



Public Health  
Agency of Canada

Agence de la santé  
publique du Canada

Canada

# Rethinking Public Health Surveillance for the Information Age

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Philip AbdelMalik  
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PROTECTING AND EMPOWERING CANADIANS  
TO IMPROVE THEIR HEALTH



# PART 1: WHY RETHINK PUBLIC HEALTH SURVEILLANCE?





# 48 YEARS AGO...



AS11-40-5868; Copyright/Owner: NASA

[https://spaceflight.nasa.gov/gallery/images/apollo/apollo11/html/as11\\_40\\_5868.html](https://spaceflight.nasa.gov/gallery/images/apollo/apollo11/html/as11_40_5868.html)

## 20 July, 1969



## Apollo Guidance Computer

24 x 12.5 x 6 inches

70.1 lbs

76 kilobytes of memory

<https://history.nasa.gov/computers/Ch2-5.html>

**49 YEARS AGO...**

**OFFICIAL RECORDS  
OF THE  
WORLD HEALTH ORGANIZATION**

**No. 168**



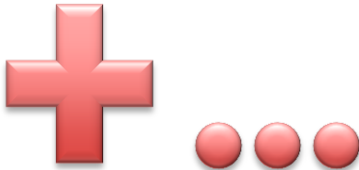
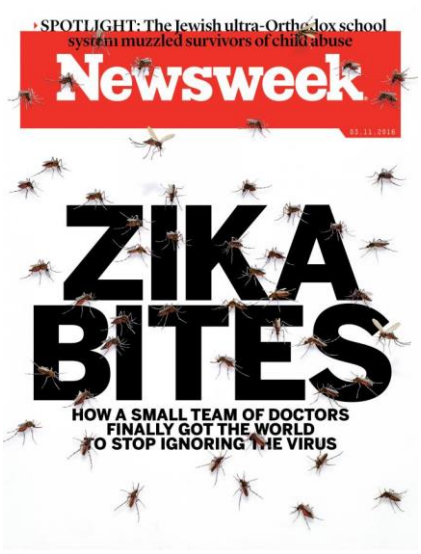
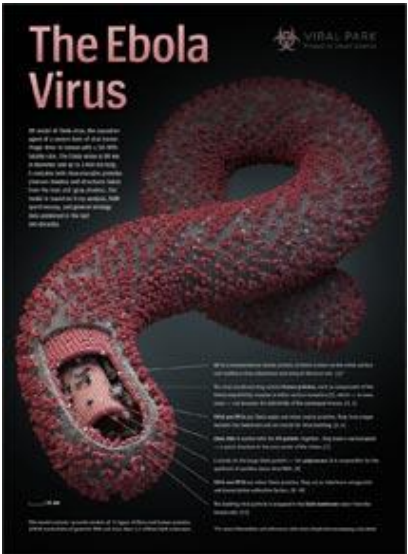
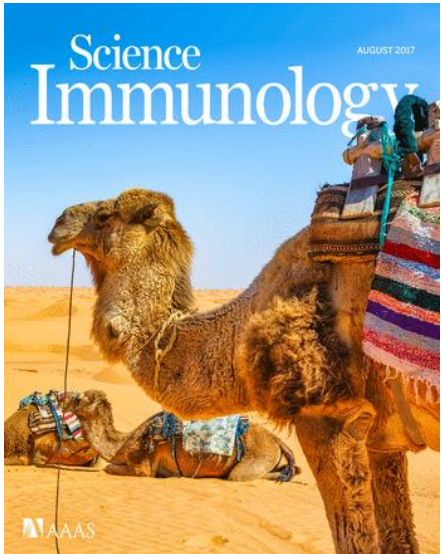
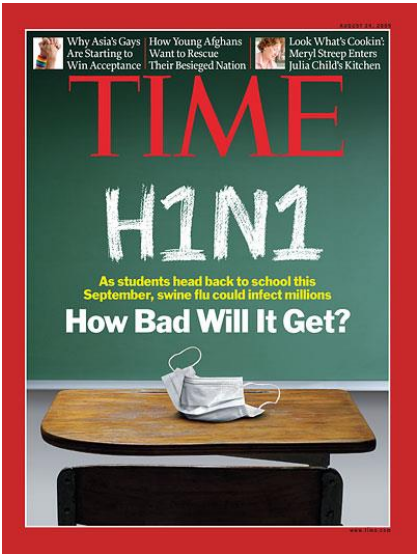
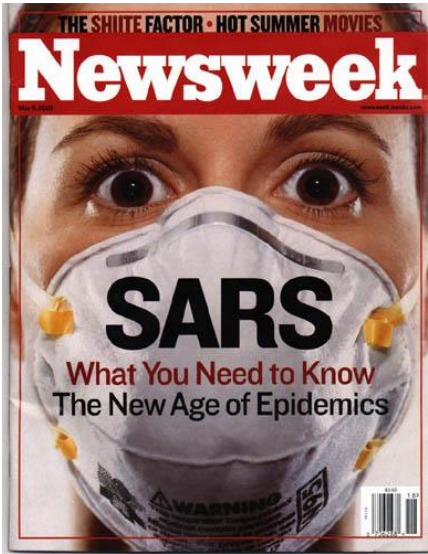
**TWENTY-FIRST  
WORLD HEALTH ASSEMBLY**

**GENEVA, 6-24 MAY 1968**

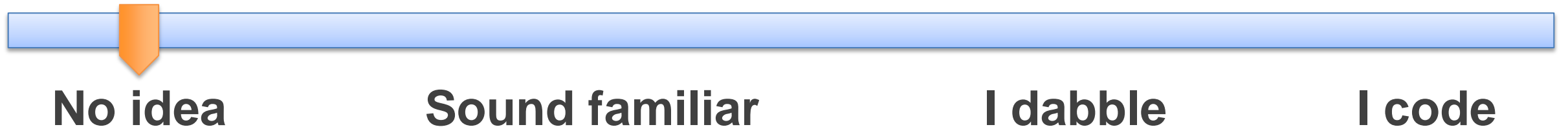
<http://apps.who.int/iris/handle/10665/85808>



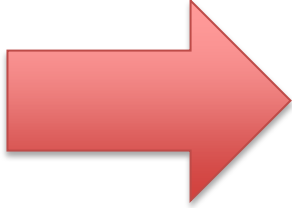
LAST 15 YEARS...



Natural Language Processing  
Semantic Parsing  
Entity Tagging  
Neural Network  
Supervised Machine Learning



# WHY DO PUBLIC HEALTH SURVEILLANCE?

**early  
detection**  **better  
outcome**





**~3,000 BC**  
**Pharaoh Mempses (Semerkhet)**  
**“great pestilence”**



*Bernard C. K. Choi, “The Past, Present, and Future of Public Health Surveillance,” Scientifica, vol. 2012, Article ID 875253, 26 pages, 2012. doi:10.6064/2012/875253*

*Iry-Hor / [CC BY-SA 3.0](https://en.wikipedia.org/wiki/Semerkhet)  
<https://en.wikipedia.org/wiki/Semerkhet>*





## 1348 Venetian Republic

Declich, S., & Carter, A. O. (1994). Public health surveillance: historical origins, methods and evaluation. *Bulletin of the World Health Organization*, 72(2), 285–304.



## 17<sup>th</sup> century London, England

Declich, S., & Carter, A. O. (1994). Public health surveillance: historical origins, methods and evaluation. *Bulletin of the World Health Organization*, 72(2), 285–304.

