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CHIKV Challenge Announces Winners, Progress toward Forecasting the Spread of Infectious Diseases

Eleven teams developed potentially revolutionary advances in forecasting methods that could help disaster response organizations act more effectively both before and during outbreaks

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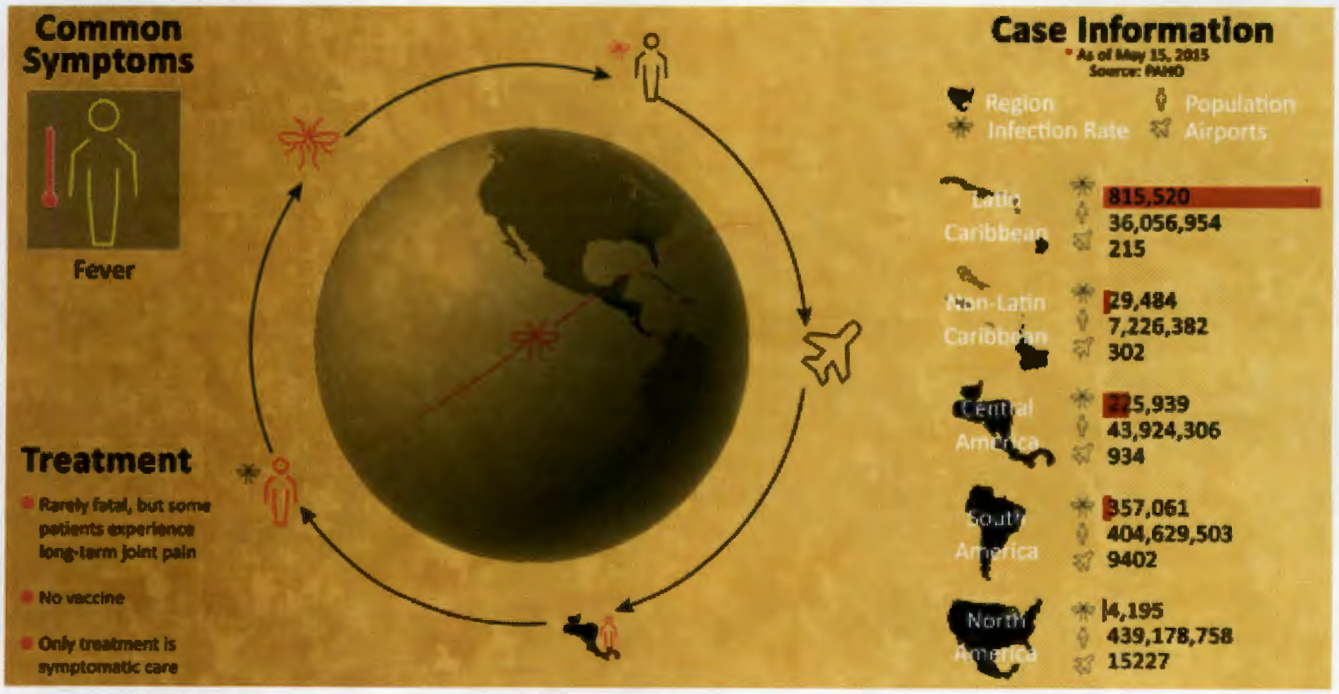
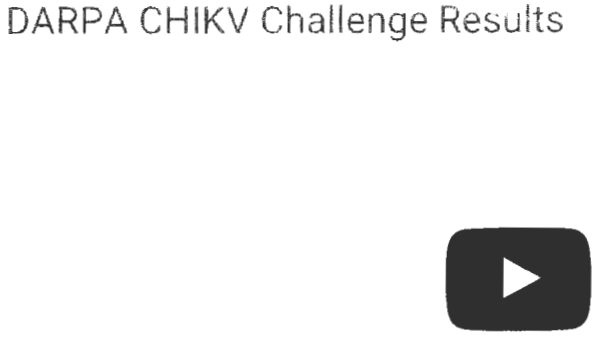
5/26/2015





