

# **Geospatial Health Risk Mapping**

## Executive Summary

In 2012, the healthcare consumed 10.9% of Canada's gross domestic product [1] whereas United States spend a whopping 17.6% on healthcare expenses [14]. With a large portion of our country's GDP being invested for healthcare, it is important to improve our understanding of ecology and complex health issues as this equates to not only bettering people's lives but also reducing excess burden on the National economy. Finding integrated solutions to health issues requires us to focus on both the environment and health parameters. Geographic analysis allows users to explore and overlay data by location and to generate clear and accessible maps and data reports that are powerful tools for project development, community outreach, and policy design [16]. Geographic information systems (GIS) holds great promise in the healthcare sector by allowing us to gain insight into the relationships between environmental exposure and illnesses [2]. GIS are computer-based systems that can dynamically link the location and attributes of things into an analytical environment in order to build insights [3]. The opportunities to apply GIS in healthcare are myriad, specifically in areas such as tracking disease progression, identifying contributing factors to the spread of illnesses, and locating pockets of abnormally high health risk indicators [4]. This leads to faster, better and more robust understanding and decision making-capabilities in the public health sector.

The scope of GIS in healthcare is definitely not limited to the public health sector, but it can also prove to be valuable to the government, pharmaceutical and travel industries. Despite the large numbers of residents from United States and Canada who travel internationally every year, research has shown that their overall risk awareness and practice concerning preventive travel health measures, especially the use of itinerary-specific immunizations, was low. [21]. Hence a geospatial map showing the risks associated with travel to specific regions is very much necessary. The data, if presented in a user friendly fashion, can help raise awareness and increase rates of preventative health practices before travel. This in turn can help the government save a significant amount of money. The proposed geospatial health map consists of a map with relevant health related data associated with a particular region. By clicking on a region in the map, one can bring up all the health related information they would need to travel to that region. The information consists of historic and current data on the outbreaks, animal attacks, insect bites and natural disasters. Information such as how these risks can be minimized, what precautions can be taken, how to identify the symptoms, etc. is also included.

## **Company and Industry:**

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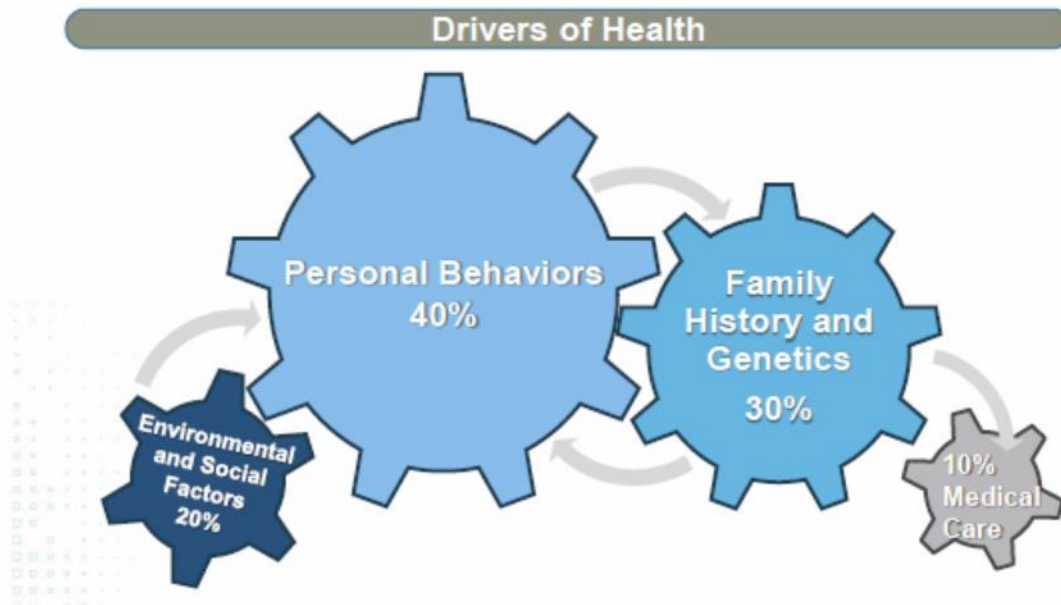
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## The Industry

The healthcare industry is one of the world's largest and fastest growing industries. In most developed nations, healthcare costs consume over 10% of the gross domestic product (GDP), hence making a tremendous impact on the country's economy. The healthcare sector currently faces basic challenges of operations, logistics, resource allocation, customers and management. To overcome these issues, more relevant information is required [4]. GIS and other geospatial technologies offer tremendous benefits for the healthcare industry and they offer a unique way of combining and analyzing information. GIS plays a critical role in determining where and when to intervene, improving the quality of care, increasing accessibility of service, finding more cost-effective delivery modes, and preserving patient confidentiality while satisfying the needs of the research community for data accessibility. With the possibilities of GIS in healthcare being myriad, it has become increasingly important for accurate and nuanced analysis and decision support [12].



