



UNDERSTANDING AND PREDICTING MALARIA EPIDEMICS

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Salvador, 8 November 2018

Malaria continues to spread in most regions



nature Current issue

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▶ PLAY VIDEO

Malaria is on the rise in northeastern Cambodia, where villages are expanding.

Malaria's ticking time bomb

Scientists are racing to stamp out the disease in southeast Asia before unstoppable strains spread.

By Amy Maxmen

Photography by Adam Dean for Nature

Malaria by numbers: global and regional malaria burden

In 2016, there were 216 million cases of malaria in 91 countries, 5 million more than the 211 million cases reported in 2015. This marks a return to 2012 levels.

Malaria continues to claim a significant number of lives: in 2016, 445 000 people died from malaria globally, compared to 446 000 estimated deaths in 2015.

Children under 5 are particularly susceptible to malaria. The disease claims the life of a child every 2 minutes.

Fifteen countries – all but one in sub-Saharan Africa – carry 80% of the global malaria burden.

Estimated malaria burden by WHO region in 2016

WHO REGION	MALARIA CASES	MALARIA DEATHS
African	194 million	407 000
Americas	875 000	650
Eastern Mediterranean	4.3 million	8200
South-East Asia	14.6 million	27 000
Western Pacific	1.6 million	3300
World	216 million	445 000

malERA: An updated research agenda for malaria elimination and eradication

Regina N. Rabinovich^{1,2*}, Chris Drakeley³, Abdoulaye A. Djimde⁴, B. Fenton Hall⁵, Simon I. Hay^{6,7}, Janet Hemingway⁸, David C. Kaslow⁹, Abdisalan Noor^{10,11}, Fredros Okumu^{12,13,14}, Richard Steketee¹⁵, Marcel Tanner^{16,17}, Timothy N. C. Wells¹⁸, Maxine A. Whittaker¹⁹, Elizabeth A. Winzeler²⁰, Dyann F. Wirth², Kate Whitfield¹, Pedro L. Alonso²¹