The chikungunya virus (CHIKV) is quickly spreading through the Western Hemisphere; as of May 15, 2015, the Pan-American Health Organization (PAHO) had tallied close to 1.4 million suspected cases and more than 33,000 confirmed cases since the virus' first appearance in the Americas in December 2013. Spread by mosquitoes, chikungunya is rarely fatal but can cause debilitating joint and muscle pain, fever, nausea, fatigue and rash, and poses a growing public health and national security risk. Governments and health organizations could take more effective proactive steps to limit the spread of CHIKV if they had accurate forecasts of where and when it would appear. But such predictions for CHIKV and other emerging infectious diseases remain beyond the reach of current modeling capabilities.

To accelerate the development of new infectious disease forecasting methods, DARPA launched its CHIKV Challenge competition last year. Thirty-eight teams from around the world vied to develop the most accurate predictions of CHIKV cases for all Western Hemisphere countries and territories between September 2014 and March 2015. On May 12, DARPA unveiled the 11 winners of the competition during a scientific review event held at the Agency's offices in Arlington, Va.

The event, which included representation from the Centers for Disease Control and Prevention (CDC), the U.S. Department of Health and Human Services (HHS), the Department of Defense (DoD), and the White House Office of Science and Technology Policy (OSTP), highlighted results, lessons learned and potential next steps to improve state-of-the-art infectious disease forecasting. The winning teams received a total of $500,000 in prize money.

"Predicting the speed, severity and direction of infectious disease outbreaks is incredibly challenging, in part because it's difficult to determine the relative contributions of multiple factors—such as weather and climate, population density and travel patterns—under various conditions," said Col. Matt Hepburn, DARPA program manager for the CHIKV Challenge.

Yet in just six months' time, the participants made notable progress, Hepburn added. "The teams in the CHIKV Challenge identified gaps in current forecasting capabilities and created a set of tools that can

immediately help improve forecasting and guide response decisions for the current chikungunya outbreak. We are on the cusp of enabling a revolutionary improvement in disease forecasting, in much the way that weather reports transitioned from surveillance to forecasting."

Six teams provided the most accurate results overall and earned the following prizes:

Gold: Joceline Lega and Heidi Brown, University of Arizona ($150,000)

Silver: Mark Leany, Utah Valley University ($100,000)

Bronze: Ioannis Pantazis, University of Massachusetts ($50,000)

Bronze: David Roberts, John Radcliffe Hospital, Oxford, United Kingdom ($50,000)

Bronze: Sean Moore, Johns Hopkins University ($50,000)

Bronze: A. Townsend Peterson, University of Kansas ($50,000)

DARPA also awarded a $10,000 prize to each of five teams that excelled in particular challenge domains:

Best Applicability Methodology: Dhananjai Rao, Miami University of Ohio

Best Computational Requirements Methodology: Ann Fruhling, University of Nebraska Omaha

Best Data Sources Methodology: Tingzhuang Yan, Coastal Carolina University

Best Presentation: Ajitesh Srivastava, University of Southern California

Best Robustness Methodology: Diego Ruiz-Moreno, University of Michigan

DARPA invited Los Alamos National Laboratory (LANL) to independently analyze the accuracy and methodology of the teams' research. LANL found that, in general, the best performers used simpler models and that quality of data mattered more than quantity; in fact, gaps in reported data were more easily accommodated via modeling than misreported data.

By design, CHIKV Challenge participants were allowed to update their predictions every two months as they learned from experience—a challenge structure that sped development of better methods. On average, the top participants succeeded in doubling the accuracy of their predictions every two months relative to their initial forecasts.