More than a century ago, epidemiologists and other medical scientists began to explore the potential of maps for understanding the spatial dynamics of disease [9]. Today, a GIS is rapidly becoming an important tool for health researchers and planners. A GIS has many uses in the healthcare sector and some of the most important ones are discussed below:

#### *Prediction and control of disease spread:*

A GIS has become an important tool in mapping and predicting the spread of disease, thus allowing the healthcare planners to develop a containment plan. For example, a recent study in China has used GIS and determined that the next at-risk region for the H7N9 avian flu virus is located in a north region of Vietnam. This was determined by mapping the previous cases of flu which created a cookie-crumble trail that led them to predict northern Vietnam as the next impact area [10]. If hospitals build databases using patient home addresses they would be able to detect trends based on patient geography. This could allow hospitals to stock medical inventory based on new information, train their staff in advance of the diseases, and forecast the number of patients that will be affected [10].

#### *Improving healthcare delivery:*

In emergency medicine, time is of utmost importance. Using GIS to analyze emergency vehicle deployment times provides a foundation for recommending improvements. A GIS developed for southern Ontario combined data on ambulance locations with a data set containing the location, time of day, response time, and type of call for each ambulance call. This system allowed analysts to display maps of response times by type of call and responding ambulance, and to identify calls and locations with unusually high response times [11].

#### *Nursing case management:*

Using GIS, a nurse case manager is able to see which community resources are in proximity to their patients (e.g. Therapy providers, home health agencies and pharmacies). This information is very beneficial in rural locations and for a community to assess the need for expanding resources or to figure out where there is a need for a certain resource they might lack [13].

#### *Geomedicine:*

Patients will benefit from a more precise understanding of the links between their health and where they live, work and play. The geographic location can provide the context within which the clinician can assess environmental factors and make judgments about diagnosis, treatment and prognosis. Overall, Geomedicine has the potential to transform the way physicians see patients and the potential to provide a more holistic view of the many hidden factors that often defeat achieving successful long-term health outcomes [13].

An area of Geomedicine that can be particularly useful is travel health mapping. When traveller's health is considered, one needs to look beyond the narrow content of travel advice

that is available and encompass a wider range of issues that could impact the traveller [19]. Despite the wide range of potential benefits of using GIS and related technologies for public health in general and travel health in particular, it is important to be aware of the issues associated with doing so. Some of the most important aspects include access to appropriate data, the cost of setting up and maintaining a GIS, and the necessity for ongoing staff training to effectively use the system [19].

### **Product and Related Services:**

#### *A comprehensive health map:*

Globalization presents new challenges and opportunities in combating diseases likely to cause epidemics. As a result of increased international travel and trade, local events acquire international importance. At the same time, the rapid global expansion of telecommunications and broadened access to news media and the Internet have changed the way society treats information. Reports of disease outbreaks are more widely disseminated and more easily accessible than ever before. However, the quality of information is no longer controlled and may be provided out of context, often causing unnecessary public anxiety and confusion [20]. Hence it has become increasingly important to have a platform through which accurate and verified health information is published in a user friendly manner.

The proposed health map is a comprehensive geospatial representation of various factors that can impact one's health. High risk regions where potential threat of contracting an infection can be also be clearly plotted on the map. For example, the current presence of snails of the genus *Bulimus* or *Biomphalaria* in African rivers and lakes could be displayed to highlight where travelers have to be particularly careful in order to prevent a schistosomiasis infection [19].