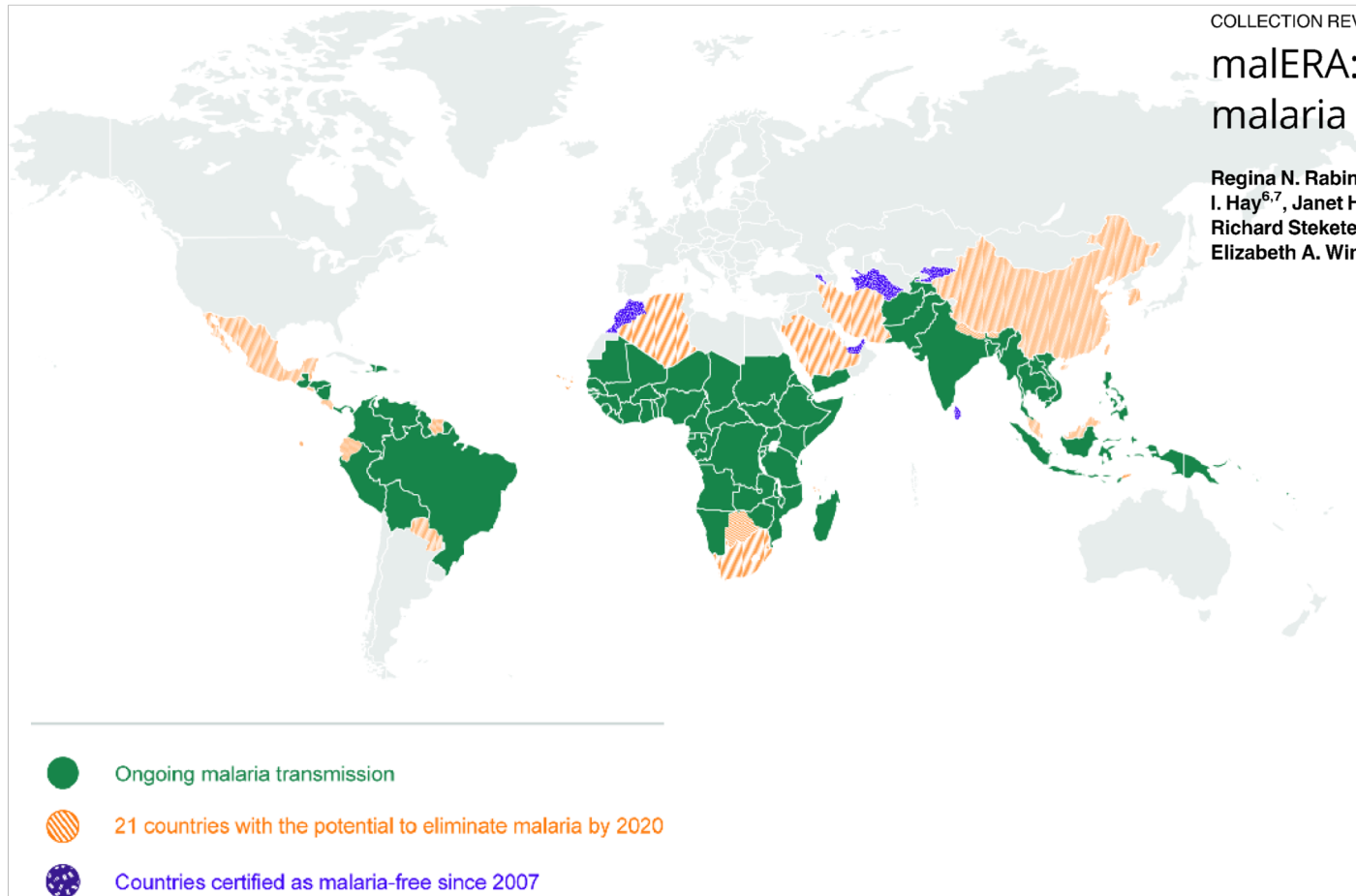


Fig 1. Map of 21 countries with the potential to eliminate malaria by 2020. There are 91 countries and territories with ongoing malaria transmission [9]. An analysis by WHO has identified 21 countries with the potential to eliminate by 2020: Algeria, Belize, Bhutan, Botswana, Cabo Verde, China, Comoros, Costa Rica, Ecuador, El Salvador, Iran (Islamic Republic of), Malaysia, Mexico, Nepal, Paraguay, Republic of Korea, Saudi Arabia, South Africa, Suriname, Swaziland, and Timor-Leste [10]. Countries and territories that have been certified malaria-free since 2007 are the United Arab Emirates (2007), Morocco (2010), Turkmenistan (2010), Armenia (2011), Maldives (2015), Sri Lanka (2016), and Kyrgyzstan (2016) [9,10]. Argentina and Paraguay have formally requested certification of malaria elimination and are in the process. Note that not all countries that have achieved zero indigenous cases for 3 consecutive years have sought certification from WHO. *Map base vector created by Freepik.*


<https://doi.org/10.1371/journal.pmed.1002456.g001>



Project overview


Integrating socioeconomic and healthcare data to combat malaria

- ✓ Phase I: November 2016 - October 2018
- ✓ Focus on i) data aggregation and ii) epidemic forecasting.