# DEVELOPMENT...



**02 September 1945**

**U.S. Navy - Naval History and Heritage Command**  
**<https://www.history.navy.mil/our-collections/photography/us-people/m/macarthur-douglas-in-japan-august-1945-june-1950/80-g-332701.html>**



# DEVELOPMENT...



**25 June 1950**

# DEFINITIONS...

*The continued watchfulness over the distribution and trends of incidence through the **systematic collection**, consolidation, and **evaluation** of morbidity and mortality reports and other relevant **data**. Intrinsic in the concept is the regular **dissemination** of the basic data and interpretations to all who have contributed and to all others who need to know*



*Alexander Langmuir*

*The surveillance of communicable diseases of national importance. New England Journal of Medicine. 268:182-192, 1963  
DOI 10.1056/NEJM196301242680405*



***...the epidemiological study of a disease as a dynamic process involving the ecology of the infectious agent, the host, the reservoirs and the vectors, as well as the complex mechanisms concerned in the spread of infection and the extent to which this spread occurs***

***Raska, K.***

***National and international surveillance of communicable diseases. WHO Chronicle. 20(9):315-321, 1966***

***[http://apps.who.int/iris/bitstream/10665/74658/1/WHO\\_CHRON\\_1966\\_20\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/74658/1/WHO_CHRON_1966_20_eng.pdf)***



# DEFINITIONS...

*...surveillance implies the systematic collection and use of epidemiologic information for the planning, implementation and assessment of control of communicable disease; in short, it is “INFORMATION FOR ACTION”.*

*...three main features of surveillance are identifiable:*

- (a) The systematic collection of pertinent data*
- (b) The orderly consolidation and evaluation of these data and*
- (c) The prompt dissemination of the results to those who need to know, particularly those who are in a position to take action*

WHO 1968

[http://apps.who.int/iris/bitstream/10665/143808/1/WHA21\\_TD-5\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/143808/1/WHA21_TD-5_eng.pdf)

## *Indicator Based Surveillance*

the routine reporting of cases of disease, including through notifiable diseases surveillance systems, sentinel surveillance, laboratory based surveillance etc. This routine reporting originates typically from a healthcare facility where reports are submitted at weekly or monthly intervals.

*WHO. Checklist and Indicators for Monitoring Progress in the Development of IHR Core Capacities in States Parties (2011)*

## *Syndromic Surveillance*

Syndromic surveillance uses health-related data that precede diagnosis and signal a sufficient probability of a case or an outbreak to warrant further public health response

*Eysenbach G. Infodemiology: Tracking Flu-Related Searches on the Web for Syndromic Surveillance.*

*AMIA Annu Symp Proc. 2006; 2006: 244–248.*

## *Event Based Surveillance*

the organized and rapid capture of information about events that are a potential risk to public health including events related to the occurrence of disease in humans and events related to potential risk-exposures in humans. This information can be rumours or other ad-hoc reports transmitted through formal channels (e.g. established routine reporting systems) or informal channels (e.g. media, health workers and nongovernmental organizations reports)

*WHO. Checklist and Indicators for Monitoring Progress in the Development of IHR Core Capacities in States Parties (2011)*

# METHODOLOGICAL RIGOUR...

<https://www.youtube.com/watch?v=jCK2mflwESM&t=16s>



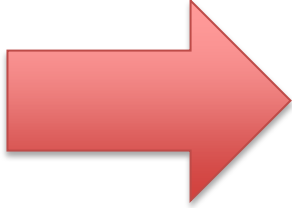
*Epidemiology often forsakes the richness of a people's way of living for quantitative rigour.*

*Marilyn K Nations in Anthropology & Epidemiology  
Craig R. Janes et al (eds); p. 97  
D Reidel Publishing Company, 1986*

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*Marilyn K Nations in Anthropology & Epidemiology  
Craig R. Janes et al (eds); p. 97  
D Reidel Publishing Company, 1986*