#### *Design of the website:*

##### Design 1:

For any specified location in the world, the user will be able to access data such as current and past disease outbreaks, animal attacks, parasites, what are the precautions one needs to take, what are the vaccinations recommended, the closest health facility

one can go to get the vaccine etc. The information will be presented in a user friendly manner such that by clicking on a particular region on the map, pertinent information to that location can be accessed. For example, if one were to click on Calgary in the map, some of the details that would pop up are:

- Flu statistics and information: when is the flu season, how many cases in the past, how many fatalities, which vaccine to take, location of the vaccination clinics, precautionary measures to avoid flu, what are the symptoms etc.
- Animal attacks: how many bear attacks, cougar attacks, areas where these attacks took place, current bear sightings, precautions, what to do if attacked by a bear etc.
- Insect bites: Mosquito season, precautions, areas where mosquito infestation is predominant, what are the diseases one to get if bitten by mosquito (e.g. West Nile), how to identify symptoms, treatment etc.
- Natural disasters: flood, hail, snow storm, tornado warnings etc.
- Swimming in lakes and rivers: Algae to watch out for, contaminations etc.

The picture below shows what the health map could potentially look like.



Figure 1 - Health Map

Design 2:

Alternatively, the information could also be accessed on the website through a basic keyword search. For example, the keywords Cancun, animals would bring up information about the various animals found near Cancun, what they look like, what threats they pose, what their bites look like, what to do if you encounter the animal, what to do if attacked by the animal, previous attack statistics etc.

*Cost of developing the website:*

Based on a rough estimation, the current cost of developing the website is around 15000\$.

*Accessing health data:*

Three possible ways of obtaining the data have been currently identified and are briefly discussed below.

Method 1:

There are a number of websites have open data sets that can be accessed for free. These datasets can be accessed and the information can be plotted on the map. Some of the websites containing the data sets are listed below:

Alberta Health Services

Government of Alberta

Center for Disease Control

U.S. Department of Health and Human Services

The challenges faced in this method are:

1. All the health data is not available through open data
2. Each data set is formatted in a different way making it difficult for the programmer to plot the information on the map.

The advantages of this method are as follows:

1. Costs associated with accessing the data is minimal
2. The personnel required for this method will be less



#### Method 2:

Several organizations such as CDC and WHO have access to this information and it might be possible to purchase the information from them. However these agencies do not give out information to companies that will use it for profit, thus posing a big challenge in attaining the data from them.

#### Method 3:

Another way to access accurate health information from all over the world would be by hiring representatives from all the major travel locations such as Mexico, Canada, USA, UK, Dominican Republic, France, Italy, Germany, Jamaica, China and Spain. These representatives would report on any current outbreaks, animal bites etc. in their location. This information can then be updated on the website. The advantage of this method is that the information can be entered into a standard format, thus making it easy for the programmers to work with the data. However, the main drawback of this method is that it can cost a lot of money. For example, nurses hired in at least two different locations in each of these countries can cost approximately  $11 \times 2 \times 75,000 = 1,650,000$  \$ annually.

#### **Market Analysis:**

By 2015, the global healthcare market is forecasted to be worth over \$3 trillion. Of that, the healthcare analytics industry will be worth approximately \$10 billion [5]. A recent study estimated the healthcare analytics market at \$4,430.9 million in 2013 and projected it to reach \$21,346.4 million by 2020, growing at a CAGR of 25.2% from 2013 to 2020 [6]. In 2013, North America accounted for the largest share of 58.5% and also registered the highest CAGR during the forecast period [8]. From these statistics, it is clear that there is a massive demand for healthcare analytics. This demand has led the developers to focus their efforts on GIS solutions for the healthcare sector.

A GIS can especially be useful in the travel health sector with international travel projected to grow every year. In 2012 the worldwide international tourist arrivals was projected to reach 1 billion arrivals- a 48% increase since 2000. With increased travel, there is an associated increase in spread of diseases as travellers have contributed to global spread of infectious diseases, including novel and emerging pathogens [23]. Travel-related morbidity is a serious issue, with 20%- 70% of travellers returning from

developing countries self-reporting some sort of illness where as 8% were ill enough to seek healthcare [23]. The costs associated with travel-related illnesses can be a huge amount. In the year 2000 United Kingdom, reportedly spent over 11 million pounds. Over 30 million people travel abroad from UK every year and nearly 42% of these people become ill when they are abroad [22]. A GeoSentinel Surveillance System initiated in the year 1995 to track travel related morbidity, showed that out of 164,378 patients entered into the system, 141,789 were diagnosed with a travel-related illness. The Figure 1 below shows the flowchart of patients in the GeoSentinel database [23].