SIVEP

- ✓ Coverage: 2003-2018
- ✓ Records: 5,340,564
- ✓ Attributes: 52




SIM

- ✓ Coverage: 2003-2018
- ✓ Records: 1,004
- ✓ Attributes: 37



SINAN

- ✓ Coverage: 2003-2018
- ✓ Records: 46,170
- ✓ Attributes: 20

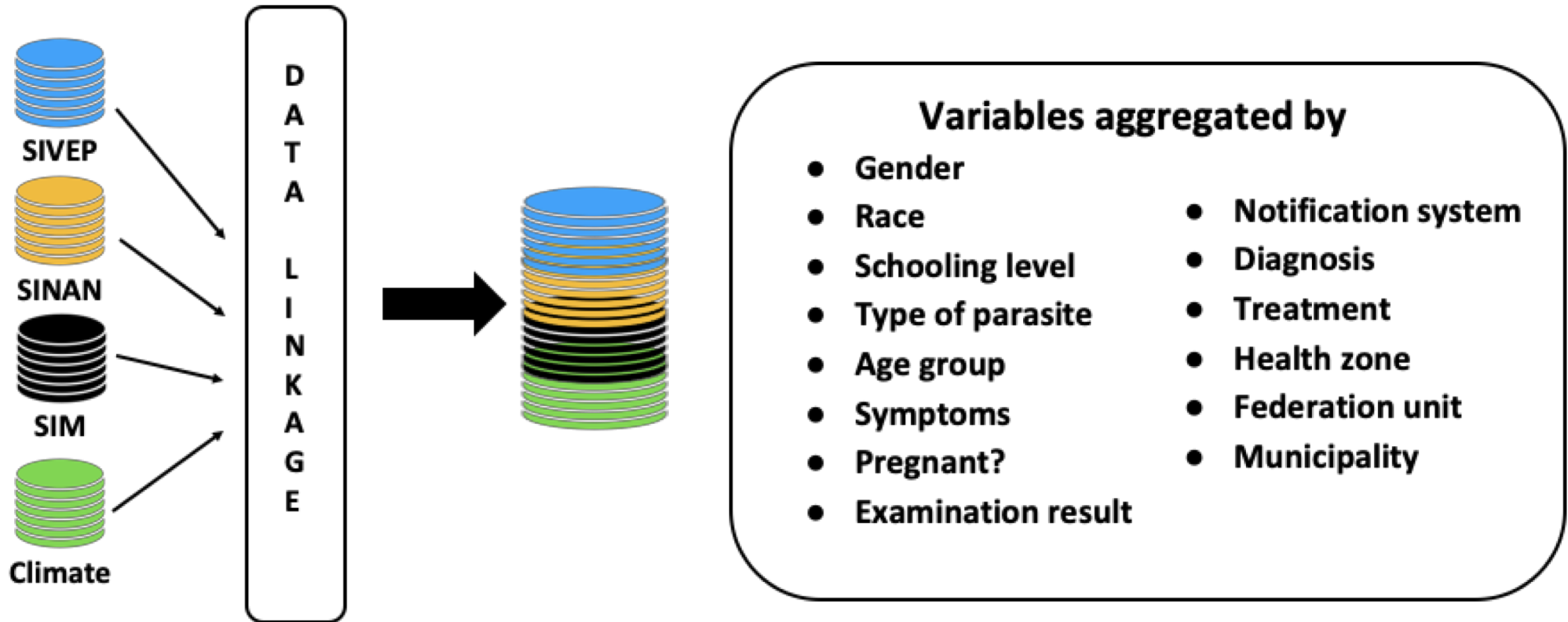


Climate

- ✓ Coverage: 2003-2018
- ✓ Records: 5,570
- ✓ Attributes: 5



Unified Database of Malaria Notifications



cod_ibge_infeccao ▾ cod_ibge_residencia ▾ cod_ibge_notificacao ▾ pais_infec ▾ ano_infec ▾ mes_infec ▾ sem_epid ▾

1100015	1100015	1100015	BRASIL	2005	5	21
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1100015	1100015	1100015	BRASIL	2006	9	38
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1100015

raca ▾ resexame ▾ faixa_etaria ▾ sintomas ▾ zona ▾ gestante ▾ lamina_ver_cura ▾ oport_diag ▾ oport_trat ▾

1100015	999	VIVAX	FAIXA_45-49	SIM	999	NAO	NAO	TARDIO	TARDIO
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1100015	999	VIVAX	FAIXA_0-4	SIM	999	NAO	NAO	TARDIO	TARDIO
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1100015	999	VIVAX	FAIXA_0-4	SIM	999	NAO	NAO	TARDIO	TARDIO
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1100015	999	VIVAX	FAIXA_35-39	SIM	999	NAO	NAO	TARDIO	TARDIO
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1100015	999	VIVAX	FAIXA_60-64	SIM	999	NAO	NAO	TARDIO	TARDIO
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1100015	999	VIVAX	FAIXA_10-14	SIM	999	NAO	NAO	TARDIO	TARDIO
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1100015	999	VIVAX	FAIXA_05-9	SIM	999	NAO	NAO	TARDIO	TARDIO
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Showing 1 to 50 of 3,867,189

Showing 1 to 50 of 3,867,189 entries

autoctone_importado ▾ sistema_notificacao ▾ total ▾ nome_municipio ▾ UF ▾ Estado ▾ Latitude ▾ Longitude ▾