# WHY DO PUBLIC HEALTH SURVEILLANCE?

**early  
detection**  **better  
outcome**



## PART 2: HOW SHOULD WE RETHINK PUBLIC HEALTH SURVEILLANCE?

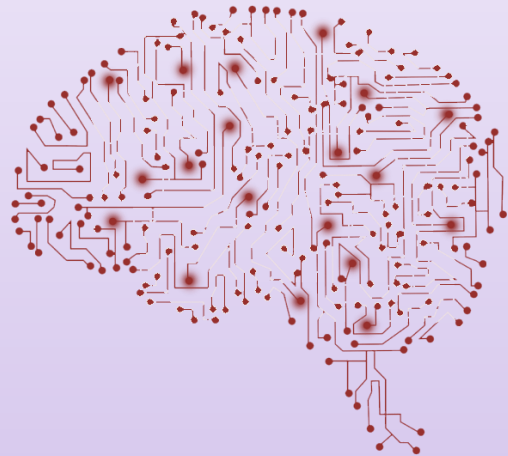


# FOUR KEY ELEMENTS

INPUT



PROCESSING



ANALYTICS



OUTPUT



# FOUR KEY ELEMENTS

INPUT



PROCESSING



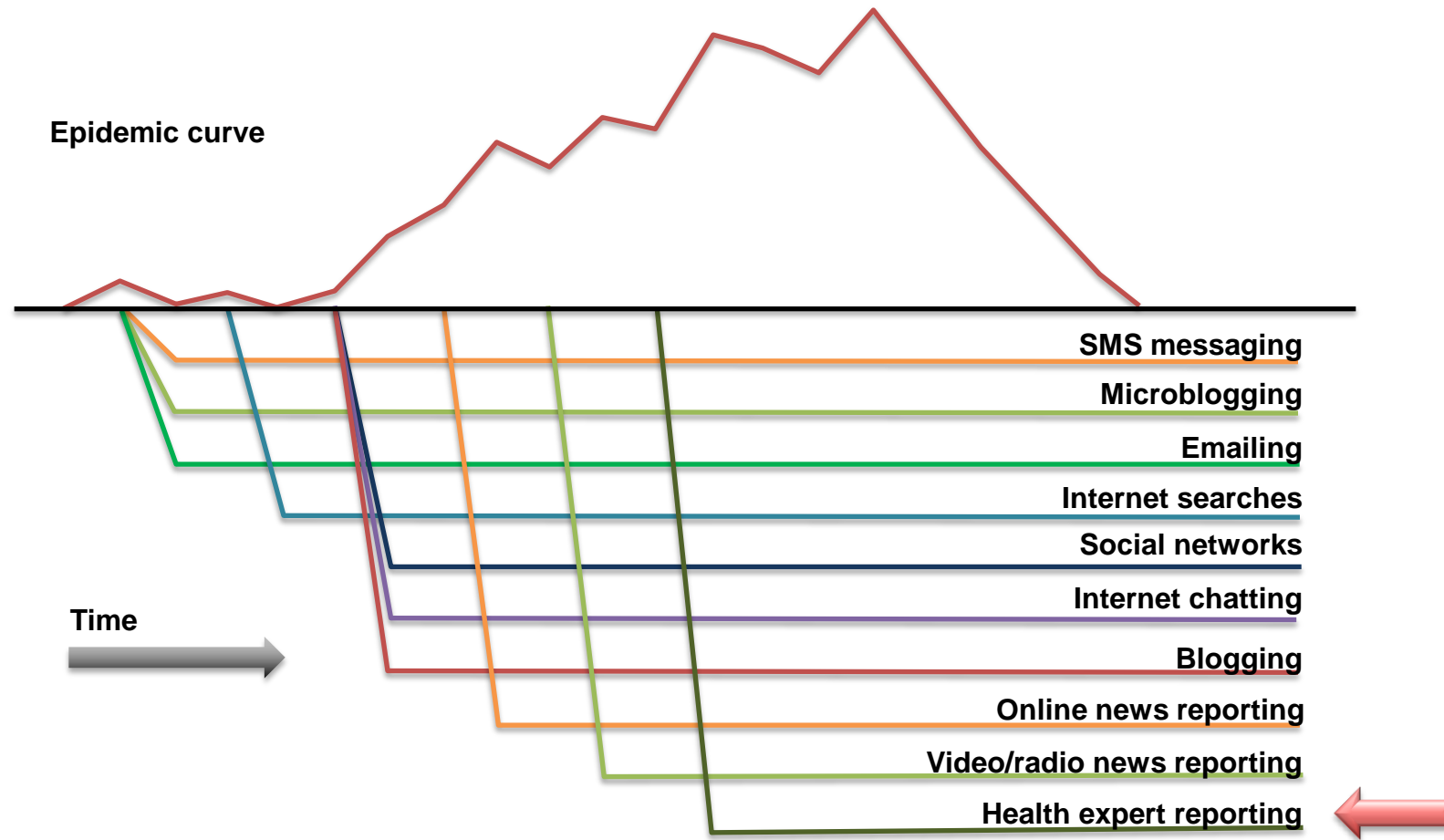
ANALYTICS



OUTPUT



# INFORMATION CONTINUUM



**Figure.** Hypothetical timing of informal electronic sources available during an outbreak.

*Ref: <http://wwwnc.cdc.gov/eid/article/15/5/08-1114-f1.htm>*



# EARLY WARNING INITIATIVES



Global Health Security Initiative

**GLEWS+** THE JOINT FAO-OIE-WHO GLOBAL EARLY WARNING SYSTEM  
FOR HEALTH THREATS AND EMERGING RISKS  
AT THE HUMAN-ANIMAL-ECOSYSTEMS INTERFACE

# AN INCREASINGLY OPEN WORLD...

## Facebook And Twitter Snapshot



4.75 billion items are shared each day on Facebook



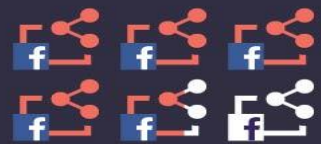
66% of total social media sharing is from the Facebook iPhone app



The number one life event reported by Facebook users is "adding a relationship"



Average number of followers per twitter user is 208



4.75 billion items are shared each day on Facebook

### Facebook



Uploaded and shared photos

(Millions)	(Millions)	(Millions)
476.59	239.17	108.37



Posted comment about daily activities

349.60	184.71	87.86
--------	--------	-------



Shared a link to an article

287.82	112.19	67.37
--------	--------	-------



Shared videos created by other users

259.86	93.31	54.64
--------	-------	-------

### Twitter



Posted comment about daily activities

(Millions)	(Millions)	(Millions)
140.86	94.15	51.63



Uploaded and shared photos

171.75	96.24	55.23
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Shared link to blogs

118.08	65.60	40.86
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Shared a link to an article

109.15	61.26	39.10
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Shared videos created by other users

97.08	53.10	34.91
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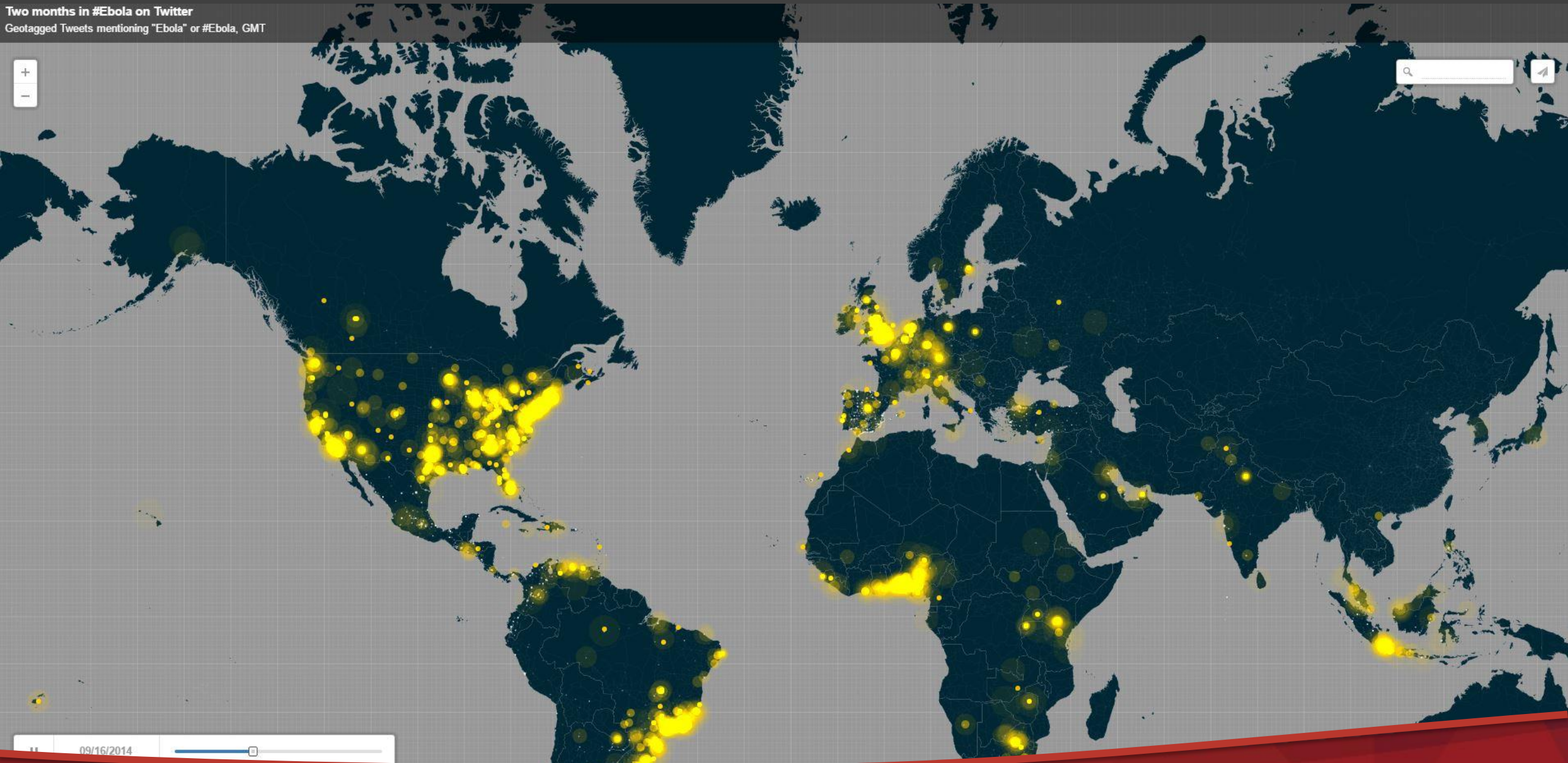
## Top 10 Live Events People Shared Most Frequently On Facebook In 2013

- 1 Added a relationship, got engaged or got married
- 2 Traveled
- 3 Moved
- 4 Ended a relationship
- 5 First met a friend
- 6 Added a family member, expecting a baby or had a baby
- 7 Got a pet
- 8 Lost a loved one
- 9 Got a piercing
- 10 Quit a habit