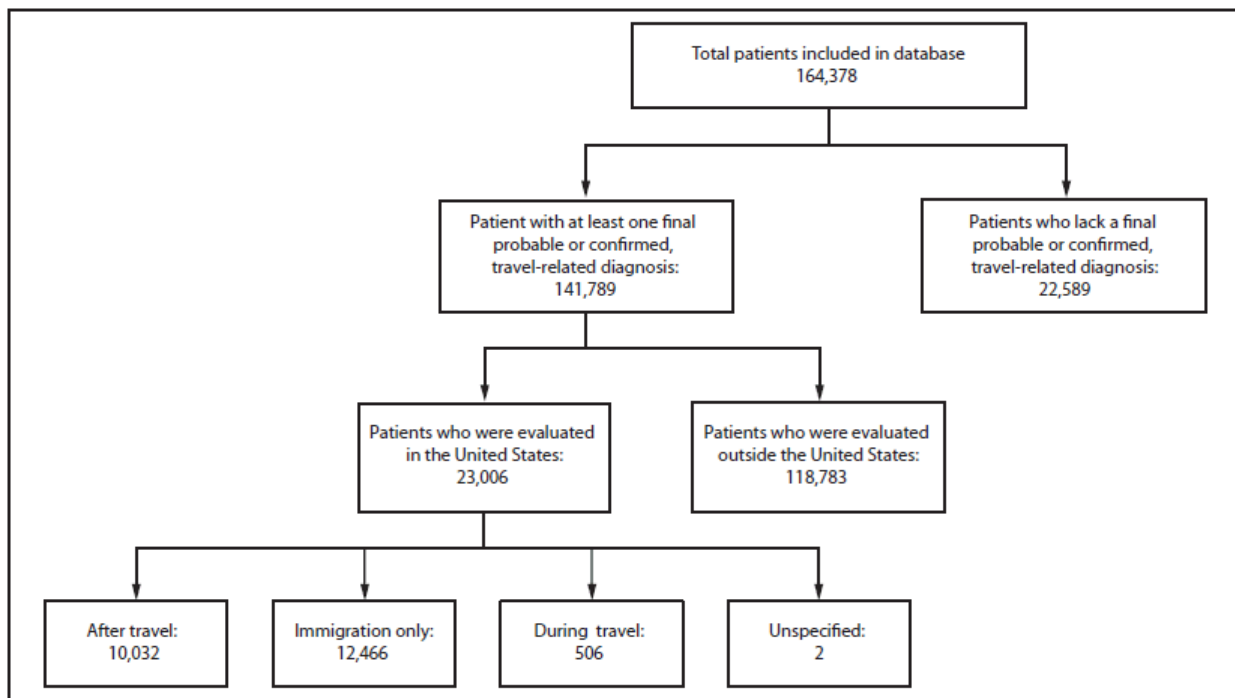


Figure 2 - Flowchart of patients included in the GeoSentinel database - GeoSentinel Surveillance System, worldwide, 1997-2011

A similar study in Canada by CanTravNet between 2009- 2011 showed that out of the 4365 sick travellers and immigrants, 3943 (90.3%) were assigned a travel-related diagnosis. Among the 3115 non-immigrant travellers with a definitive travel-related diagnosis, arthropod bite (n = 127 [4.1%]), giardiasis (n = 91 [2.9%]), malaria (n = 77 [2.5%]), latent tuberculosis (n = 73 [2.3%]), and strongyloidiasis (n = 66 [2.1%]) were the most common specific etiologic diagnoses [24].

From the above mentioned studies, it is clear that travel related sicknesses have a pretty big impact on a country's economy. Travellers need to be aware of the health risks their country of travel poses. They also need to take preventative measures such as travel