AUTOCTONE	SIVEP	1	Alta Floresta D'Oeste	RO	RONDÔNIA	-11.9283	-61.9953
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AUTOCTONE	SIVEP	1	Alta Floresta D'Oeste	RO	RONDÔNIA	-11.9283	-61.9953
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AUTOCTONE	SIVEP	1	Alta Floresta D'Oeste	RO	RONDÔNIA	-11.9283	-61.9953
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IMPORTADO	SIVEP	1	Alta Floresta D'Oeste	RO	RONDÔNIA	-11.9283	-61.9953
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AUTOCTONE	SIVEP	1	Alta Floresta D'Oeste	RO	RONDÔNIA	-11.9283	-61.9953
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AUTOCTONE	SIVEP	1	Alta Floresta D'Oeste	RO	RONDÔNIA	-11.9283	-61.9953
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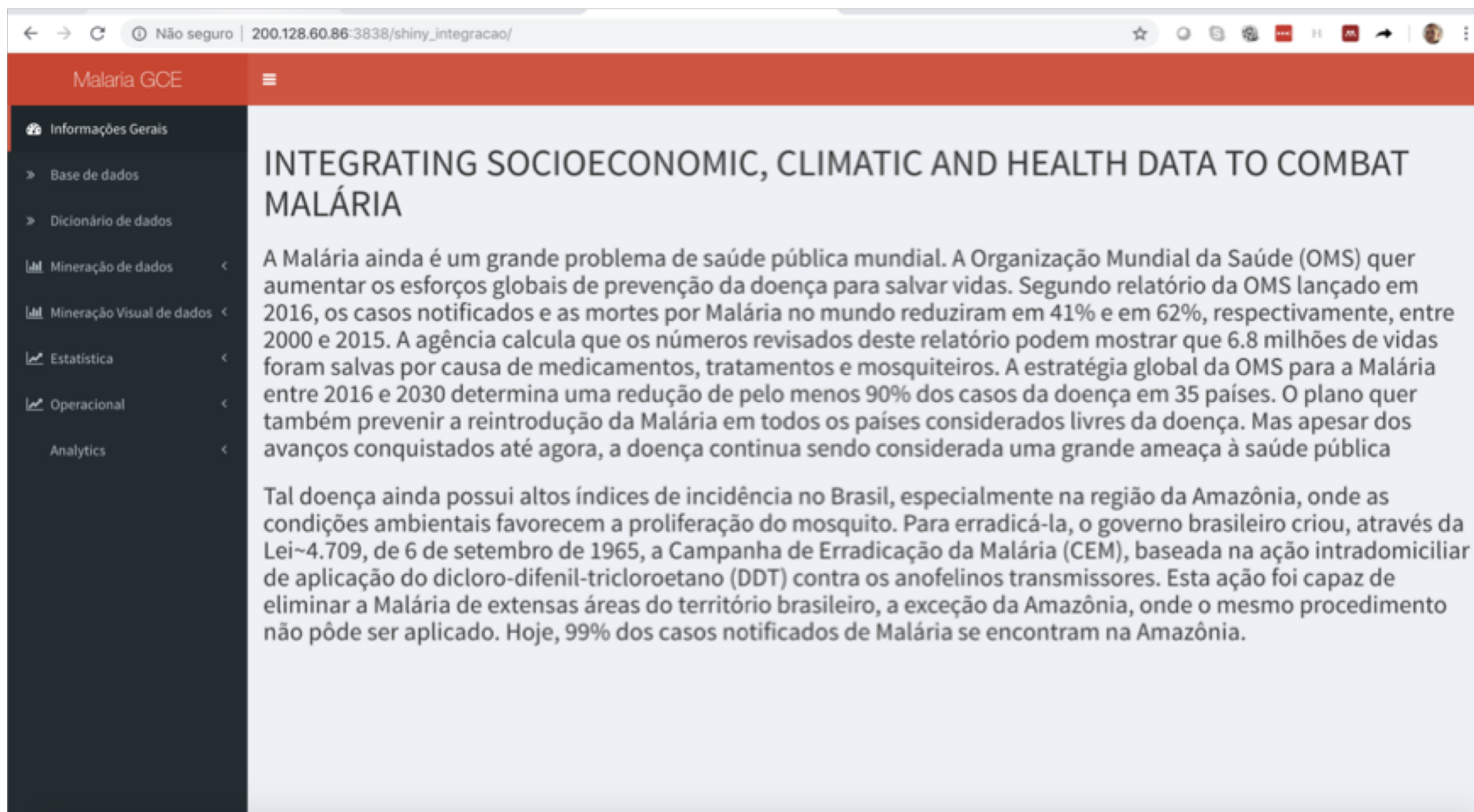
AUTOCTONE	SIVEP	1	Alta Floresta D'Oeste	RO	RONDÔNIA	-11.9283	-61.9953
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Showing 1 to 50 of 3,867,189 entries

Previous **1** 2 3 4 5 ... 77344 Next

Visual analytics tool

http://200.128.60.86:3838/shiny_integracao/



The screenshot shows a web browser window with the address bar displaying "200.128.60.86:3838/shiny_integracao/". The page title is "Malaria GCE". A sidebar menu on the left contains the following items: "Informações Gerais", "Base de dados", "Dicionário de dados", "Mineração de dados", "Mineração Visual de dados", "Estatística", "Operacional", and "Analytics". The main content area features the heading "INTEGRATING SOCIOECONOMIC, CLIMATIC AND HEALTH DATA TO COMBAT MALÁRIA". Below the heading, there are two paragraphs of text in Portuguese. The first paragraph discusses the global health problem of malaria, the WHO's efforts, and the 2016 report showing a 41% decrease in cases and a 62% decrease in deaths between 2000 and 2015. The second paragraph focuses on Brazil, mentioning the high incidence in the Amazon region and the historical eradication campaign (CEM) using DDT, which is still not applicable there today as 99% of cases are found in the Amazon.

Malaria GCE

Informações Gerais

Base de dados

Dicionário de dados

Mineração de dados

Mineração Visual de dados

Estatística

Operacional

Analytics

INTEGRATING SOCIOECONOMIC, CLIMATIC AND HEALTH DATA TO COMBAT MALÁRIA

A Malária ainda é um grande problema de saúde pública mundial. A Organização Mundial da Saúde (OMS) quer aumentar os esforços globais de prevenção da doença para salvar vidas. Segundo relatório da OMS lançado em 2016, os casos notificados e as mortes por Malária no mundo reduziram em 41% e em 62%, respectivamente, entre 2000 e 2015. A agência calcula que os números revisados deste relatório podem mostrar que 6.8 milhões de vidas foram salvas por causa de medicamentos, tratamentos e mosquiteiros. A estratégia global da OMS para a Malária entre 2016 e 2030 determina uma redução de pelo menos 90% dos casos da doença em 35 países. O plano quer também prevenir a reintrodução da Malária em todos os países considerados livres da doença. Mas apesar dos avanços conquistados até agora, a doença continua sendo considerada uma grande ameaça à saúde pública

Tal doença ainda possui altos índices de incidência no Brasil, especialmente na região da Amazônia, onde as condições ambientais favorecem a proliferação do mosquito. Para erradicá-la, o governo brasileiro criou, através da Lei 4.709, de 6 de setembro de 1965, a Campanha de Erradicação da Malária (CEM), baseada na ação intradomiciliar de aplicação do dicloro-difenil-tricloroetano (DDT) contra os anofelinos transmissores. Esta ação foi capaz de eliminar a Malária de extensas áreas do território brasileiro, a exceção da Amazônia, onde o mesmo procedimento não pôde ser aplicado. Hoje, 99% dos casos notificados de Malária se encontram na Amazônia.