Another gratifying aspect of the competition was that it succeeding in creating new communities of expertise and connecting them with DARPA. "None of the winners had previous experience working with the Agency, and participating teams were multidisciplinary, including not only specialists in public health and infectious disease but also experts in mathematics, ecology, computer science and bioinformatics," Hepburn said. "This forward-thinking collaboration is exactly what it will take to stay ahead of the global threat that emerging diseases pose."

More information about the CHIKV Challenge is available at http://ow.ly/N64D0.

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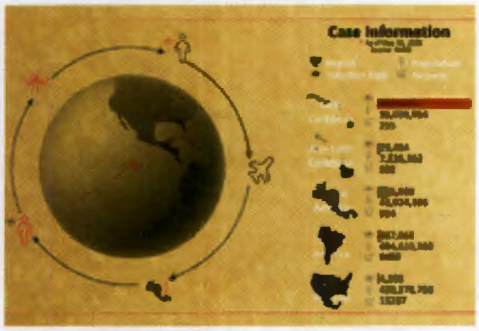

To accelerate the development of new infectious disease fore ...

CHIKV Challenge Asks Teams to Forecast the Spread of Infectious Disease

Teams will build models that predict the spread of the Chikungunya virus in the Americas; the products could be applied to other diseases and inform responses to emergencies

OUTREACH@DARPA.MIL
8/14/2014

The Chikungunya virus (CHIKV) is on the move. Spread among humans by mosquitoes, and spread across geographic boundaries by humans who travel, the virus—which causes a debilitating illness—is now expanding through the Western Hemisphere. Governments and health organizations could take proactive steps to limit its spread if they had accurate forecasts of where and when it would appear. DARPA's CHIKV Challenge asks teams to create models to deliver such forecasts for all of the countries and territories in the Americas and the Caribbean over a six-month period starting in September 2014. The winning team will take home $150,000, with additional cash prizes for runners-up. Full details, rules, and registration instructions for the Challenge are available at: http://www.innocentive.com/DARPAChikvChallenge.

Chikungunya causes fever, severe joint and muscle pain, nausea, fatigue, and rash in infected individuals. Although some candidate vaccines are being tested, there is currently no treatment beyond

symptomatic care. Prevention includes avoidance of mosquito bites and vector control (i.e., mosquito eradication). The disease poses a growing public health and national security risk, underscoring the need to accurately forecast the number, location, and peak occurrence of cases so health officials can proactively direct resources.

Modeling the future spread of infectious diseases is extremely challenging. Many current infectious diseases models tend to be based on historic data. There are numerous sources of potentially useful data that could be incorporated into a forecast, but it is difficult to predict which will be most informative, especially as different types of data may be more or less predictive under various conditions or in different regions.

"Forecasts would be extremely helpful to public health officials in containing infectious diseases, but it is really difficult. The science of forecasting is a work in progress. It's akin to trying to solve a jigsaw puzzle with some of the pieces missing and a vague sketch of what the finished image should look like," said COL Matthew Hepburn, the DARPA program manager for the CHIKV Challenge. "Identifying and acquiring the right data points and figuring out how to link them requires interdisciplinary coordination."

In fact, one goal of DARPA's challenge is to inspire the creation of teams drawn from multiple disciplines, including not only specialists in public health and infectious disease, but also experts in mathematics, meteorology, entomology, computer science, and bioinformatics, among other fields.

DARPA runs prize-based challenges to accelerate progress in scientific and technological domains it perceives as lagging behind national needs, and to ensure that the full diversity of America's innovative potential is brought to bear on pressing national security issues. Such challenges often attract individuals and consortia that might have never previously contributed to government research efforts or considered how their expertise might be applied to the national security domain.

"The CHIKV Challenge is exciting on many levels," Hepburn said. "For one, Chikungunya is already here in the Americas, so teams are going to have to work at the speed of an epidemic to build their models. But equally exciting, we believe this effort could lead to the creation of tools that work even faster than the speed of an epidemic, giving us the opportunity to act effectively before an infectious disease actually arrives and spreads."