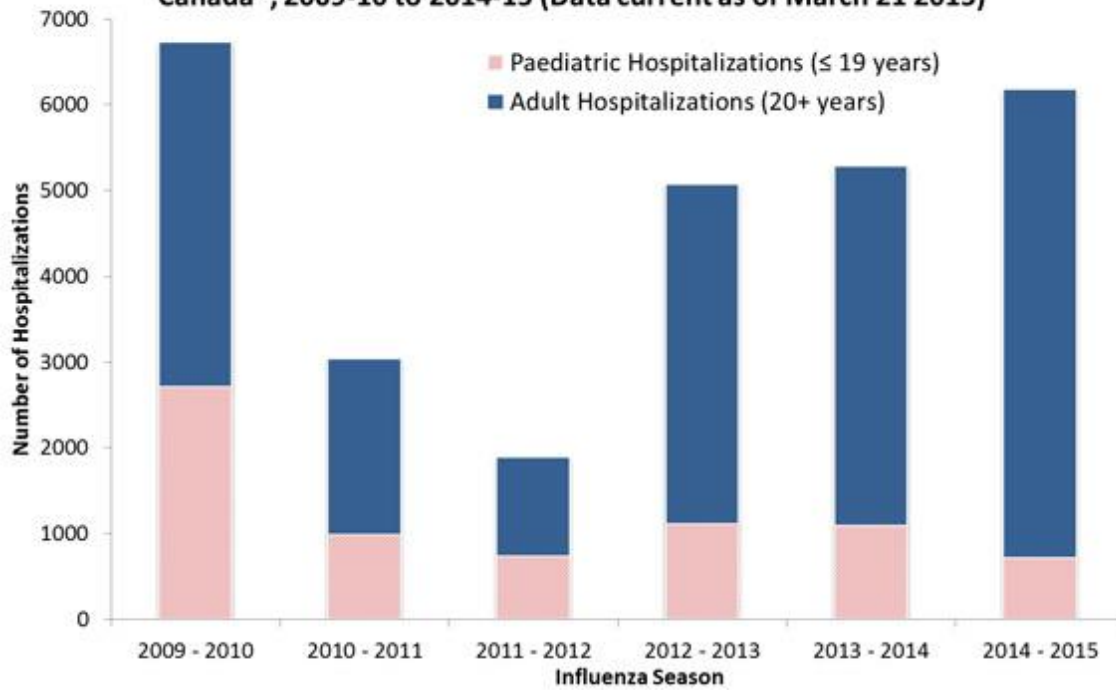
vaccines etc. to avoid contracting any diseases during their travel. Currently, no single platform exists that can provide travellers accurate and comprehensive health information associated with their travel. Having such a platform can be very beneficial for governments as well as general public.

### **Return on Investment:**

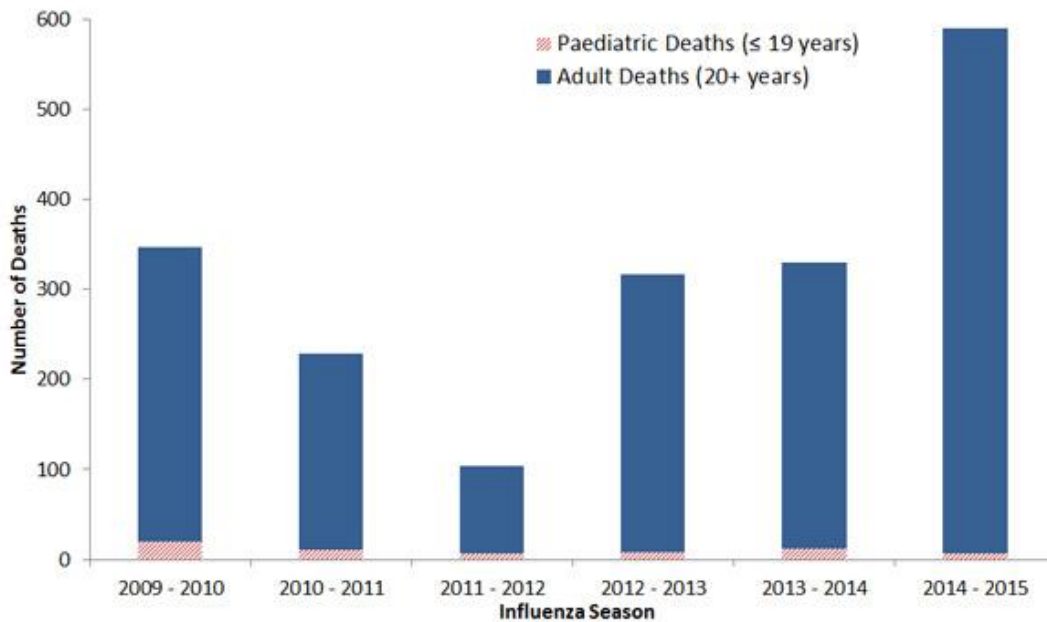
#### *For Health Organizations:*

Health Canada currently spends over 5 million on its advertising budget. Close to 30% of this amount is spent on advertising campaigns over the internet. However, even with massive amount of money being spent, data does not suggest that there are any improvements in public health. For example, statistics have shown that the number of hospitalizations due to influenza have increased every year since 2011 (refer to Figure 2). Similarly, the number of influenza related deaths have gone up as well (refer to Figure 3). Hence a better way of reaching out to people regarding public health issues becomes necessary. A single platform with a comprehensive health data set presented in a user friendly fashion, might be the best way to reach out to people.