- Informações Gerais
- » Base de dados
- » Dicionário de dados
- Mineração de dados <
- Mineração Visual de dados <
- Estatística** v
- Análise Univariada
- Séries Temporais
- Gráficos de Controle
- Análise Bivariada
- Operacional <
- Analytics <

- Informações Gerais
- » Base de dados
- » Dicionário de dados
- Mineração de dados <
- Mineração Visual de dados** v
- Mapas
- Total-Casos
- Autoctone-Importado
- Epidem-Mensal
- Faixa-Etaria
- Estatística <
- Operacional <
- Analytics <

- Informações Gerais
- » Base de dados
- » Dicionário de dados
- Mineração de dados <
- Mineração Visual de dados <
- Estatística <
- Operacional** v
- Mapa Laboratorio
- Analytics <

- Informações Gerais
- » Base de dados
- » Dicionário de dados
- Mineração de dados <
- Mineração Visual de dados <
- Estatística <
- Operacional <
- Analytics** v
- » Machine Learning - Prediction



Informações Gerais

» Base de dados

» Dicionário de dados

Mineração de dados <

Mineração Visual de dados <

Estatística <

Análise Univariada

Séries Temporais

Graficos de Controle

Análise Bivariada

Operacional <

Analytics <

Inputs

Malaria Cases By:

Município de Notificação

Subtype:

Falci-parum

Climate Variable:

Umidade do Ar

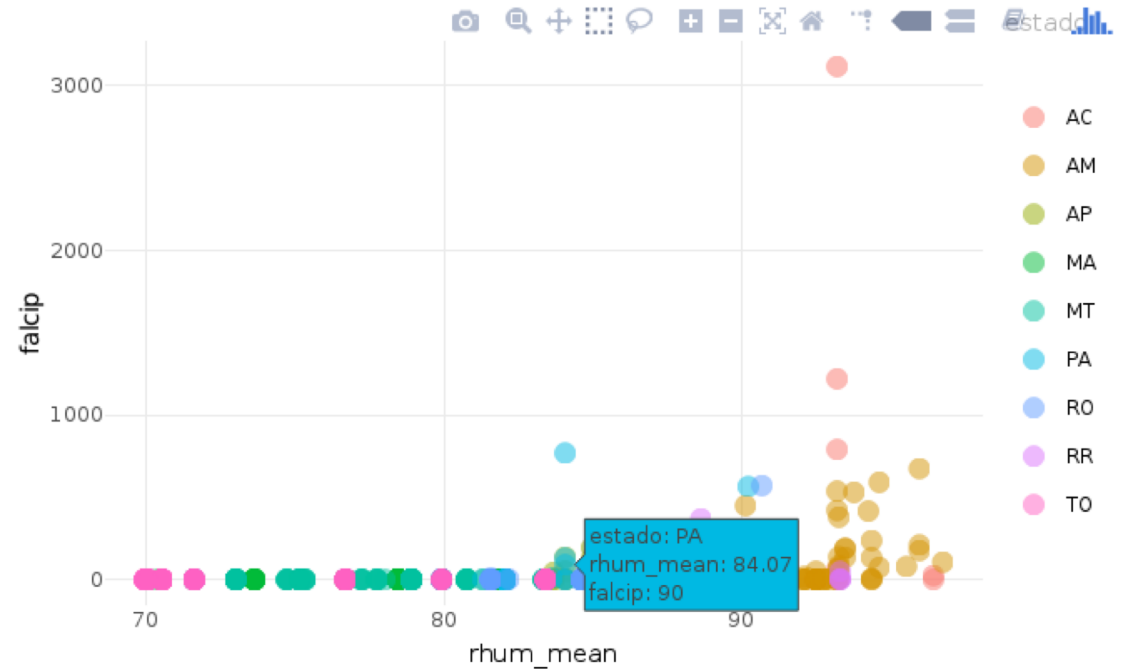
Coloring by:

Estado

Year:

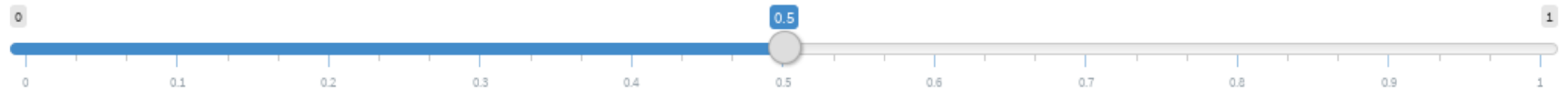
2015

Scatterplot



More Inputs

Transparency:



Descriptive analytics



Informações Gerais

» Base de dados

» Dicionário de dados

Mineração de dados <

Mineração Visual de dados <

Estatística <

Análise Univariada

Séries Temporais

Graficos de Controle

Análise Bivariada

Operacional <

Analytics <

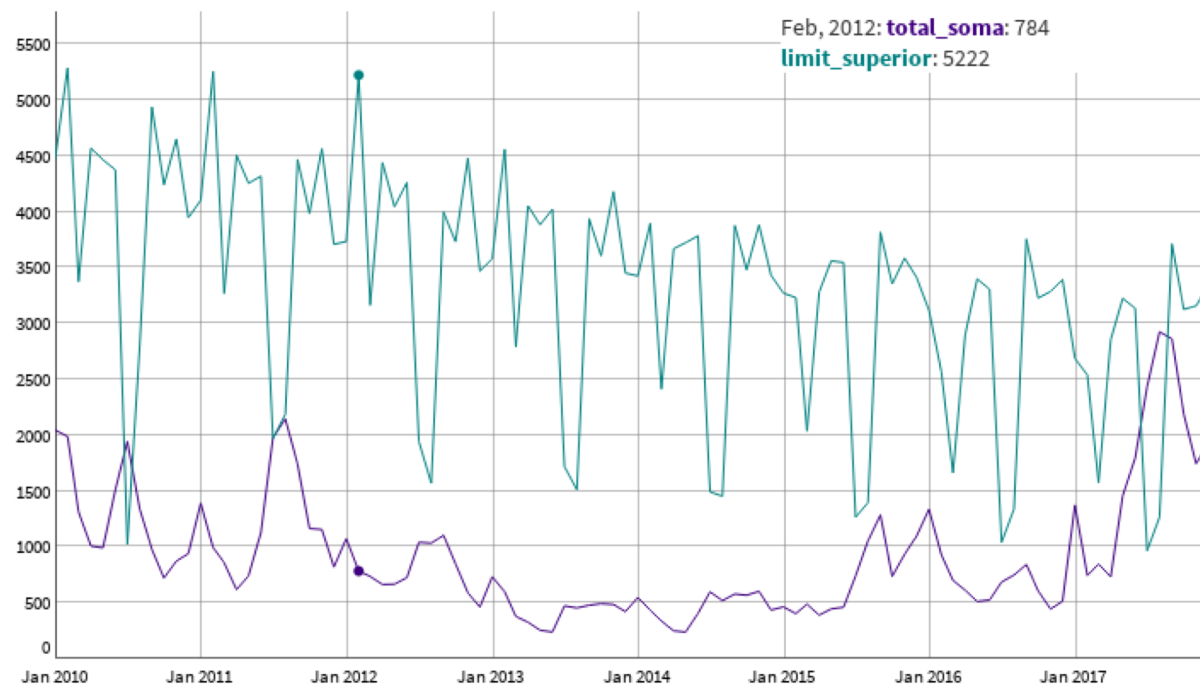
Input

Select the Variable:

3° Quartil

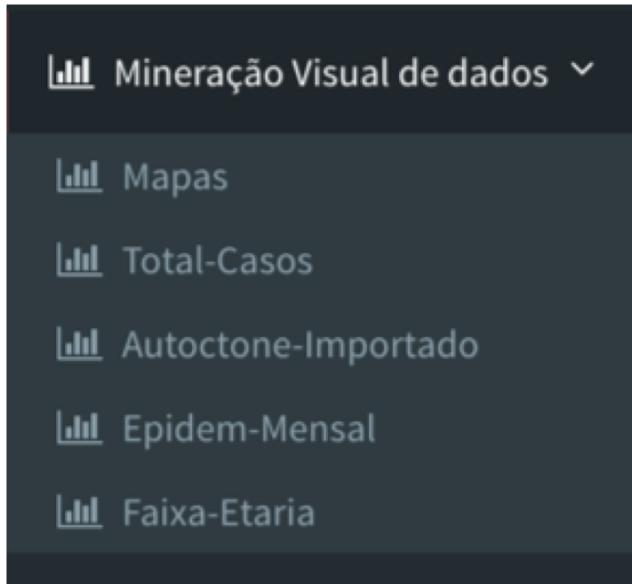
Manaus-AM

Grafico de controle



Descriptive analytics

Visual analytics



Total casos por resultado exame



4,783,335

VIVAX - Total casos

1,098,721

FALCIPARUM - Total casos

73,116

MISTA - Total casos

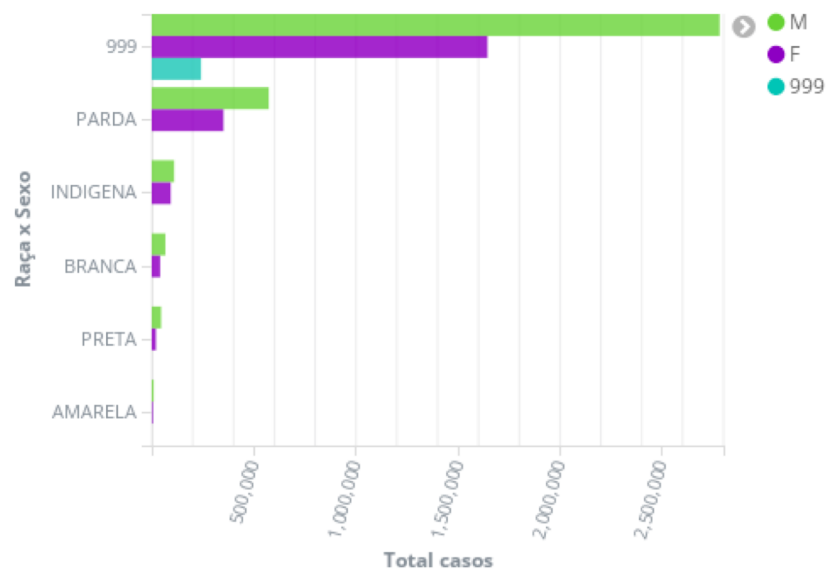
25,300

999 - Total casos

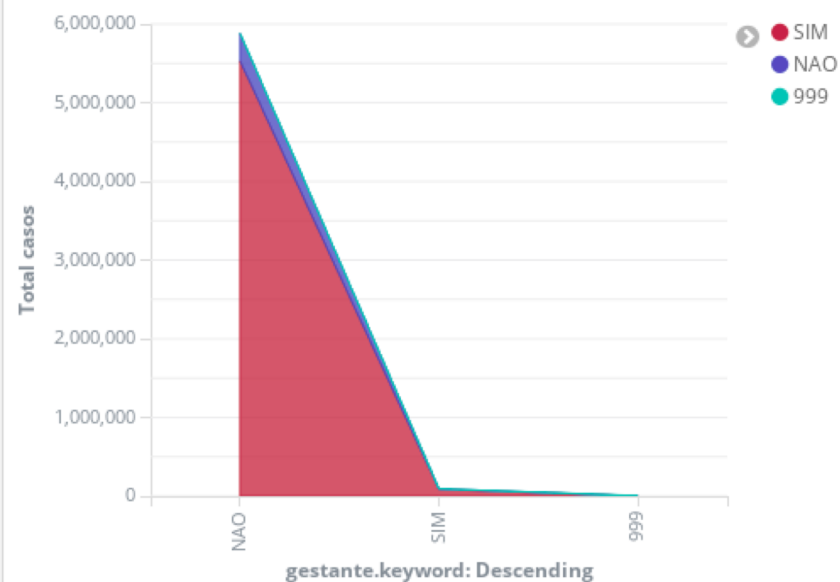
119

OVALE - Total casos