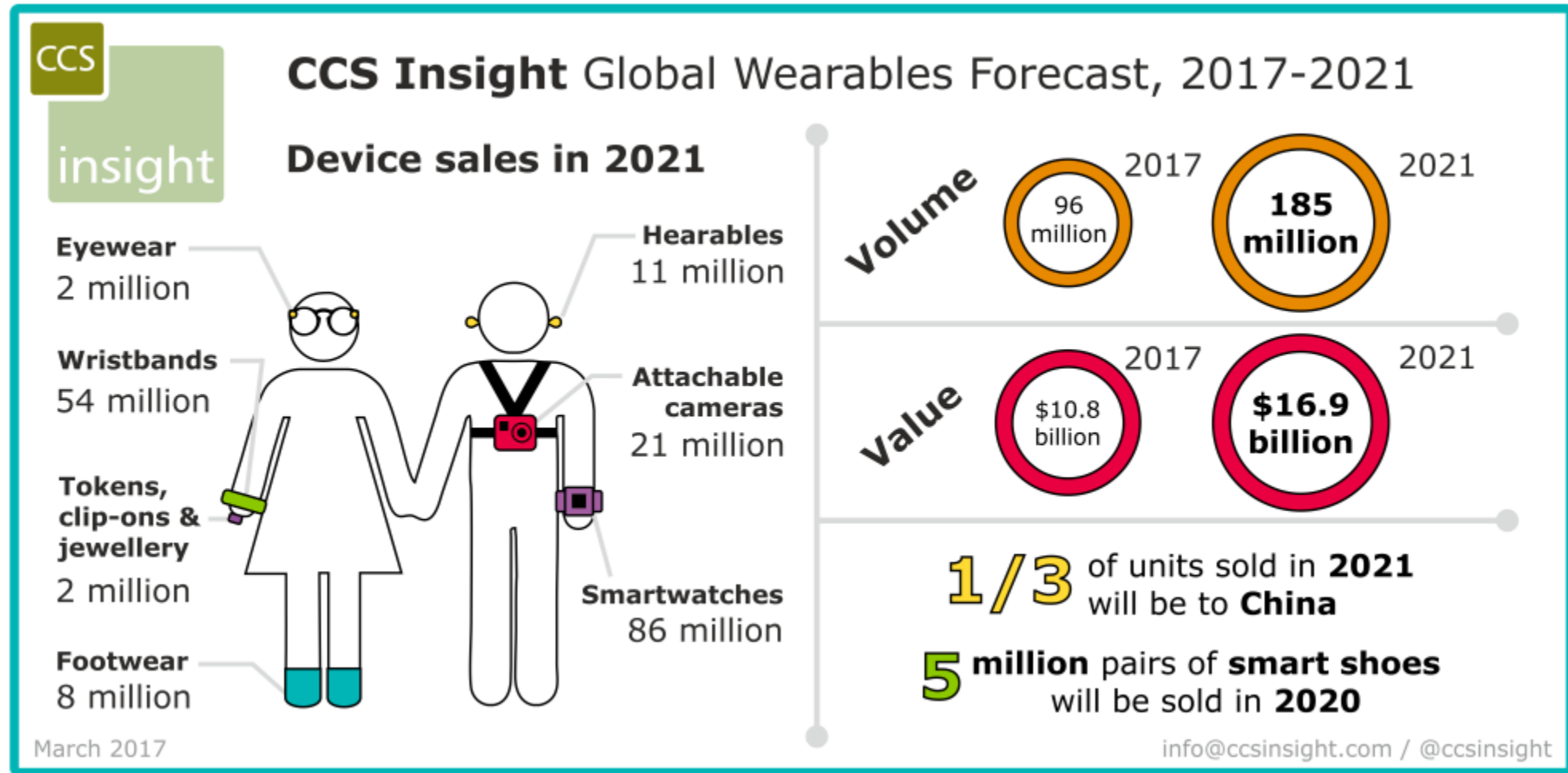


# #EBOLA: 31 AUGUST 2014 - 12 OCTOBER 2014

Two months in #Ebola on Twitter  
Geotagged Tweets mentioning "Ebola" or #Ebola, GMT



# TAPPING INTO REAL-TIME DATA



<http://www.ccsinsight.com/press/company-news/2968-ccs-insight-forecast-reveals-steady-growth-in-smartwatch-market>



Jane M. Carlton, a geneticist and director of New York University's Center for Genomics and Systems Biology

*If her team could sample sewage from every neighborhood in the metro area, Dr. Carlton reasoned, the resulting genetic map would highlight the city's microbial diversity across different districts. Once public health officials knew what normal bacteria and viruses to expect in each sector of the city, she hopes, they will be better able to identify dangerous outliers — a new strain of the flu, for instance, or an outbreak of food-borne illness.*

*“It's a preventative public health question,” Dr. Carlton said. “We need to know the baseline to know how the baseline changes over time.”*



<https://mobile.nytimes.com/blogs/well/2014/11/10/what-our-sewage-can-teach-us/>  
Science Times Podcast: Claire Maldarelli interviews reporter Joshua Krisch

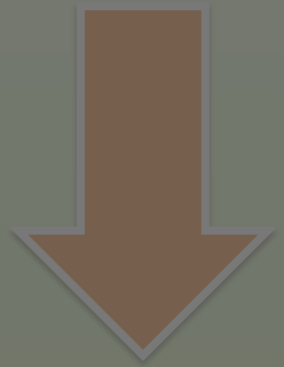
# IT'S A BIG DATA WORLD AFTER ALL





# FOUR KEY ELEMENTS

INPUT



PROCESSING



ANALYTICS



OUTPUT

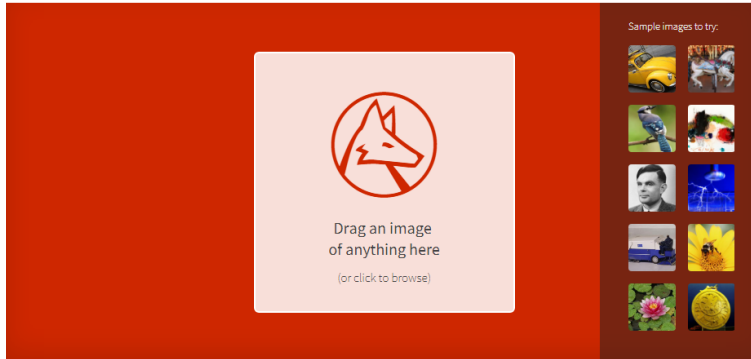






# MACHINE LEARNING AND INTELLIGENCE

## The Wolfram Language Image Identification Project

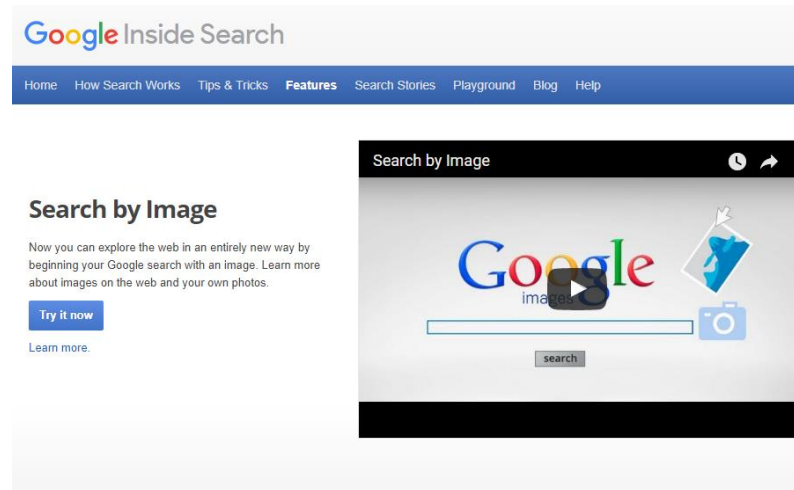


[ANNOUNCEMENT BLOG POST](#) » [HOW IT WORKS](#) » [FAQS](#) » [ABOUT WOLFRAM LANGUAGE](#) »

Powered by Wolfram Cloud Wolfram.com WolframAlpha.com All Wolfram Sites »

© 2017 Wolfram Launched 2015 Terms of use Privacy policy Contact us

<https://www.imageidentify.com/>



### Four ways to search by image



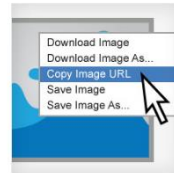
#### Drag and drop

Drag and drop an image from the web or your computer into the search box on [images.google.com](https://images.google.com).



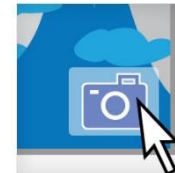
#### Upload an image

On [images.google.com](https://images.google.com), click the camera icon, then select "Upload an image." Select the image you want to use to start your search.