**Figure 1. Reported number of hospitalizations by influenza season, Canada\*, 2009-10 to 2014-15 (Data current as of March 21 2015)**



*Figure 3 - Reported number of deaths by influenza season, Canada\*, 2009-10 to 2014-15 (Data current as of June 6, 2015)*



*Figure 4 - <http://www.phac-aspc.gc.ca/influenza/flu-stat-eng.php>*

Similarly, other health organizations such as CDC, WHO etc., can benefit from a website that offers comprehensive health information to travellers. So with just a small portion their advertising budget spent on the health mapping website, they could raise awareness amongst public and increase immunization rates.

*For Pharmaceutical companies:*

Pharmaceutical companies spend anywhere between 20 to 30% of their sales on advertising costs. It is estimated that the pharmaceutical industry currently spends close to \$1 billion on DTC promotions on the internet. Hence the pharmaceutical companies can spend a portion of their advertising budget to advertise their products on the health mapping website. This would allow them to promote their drugs, vaccines etc. Pharmaceutical companies can also offer travel kits pertaining to each city of travel. These travel kits can contain any specific medications required for travel to that location and can be purchased directly from the website. Some of the big pharmaceutical that we could target for advertising are GlaxoSmithKline, Pfizer, Merck, Johnson & Johnson, Novartis, AstraZeneca, Abbott, Bayer Healthcare, Bristol-Myers and Roche. Of these pharmaceutical companies, Sanofi, GlaxoSmithKline, Merck, Novartis and Pfizer are the top five vaccine manufacturing companies based on revenues. Some of these companies were contacted and the marketing department at GlaxoSmithKline has responded and showed enthusiasm in our idea. A meeting has been set up in August with their marketing manager.

*For Travel companies:*

Travel companies such as Priceline and Expedia spend around \$1 billion on Internet advertising. Hence it would be beneficial for these travel companies to advertise on the health mapping website. For example, if there is a hotel that boasts of zero cases of bed bug bites, then they could advertise on the page where the bed bug statistics are listed so that they can attract the customers who are interested in staying only at hotels where no bed bug cases were reported. Some other travel companies that we could potentially target for advertising are Travelocity, Orbitz and TripAdvisor. Another potential way advertising on the health mapping website could prove beneficial for travel companies is, by promoting hotels and restaurants with zero cases of food poisoning.

*For Travel/Vaccination clinics:*

The travel clinics or vaccination clinics could have their information listed on the health mapping website for a small fee. The people who go on the website, to find out where they can get their vaccines, will be able to view information regarding these clinics. This in turn directs more traffic to these clinics thus boosting their revenue.

### **Competitive Analysis:**

#### *Healthcare Analytics:*

Cerner Corporation (U.S.) is the largest player in the Healthcare Analytics market, followed by McKesson Corporation (U.S.) and Epic (U.S.). The Healthcare Analytics market is consolidated, with major players accounting for more than 80% market share in 2013. Top ten major players are Cerner Corporation (U.S.), McKesson Corporation (U.S.), Epic (U.S.), IBM Corporation (U.S.), Optum (U.S.), Oracle (U.S.), Allscripts (U.S.), MedeAnalytics (U.S.), Truven Analytics (U.S.), and Information Builders, Inc. (U.S.) [8].

#### *Health mapping:*

Currently, only a handful of websites have attempted to map the health risks associated with travel. However, most of these websites just pull information off of google and other search engines and hence the information displayed is not always reliable or accurate. Some of these websites are listed below. There are other websites such as CDC and WHO which have reliable and up to date information on travel health risks, but this information is lost in the tremendous amount of data that is present on these websites and hence becomes extremely difficult for a user to access the information he is looking for. Hence it is extremely important to have a portal through which accurate and reliable information is presented in a user friendly fashion.

#### Germtrax.com

Germtrax is an unreliable website and gets information through public reporting their symptoms on their website or through social media. The website only covers general categories for common communicable sicknesses.