At the conclusion of the Challenge, the winning teams will be invited to attend an end-of-study meeting with government experts from various partner agencies with an interest in predictive modeling. A robust and scalable forecasting capability could find application in a variety of sectors, including emergency response and humanitarian assistance, in addition to public health

The CHIKV Challenge is open to individuals 18 years of age or older. A participant may compete individually or as part of a team. Only one submission per team may be submitted.

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Please note that the details of this Challenge are no longer open. This challenge is under evaluation and is no longer accepting new submissions. You can:

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DARPA Forecasting Chikungunya Challenge

TAGS: Scientific American, Life Sciences, Global Health, Math/Statistics, Computer Science/Information Technology, Nature, Public Good, RTP

AWARD: **See details** | STATUS: **Under Eval** | ACTIVE SOLVERS: 466 | POSTED: 8/15/14

DARPA (Defense Advanced Research Projects Agency) seeks methods to accurately forecast the spread of chikungunya virus in the Caribbean, and North, Central, and South America.

This Challenge has a special award structure with awards of **$150,000** and **$100,000** for the top two overall Solvers and four honorable mention awards of **$50,000** each. In addition, top Solvers in each **Methodology Category** (data, robustness, applicability, presentation, and computation) may win **$10,000**. The top six overall Solvers will be invited to DARPA for the Program Finale Meeting where they will participate in an interactive meeting to share best practices, collaborate, and facilitate continuing Solver community cohesion.

This is a **Reduction-to-Practice Challenge** that **requires written documentation** and multiple submissions of forecasts for the virus' spread. Additionally, as a **Prodigy Challenge** an online leaderboard will be available to track Solver performance.

Privacy Advisory

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Source: InnoCentive **Challenge ID:** 9933617

Challenge Overview

Chikungunya virus (CHIKV) has recently been detected in the Western Hemisphere. Previously, the virus had not been detected in the Americas for many decades. This DARPA Challenge seeks methods to forecast outbreaks and the potential spread of CHIKV throughout the Americas. This Challenge also seeks to develop forecasting capabilities for infectious diseases, with the intent of applying these capabilities to the mitigation of infectious diseases outbreaks.

There will be nine submissions to this Challenge distributed throughout the Challenge period:

1. **Methodology.** An **initial submission** containing a detailed description of the planned data sources and model applicability and a **final submission** with a detailed description of the full methodology used for the forecasts are required. The initial submission must be received by **September 1, 2014** in order to be eligible for points. The final submission is due **February 16, 2015.** Both initial and final methodology submissions should be completed, although only those submitted by the due dates will be considered for points. The project documentation should include a well-articulated rationale for the methodology and choice of data sources.
2. **Accuracy Forecasts.** An initial forecast submission, due **September 8, 2014,** with predictions for the next six months, followed by five monthly update submissions, due on the **1st of each subsequent month,** with predictions for the remaining period of the Challenge.
3. **Peak Forecasts.** A forecast of Peak New Cases per Country or Territory, due **October 1, 2014.**

Solvers are encouraged to submit all nine deliverables outlined above. However, submissions are accepted throughout the Challenge. Late submissions will not be eligible to receive points associated with the deliverable. Solvers will make a new submission that includes all deliverables due on a particular date rather than updating a previous submission.

Awards are contingent upon evaluation and validation of the submitted Solutions by the Seeker.

This Challenge has a special award structure with awards of **$150,000** and **$100,000** for 1st and 2nd place, respectively. The **next four top overall Solvers** will receive awards of **$50,000** each. In addition to winning awards for the highest overall points, top Solvers in each **Methodology Category** (data, robustness, applicability, presentation, and computation) may

win **$10,000**. The top six overall Solvers will be invited to DARPA for the Program Finale Meeting where they will participate in an interactive meeting to share best practices, collaborate, and facilitate continuing Solver community cohesion.