#### Copy and paste the URL for an image

Found an image on the web you're curious about? Right-click the image to copy the URL. On [images.google.com](https://images.google.com), click the camera icon, and "Paste image URL".



#### Right-click an image on the web

To search by image even faster, download the Chrome extension or the Firefox extension. With the extension installed, simply right-click an image on the web to search Google with that image.



## AutoDraw

Fast drawing for everyone.

Start Drawing

Fast How-To\*

This is an  
A.I.  
Experiment

\* The faster you click the faster it goes

<https://www.autodraw.com/>

<https://www.google.com/intl/es419/insidesearch/features/images/searchbyimage.html>

# MACHINE LEARNING AND INTELLIGENCE





## GELL: Automatic Extraction of Epidemiological Line Lists from Open Sources

Saurav Ghosh<sup>1, 5</sup>, Prithwish Chakraborty<sup>1, 5</sup>, Bryan L. Lewis<sup>2</sup>, Maimuna S. Majumder<sup>3, 4</sup>, Emily Cohn<sup>4</sup>, John S. Brownstein<sup>4</sup>, Madhav V. Marathe<sup>2, 5</sup>, Naren Ramakrishnan<sup>1, 5</sup>

<sup>1</sup> Discovery Analytics Center, Virginia Tech <sup>2</sup> Biocomplexity Institute, Virginia Tech

<sup>3</sup> Massachusetts Institute of Technology <sup>4</sup> Boston Children's Hospital

<sup>5</sup> Dept. of Computer Science, Virginia Tech

### ABSTRACT

Real-time monitoring and responses to emerging public health threats rely on the availability of timely surveillance data. During the early stages of an epidemic, the ready availability of *line lists* with detailed tabular information about laboratory-confirmed cases can assist epidemiologists in making reliable inferences and forecasts. Such inferences are crucial to understand the epidemiology of a specific disease early enough to stop or control the outbreak. However, construction of such line lists requires considerable human supervision and therefore, difficult to generate in real-time. In this paper, we motivate Guided Epidemiological Line List (GELL), the first tool for building automated line lists (in near real-time) from open source reports of emerging disease outbreaks. Specifically, we focus on deriving epidemiological characteristics of an emerging disease and the affected population from reports of illness. GELL uses distributed vector representations (ala word2vec) to discover a set of indicators for each line list feature. This discovery of indicators is followed by the use of dependency parsing based techniques for final extraction in tabular form. We evaluate the performance of GELL against a human annotated line list provided by HealthMap corresponding to MERS outbreaks in Saudi Arabia. We demonstrate that GELL extracts line list features with increased accuracy compared to a baseline method. We further show how these automatically extracted line list features can be used for making epidemiological inferences, such as inferring demographics and symptoms-to-hospitalization period of affected individuals.

outbreak investigations of emerging diseases to identify key features, such as incubation period, symptoms, associated risk factors, and outcomes. The ultimate goal is to understand the disease well enough to stop or control the outbreak. Ready availability of line lists can also be useful in contact tracing as well as risk identification of spread such as the spread of Middle Eastern Respiratory Syndrome (MERS) in Saudi Arabia or Ebola in West Africa.

Formats of line lists are generally dependent on the kind of disease being investigated. However, some interesting features that are common for most formats include demographic information about cases. Demographic information can include age, gender, and location of infection. Depending on the disease being investigated, one can consider other addendums to this list, such as disease onset features (onset date, hospitalization date and outcome date) and clinical features (comorbidities, secondary contact, animal contact).

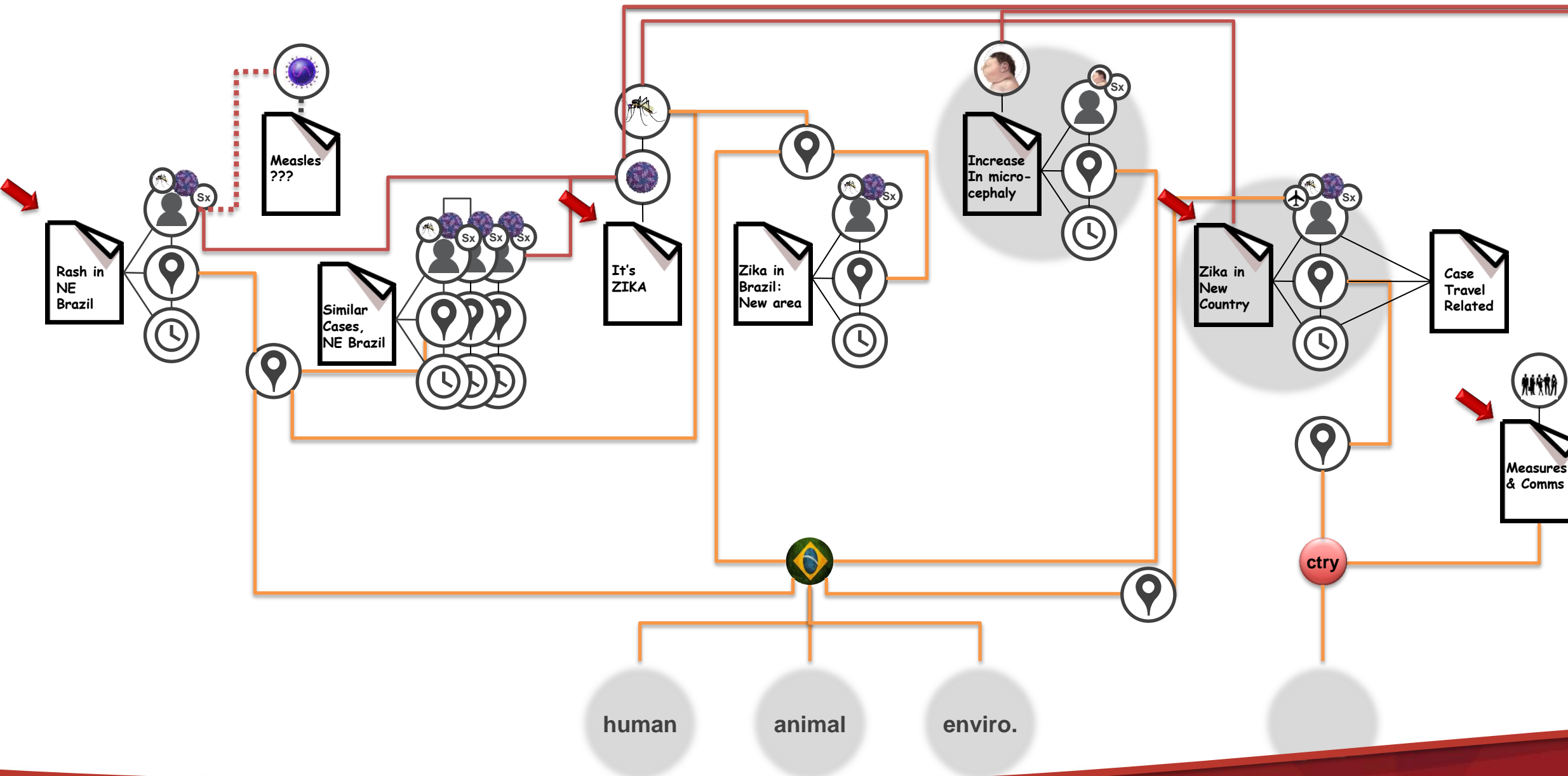
Traditionally, line lists have been curated manually and have rarely been available to epidemiologists in near-real time. Our primary objective is to automatically generate line lists of emerging diseases from open source reports such as WHO bulletins [22] and make such lists readily available to epidemiologists. Previous work [7, 13] has shown the utility in creating such lists through labor intensive human curation. We now seek to automate much

Code available on GitHub

[https://github.com/sauravcsvt/KDD\\_linelisting](https://github.com/sauravcsvt/KDD_linelisting)

<https://arxiv.org/abs/1702.06663>

# BUILDING AND FOLLOWING STORIES







<http://www.newsreader-project.eu/>



## Welcome!

### The Stanford NLP Group

The Natural Language Processing Group at Stanford University is a team of faculty, postdocs, programmers and students who work together on algorithms that allow computers to process and understand human languages. Our work ranges from basic research in computational linguistics to key applications in human language technology, and covers areas such as sentence understanding, automatic question answering, machine translation, syntactic parsing and tagging, sentiment analysis, and models of text and visual scenes, as well as applications of natural language processing to the digital humanities and computational social sciences.