Monthly visitors: 8340

#### Healthmap.org

Healthmap collects and integrates outbreak data from a variety of sources, including news media (e.g., Google News), expert-curated accounts (e.g., ProMED Mail), and validated official alerts (CDC, WHO). It is not always reliable and sometimes data is misrepresented.

Monthly users: 237,138

[wwwnc.cdc.gov/travel/](http://wwwnc.cdc.gov/travel/)

This website has a lot of data and is very accurate. However the information is not represented in a user friendly fashion.

<http://www.medaire.com/home>

The health risk map 2015 is a map that has all the disease out breaks and health risk for the year 2015. However, this map does not get updated and current events are not listed.

<http://outbreaks.globalincidentmap.com/>

The Disease Outbreaks Map is based on reports of outbreaks reported on local media websites around the world as well as other sources.

<http://gamapserver.who.int/mapLibrary/>

WHO- World Health Organization

Information is hard to find on the website and it is not presented in a user friendly fashion.

## **Technical Risks & Challenges:**

### **Method/mechanism to harvest and synchronize all the data**

What makes MGIS unique is its focus on local health and medical conditions. Compiling this information poses three forms of risks and challenges.

- Local health information is not readily available in a convenient data format.
- Where there is information, it needs to be medically verified.
- Once the information is verified, it needs to be analysed to draw deeper meaning from it.

Information can be harvested manually using a team of people to collect the information and a search algorithm can be used to gather the data online. Once the information is collected, a second more qualified team is needed to vet the information and massage it into a standard useable database. A third team is then used to perform the analytics on the data and format the results in a way that can be seamlessly updated onto a website or smart phone app.

### **Harvesting Local Health Information Manually**

Local health practitioners can be hired to complete regular health reports based on their first-hand knowledge in the targeted areas. Since, field clinics or field hospitals are first responders to changes in local health conditions, a travelling practitioner visiting a specified route of field clinics can report on the local health conditions. Senior medical students or retired practitioners would be good candidates for this role.

Paying government institutions for local health information may not be productive. Government health institutions, especially in tourist areas, may resist publicizing health information that could jeopardise their economy. The best source of accurate information is a trained medical person reporting from the location. Manually collecting data is more cumbersome than using online sources. In addition, there are management costs to effectively manage remote personnel. However, the information collected in this manner is better than online sources because it is a first-hand report from a medical practitioner and in some ways it is pre-verified.

### **Designing a search algorithm (spyder) for gathering the specific online data.**

Gathering online information can be done using an algorithm which is finely tuned and targeted to filter and scrape medical information off the internet. This type of algorithm is often referred to as a web crawler or a web spyder. A good example of a focused crawler is *Citeseerxbot* which is an academic crawler. This search algorithm crawls the internet for free-access academic



related documents primarily in the fields of computer and information science. The same approach can be used to scrape the web for freely accessible medical information. Local online newspapers normally have a health section. Dramatic changes in the local health conditions normally will appear in the leading sections of a newspaper. Government websites such as the Public Health Agency of Canada are a source of region specific health condition information. Expat websites and local health agencies are another source of information. The web search spyder can focus on a library of key words. Data collected can be prioritised based on the trust level of its source. The web crawling process will also require post crawling actions to refine down the information using machine learning, modelling, pattern recognition or regular expression algorithms.<sup>1</sup>

### **Data Interpretation and Analytics**

Once data is gathered, it must be analysed. The objective of data interpretation and subsequent analytics is twofold. The first objective is to draw an accurate and comprehensive picture of the health conditions in a targeted area. This picture can be drawn to a level that serves the general population of travellers or it can be further refined to serve a more specialised section of the population such as military, business investment, major NGO's. The second objective is to spot small changes before they become *tipping points* to trends or epidemics. As Malcolm Gladwell wrote in his book, *The Tipping Point*; "Epidemics are sensitive to the conditions and circumstances of the times and places in which they occur".<sup>2</sup> Analytics serves to help understand the relationship between health conditions and circumstances of the time and place. Relationships between cause and effect are patterns that can be retained and incorporated into a library. A complex algorithm, using this library of patterns will further automate the analytical process. As more patterns are recognised or existing ones defined, they are added to the library. A library of patterns, combined with an algorithm can provide a more comprehensive picture of health conditions. It also represents a powerful predictive tool on the contagion and travelling effect of pathogenic diseases.

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<sup>1</sup> Wikipedia

<sup>2</sup> Malcolm Gladwell, p. 139, *The Tipping Point*.

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## 2.0 Appendices