DARPA claims no rights to intellectual property developed by Solvers as a result of participation in the CHIKV Challenge. DARPA may negotiate a license for the use of intellectual property developed by a Solver.

Eligibility

The CHIKV Challenge is open to academic institution, business, or individual (18 years of age or older). A Solver may be an individual competing alone or a team representing an academic institution, business, or group of individuals. Only one submission per team per deliverable should be submitted.

Foreign Participation

Non-U.S. organizations and/or individuals may participate to the extent that such participants comply with any necessary non-disclosure agreements, security regulations, export control laws, the CHIKV Challenge Rules and other governing statutes applicable under the circumstances. Employees of foreign governments are not eligible to participate in this Challenge.

Pan American Health Organization (PAHO) and Member State Reporting Institutions

Individuals affiliated with the Pan American Health Organization (PAHO) and its Member State Institutions that provide health surveillance data cannot participate in the Challenge in any capacity.

Federally Funded Research and Development Centers (FFRDCs)

FFRDCs are encouraged to participate in this Challenge but are not eligible to receive any prize award. In order to participate, FFRDCs must provide a letter on official letterhead from their sponsoring organization citing the specific authority establishing the FFRDC's eligibility to participate in Government Challenges. Individuals that supported the development of the Challenge are not eligible to participate.

Other Eligibility Requirements

DARPA employees and DARPA support contactors, including spouses, dependents, and household members, are not eligible to participate in the CHIKV Challenge. Federal employees acting within the scope of their employment are not eligible to participate in the Challenge. Federal employees acting outside the scope of their employment should consult their ethics official and appropriate management before participating in the Challenge. Federal employees may provide subject matter expertise to participants so long as they grant equal opportunity for access to each participating team or individual.

Any entities and personnel funded by DARPA to support the CHIKV Challenge are not eligible to participate in the CHIKV Challenge.

About the Seeker

Since its establishment in 1958, DARPA has demonstrated time and again how thinking beyond the borders of what is generally deemed possible can yield extraordinary breakthroughs. The Agency's mission is to foster and demonstrate revolutionary new technologies and capabilities that provide practical options for sustaining U.S. security into the future. Importantly, DARPA conceives national security broadly, and the technologies it creates frequently transition either directly or indirectly to the commercial world, where they have bolstered such critical sectors as healthcare, transportation, communications, and computing. Many of the technologies people depend on today have their origins in DARPA-funded research.

To achieve its ambitious goals, DARPA supports world-class teams of experts from academia, industry, and government laboratories, empowers them with resources, encourages them to take risks, and provides them with the flexibility to transcend conventional organizational constraints. It isn't just established research institutions that can contribute, though. DARPA recognizes that the novel capabilities it seeks may, in many instances, emerge from novel sources—including individuals or consortia that have never contributed to government research efforts or considered how their expertise might be applied to the national security domain.

It is in recognition that extraordinary solutions can emerge from unconventional sources that DARPA periodically launches prize-based challenges—ensuring that the full diversity of America's innovative potential is brought to bear toward the goal of achieving a better and more secure future.

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What is InnoCentive?

InnoCentive is the global innovation marketplace where creative minds solve some of the world's most important problems for cash awards up to $1 million. Commercial, governmental and humanitarian organizations engage with InnoCentive to solve problems that can impact humankind in areas ranging from the environment to medical advancements.

What is an RTP Challenge?

An InnoCentive **RTP (Reduction to Practice) Challenge** is a prototype that proves an idea, and is similar to an InnoCentive Theoretical Challenge in its high level of detail. However, an RTP requires the Solver to submit a validated solution, either in the form of original data or a physical sample. Also the Seeker is allowed to test the proposed solution.