A distinguishing feature of the Stanford NLP Group is our effective combination of sophisticated and deep linguistic modeling and data analysis with innovative probabilistic, machine learning, and deep learning approaches to NLP. Our research has resulted in state-of-the-art technology for robust, broad-coverage natural-language processing in a

<https://nlp.stanford.edu/>

**parts of speech parser**

<http://nlp.stanford.edu:8080/ner/>

**named entity tagger**

<http://corenlp.run/>

# THE MICROSCOPE IN YOUR HAND...



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TROPICAL MEDICINE AND HYGIENE  
official Journal of the American Society of  
Tropical Medicine and Hygiene

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ISSN: 0002-9637  
E-ISSN: 1476-1645

## Evaluation of a Mobile Phone-Based Microscope for Screening of *Schistosoma haematobium* Infection in Rural Ghana

Buy: \$15.00

Authors: Isaac I. Bogoch<sup>1,2</sup>, Hatice C. Koydemir<sup>3</sup>, Derek Tseng<sup>3</sup>, Richard K. D. Ephraim<sup>4</sup>, Evans Duah<sup>4</sup>, Joseph Tee<sup>5</sup>, Jason R. Andrews<sup>6</sup>, Aydogan Ozcan<sup>3</sup>

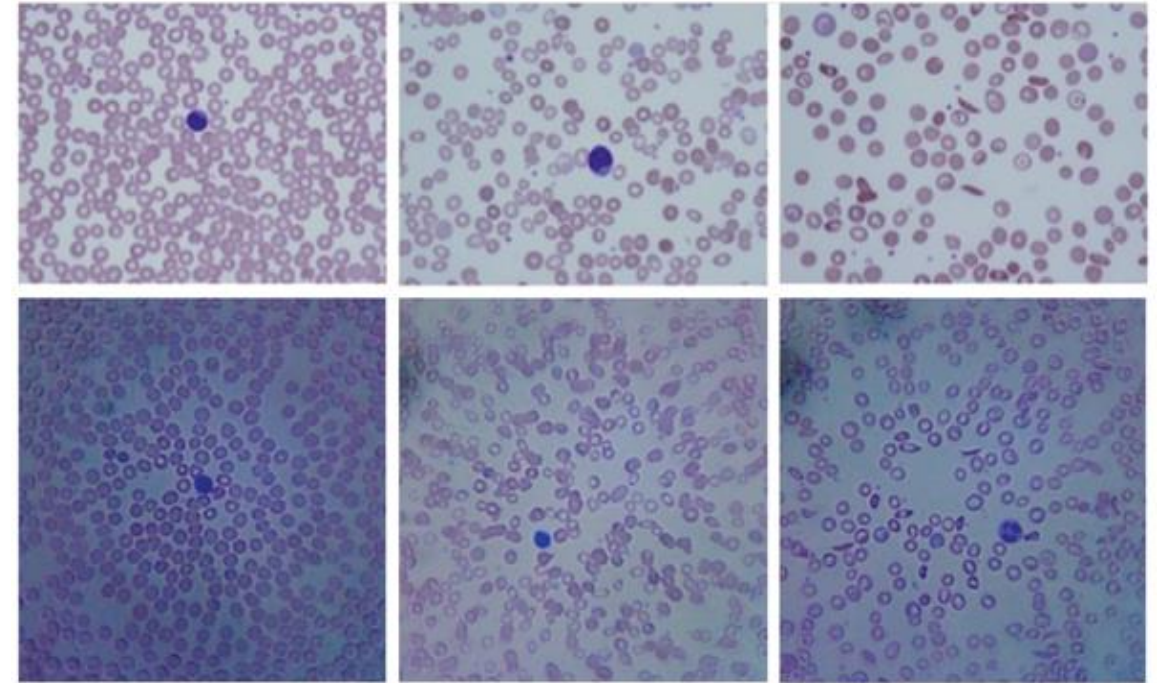
[View Affiliations](#)

Publisher: The American Society of Tropical Medicine and Hygiene

Source: The American Journal of Tropical Medicine and Hygiene, Volume 96, Issue 6, Jun 2017, p. 1468 - 1471

DOI: <https://doi.org/10.4269/ajtmh.16-0912>

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<http://www.ajtmh.org/content/journals/10.4269/ajtmh.16-0912>

<http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0017150>

### Micrographs of peripheral blood smears.

Upper row: images from a traditional microscope. Bottom row: images from a cell phone microscope. Left, blood from a normal patient. Center, blood from a patient suffering from iron deficiency anemia. Right, blood from a patient suffering from sickle cell anemia.

<https://doi.org/10.1371/journal.pone.0017150.g006>

# THE MICROSCOPE IN YOUR HAND...

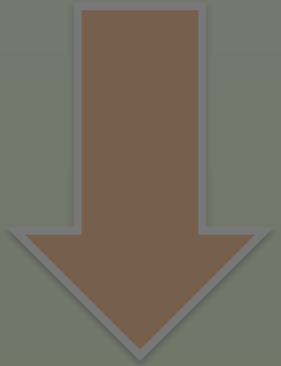


<https://www.wired.com/2011/03/diy-cellphone-microscope/>



# FOUR KEY ELEMENTS

INPUT



PROCESSING



ANALYTICS



OUTPUT



# RISK ASSESSMENT & PREDICTIVE ANALYTICS

## KNOWN

Objective (black and white)  
Characteristics or attributes that are known or calculated  
These may change as more information is acquired

