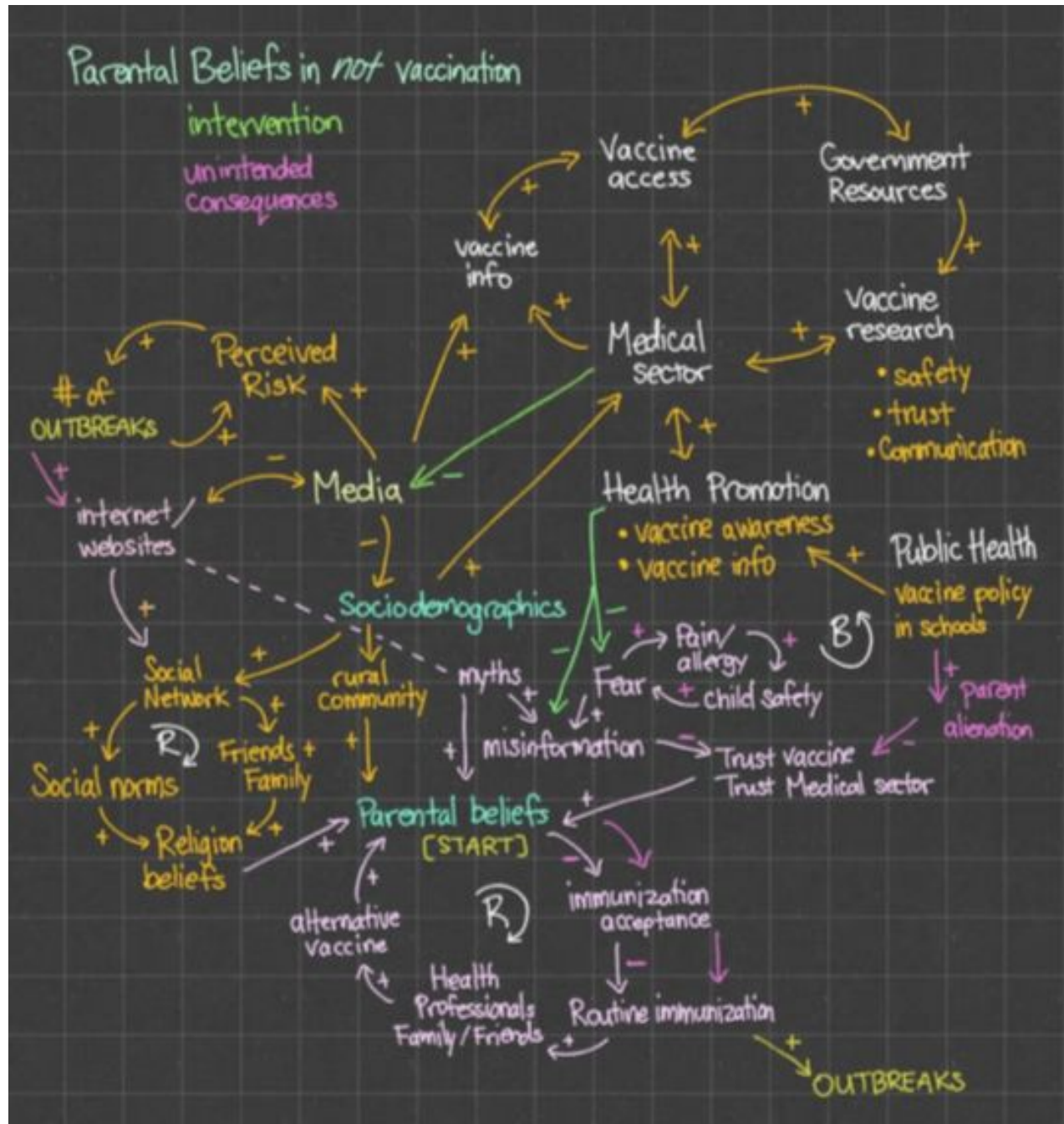


Fig. 8: Causal Loop Diagram for low vaccination

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