DARPA CHIKV Challenge Resources

Vital Data Resources

Solvers can utilize any publicly available data as the basis for their forecasts, including known or potential CHIKV mutations and effects on vector transmissibility, historic and current Chikungunya case data, vector distribution, climate models, transportation information, social media and other environmental data. Proprietary data may be used by solvers if it was previously obtained by participants and used for research, modeling, or other related efforts. Insider information on the number of Chikungunya cases in any PAHO country that is obtained prior to official release by PAHO on the PAHO website is prohibited. Those found to be in possession of insider information will be disqualified from participation and forfeit any prize.

Solvers are encouraged to explore and evaluate the utility of novel data sources that may not be traditionally used for infectious disease forecasting. For example, due to the incubation period and period of viremia with this infection, returning infected travelers could be a potential source of an outbreak. Travel patterns and transportation data could be investigated as factors in the spread of CHIKV due to variable individual exposure and multiple potential disease introduction events (simultaneous or spread temporally). Weather forecasts, ecological information, feeding patterns, or other vector related data could also be of potential benefit.

The following is an incomplete list of the kinds of data that may be useful. Solvers are not limited to nor required to use these resources.

1. PAHO:
   - Weekly updated numbers of suspected and confirmed Chikungunya cases in PAHO countries/territories: http://www.paho.org/hq/index.php?option=com_topics&view=rdmore&tt=PAHO%2FWHO+Data%2C+Maps+and+Statistics&id=5927

2. Chikungunya genomic information:
   - European Virus Archive: Complete CHIKV phylogeny, PCR systems, amino acid, and nucleotide sequence of St. Martin strain: http://www.european-virus-archive.com/article147.html
   - Chikungunya virus strain S27-African prototype, complete genome- GenBank Accession #: AF369024
   - Chikungunya virus strain La Reunion strain, complete genome- GenBank Accession #: DQ443544.2

3. IATA: International Air Transport Association
   - Commercial flight database
   - IATA is the trade association for the world's airlines, representing ~240 airlines or 84% of total air traffic

4. Bureau of Transportation Statistics, Research and Innovative Technology Administration:
   - http://www.rita.dot.gov/bts/press_releases/bts024_14
   - http://www.transtats.bts.gov/Fields.asp?Table_ID=260

5. Centers for Disease Control and Prevention Resources:
   - http://www.cdc.gov/chikungunya/resources/index.html
   - Division of Vector-Borne Diseases

6. Census data
   - IPUMS-International - World's largest collection of publicly available individual-level census data. Integrates samples from population censuses from around the world taken since 1960. For the U.S., IPUMS-USA, which is optimized for U.S. research.
   - https://usa.ipums.org/usa/
   - https://international.ipums.org/international/

7. Climate and weather data - Climate Prediction Center (NOAA) links
   - See attached appendix A for a description of the NOAA Climate Prediction Center International Desks web page
   - Main page: http://www.cpc.ncep.noaa.gov/products/african_desk/cpc_intl/index.shtml
   - Weather page for Caribbean - Central America: http://www.cpc.ncep.noaa.gov/products/african_desk/cpc_intl/camerica/camerica.shtml
   - Climate forecasting page including Caribbean - Central America: http://www.cpc.ncep.noaa.gov/products/international/nmme/nmme1.shtml

8. Vector data
   - Ecological distribution
   - Feeding behavior: day/night, locations
   - Weather channel's mosquito activity forecast: http://www.weather.com/activities/homeandgarden/home/mosquito/index.html
   - Mosquito-based arbovirus surveillance software
     - Example: CDC for West Nile virus: http://www.cdc.gov/westnile/resourcepages/mosqSurvSoft.html

- Detects the number of positive mosquito pools found in collections of a particular mosquito species over a defined time period and area.

News Items

Additional locally acquired chikungunya cases in Florida: http://www.examiner.com/article/florida-has-two-more-local-chikungunya-cases

CDC commentary on the spread of chikungunya virus in the Western Hemisphere: http://wwwnc.cdc.gov/eid/article/20/8/14-0333_article

Resources

The University of Pittsburgh Graduate School of Public Health compiles data on Chikungunya from the PAHO weekly PDF bulletins into an open-access computer readable format. The website also includes some videos of the disease progression by week.
See: http://www.tycho.pitt.edu/dev/chikungunya/ (log in required but free).