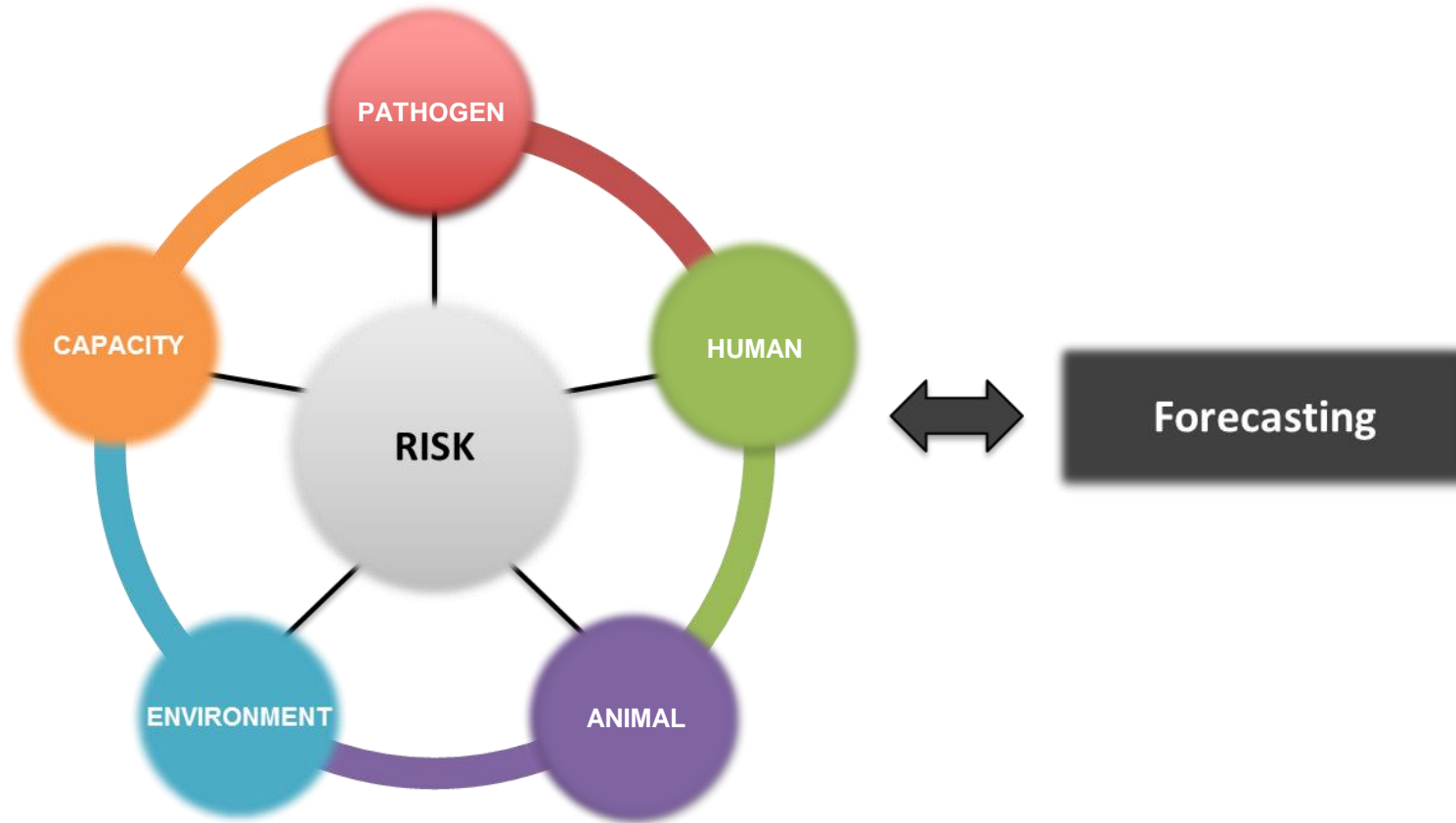
## PROBABLE

Given known facts, a probability can be calculated and assigned (e.g. to an occurrence or an outcome)

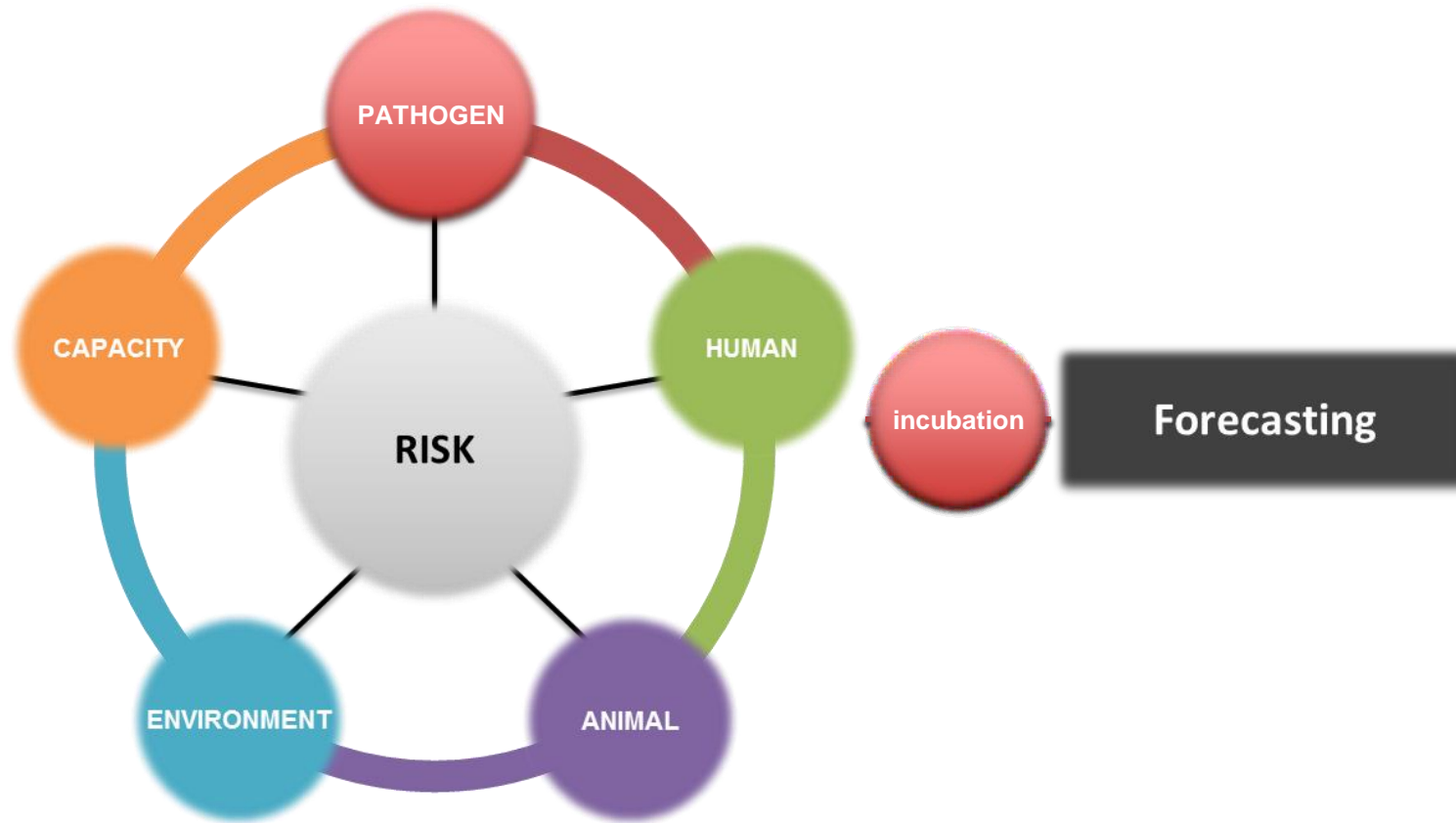
## GUT

Subjective (grey area)  
Based on knowledge, experience, etc  
Informed by known facts and probability

# RISK ASSESSMENT & PREDICTIVE ANALYTICS



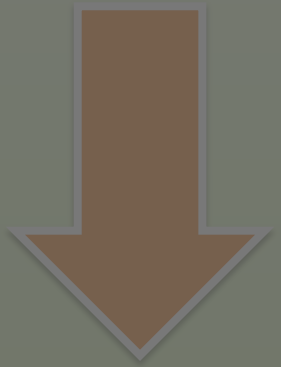
# RISK ASSESSMENT & PREDICTIVE ANALYTICS