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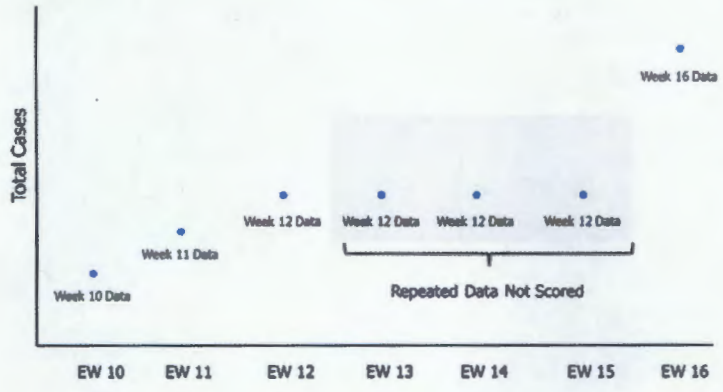
Frequently Asked Questions

Delays in PAHO Reports

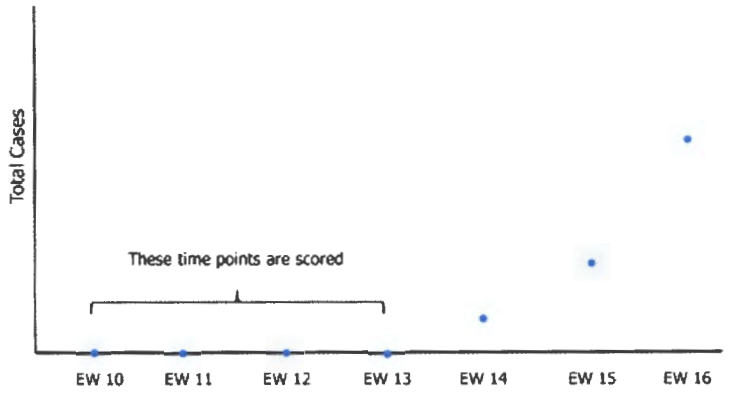
We recognize there are delays in what PAHO reports and reports by media or local health organizations. However, in order to be fair and consistent in scoring submissions, the final scoring for accuracy and peak prediction will be judged against PAHO reports. The final scores for accuracy of forecast and peak prediction will be based on PAHO data, which will be considered 'official' four weeks after the challenge ends, in case there are revisions in PAHO reports.

Solvers are encouraged to use all publicly available data sources including news articles and media reports, but should recognize that scoring will be based solely on what PAHO reports, and we cannot validate the accuracy of any information released to the media through non-PAHO channels.

Solvers will not be scored for weeks where PAHO data is repeated due to a lag in reporting. See figure below:



However, solvers will be scored for instances where PAHO reports no cases (or the country is not present on the PAHO report for a particular week) and new cases arise during the period of evaluation. See figure below:



Total Cases Decrease between Weeks

In the case that PAHO data reports that the total number of cases decreases between weeks and the cause is not obvious i.e. error in data entry, those weeks will not be scored.

Potential Errors in PAHO Reports

1. Dominica Week 24 & 25: Reported EW 20 cases during Week 25, when Week 24 reported EW 22 data. Week 25 has been set to EW 22 data in the spreadsheet.
2. Sint Maarten Week 5: Reported EW 3 confirmed cases during Week 5. Week 5 has been set to EW 4 data in the spreadsheet.

Negative Sign in Accuracy Scoring Formula

The negative sign has been removed in the formula for scoring accuracy. The threshold for eligible submissions remains at 500.

Attachment:

2014_08_28_darpa_chikv_challenge_resources.pdf
2014_08_29_1700_chikv_challenge_question_and_answer_update.pdf