# FOUR KEY ELEMENTS

INPUT



PROCESSING



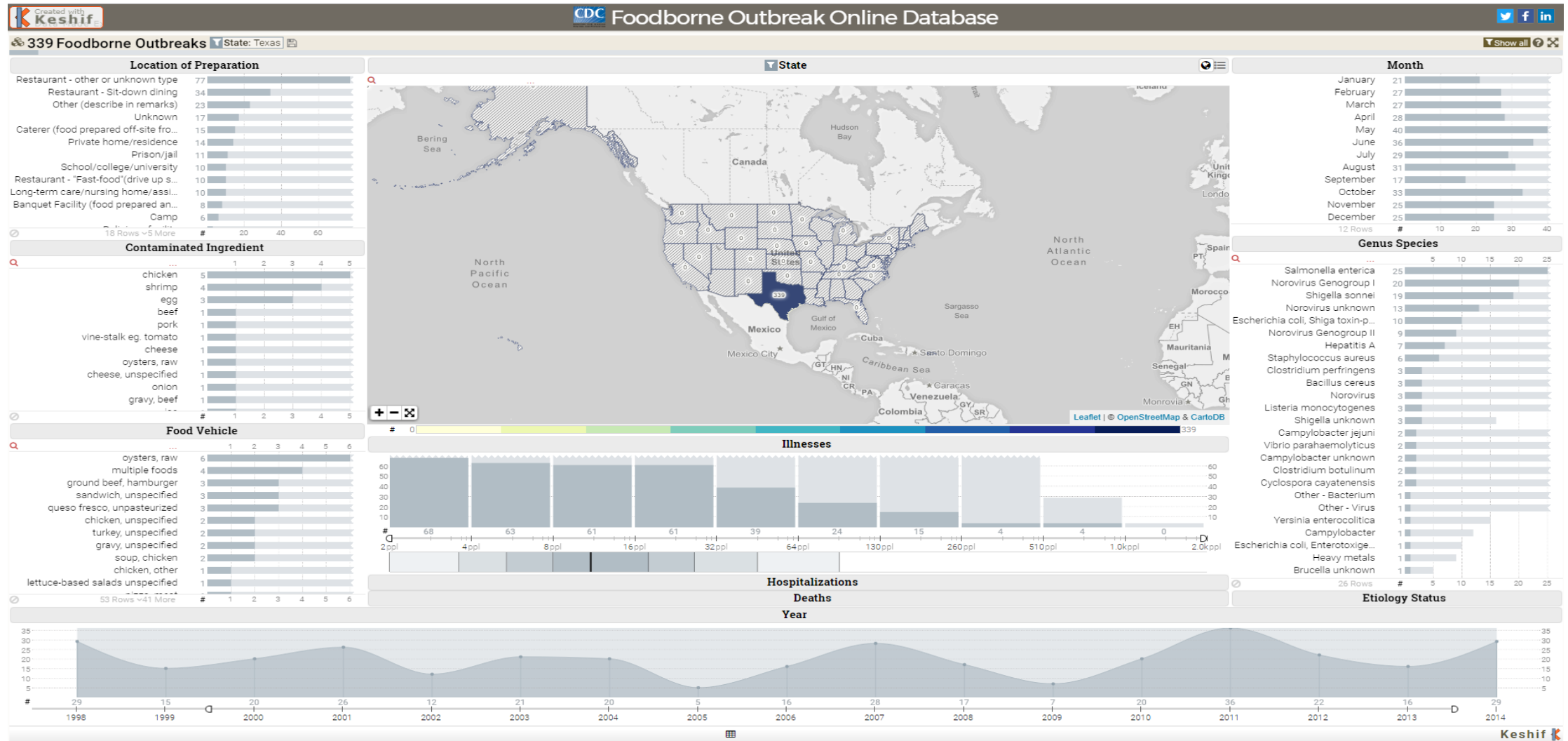
ANALYTICS



OUTPUT

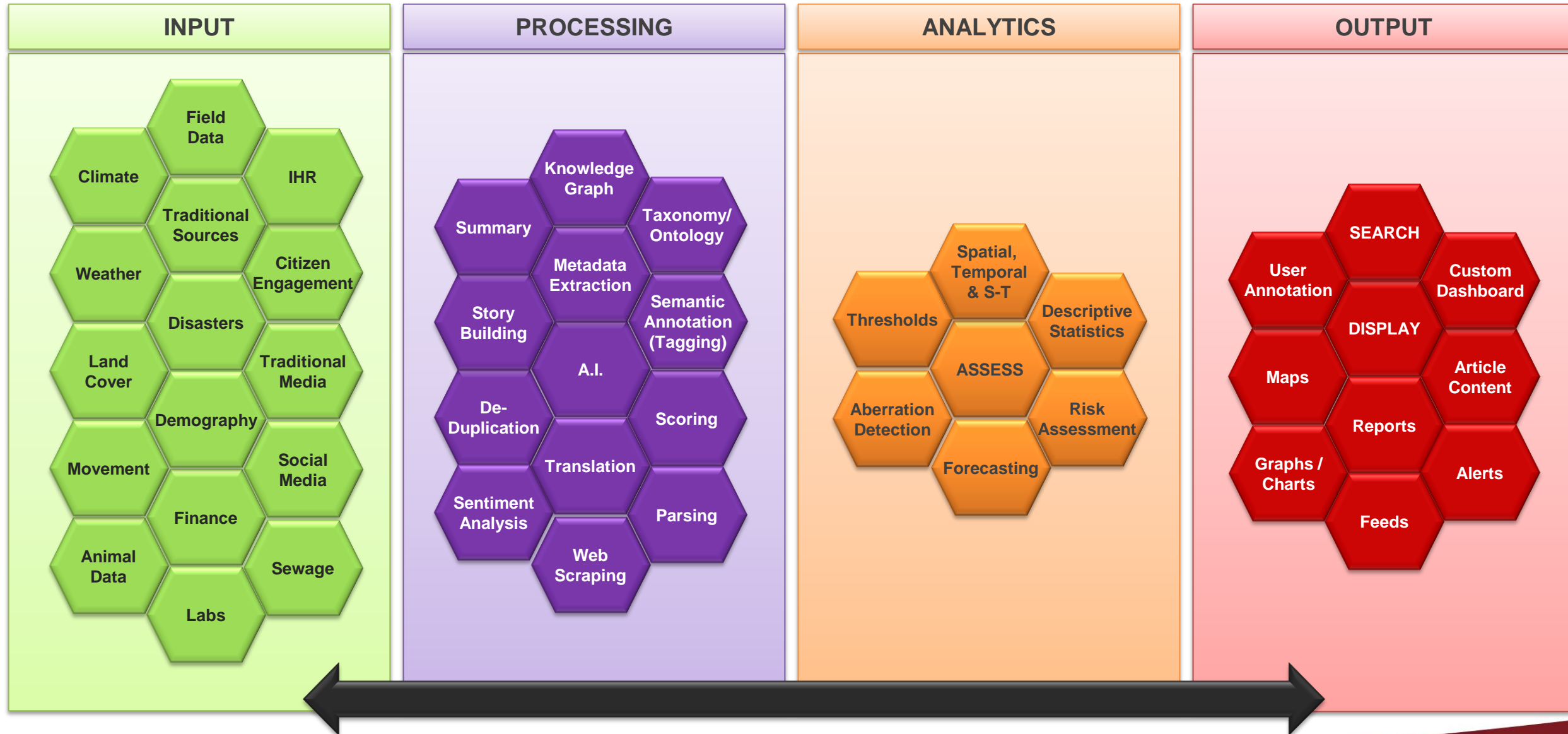


# INTERACTIVE, CUSTOMISABLE AND COORDINATED OUTPUT



<https://keshif.me/gallery/foodborneoutbreaks>

# FOUR KEY ELEMENTS



***Governance, Privacy, Confidentiality and Security***

***Competencies and Collaboration***

*the future public health practitioner will be moving beyond*

***Data Quality: Garbage In.....*** approaches, using

*novel data sources and relying on evidence that is more experiential and less robust than classic empirical research*

***Get yourself enough data and you can pretty much make it say whatever you want***



WHEN IT COMES TO  
GLOBAL HEALTH,  
THERE IS NO '**THEM**'  
ONLY '**US.**'

- Global Health Council



Apr 7 • World Health Day



**TakingITGlobal**  
INSPIRE. INFORM. INVOLVE.





Public Health  
Agency of Canada

Agence de la santé  
publique du Canada

Canada

# THANK YOU

**Philip AbdelMalik**  
Health Security Infrastructure Branch  
Field Service Training and Response  
Canadian Field Epidemiology Program

[philip.abdelmalik@phac-aspc.gc.ca](mailto:philip.abdelmalik@phac-aspc.gc.ca)

PROTECTING AND EMPOWERING CANADIANS  
TO IMPROVE THEIR HEALTH