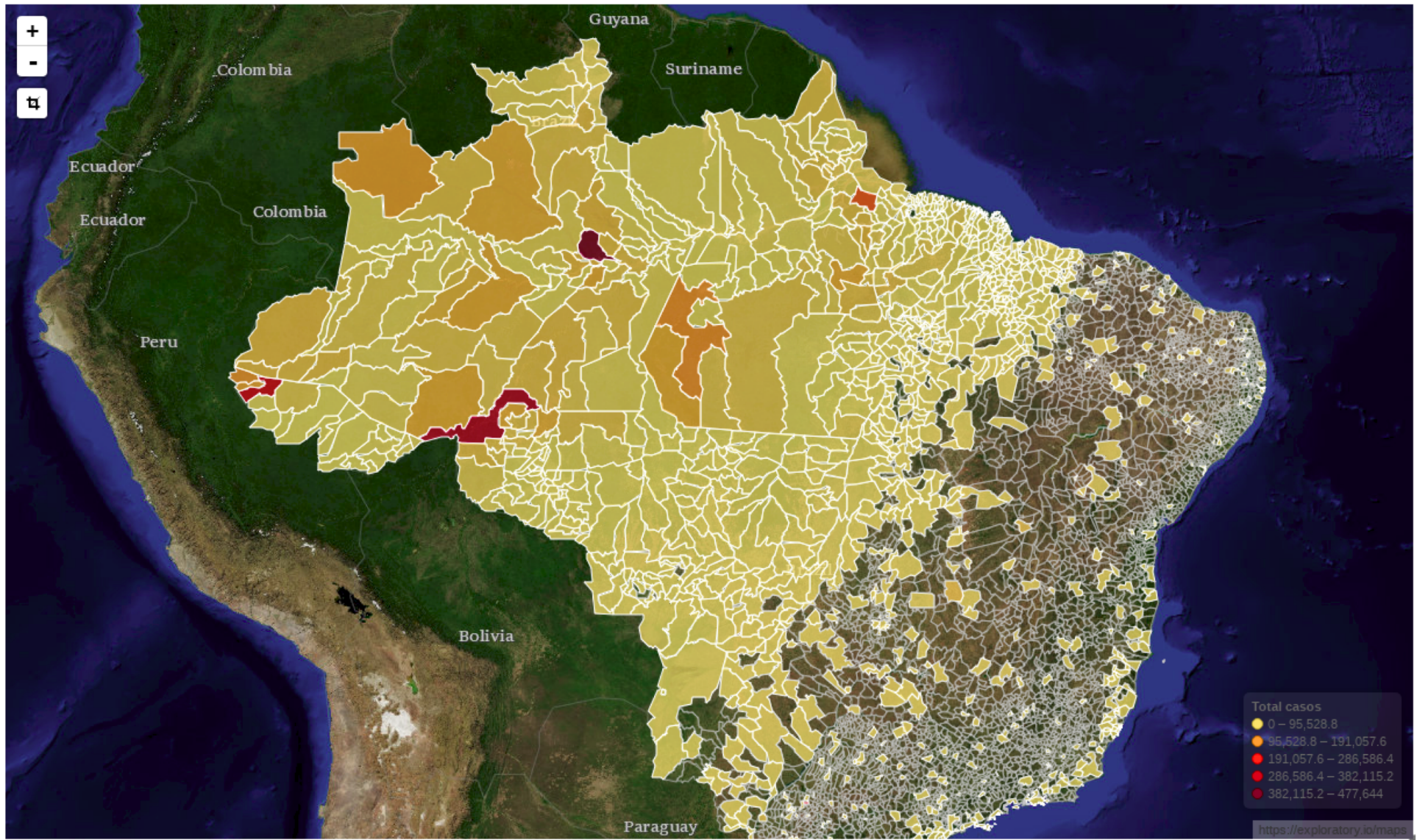
Total casos por raça e sexo



Total casos por gestante e sintoma



Total casos de malária por Municipio

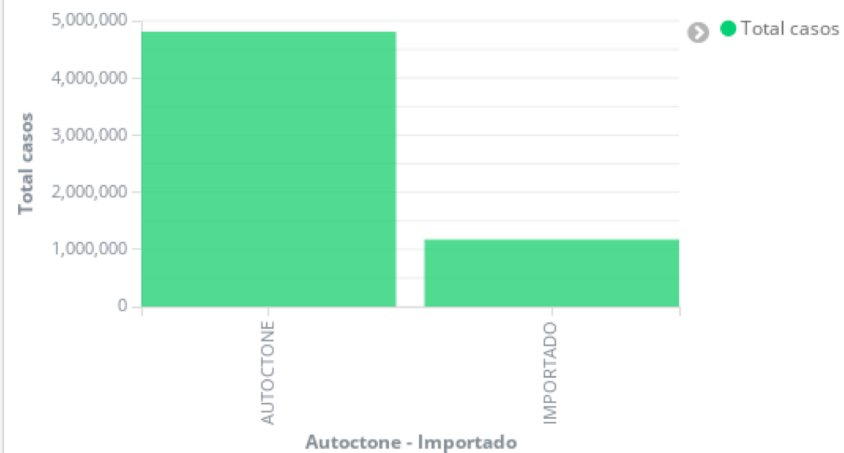


Total casos por Estado

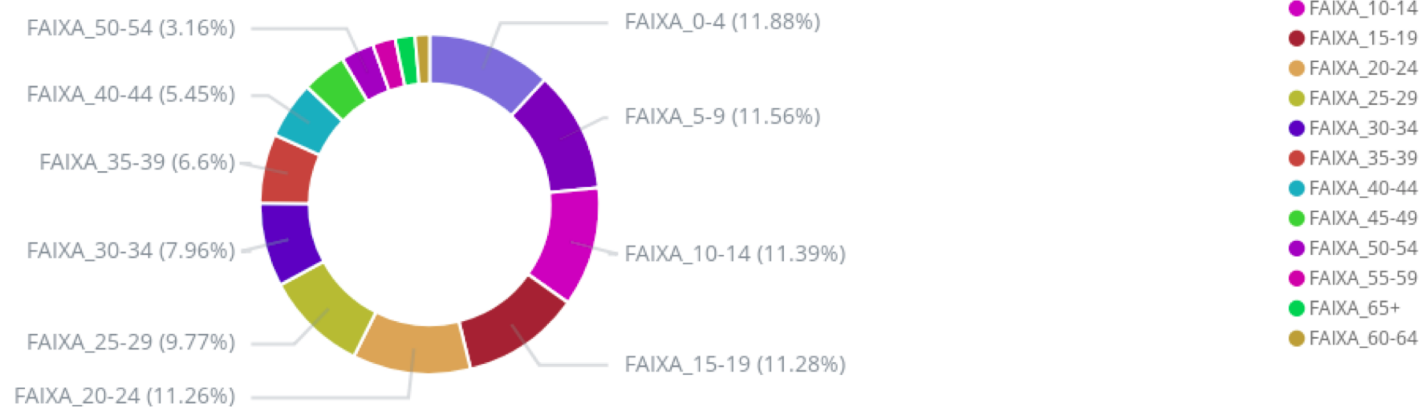
Estado.keyword: Descending ⌵ Total casos ⌵

Estado.keyword	Total casos
AMAZONAS	2,131,941
PARÁ	1,458,030
RONDÔNIA	916,211
ACRE	659,238
AMAPÁ	277,183
RORAIMA	239,007
9999999	154,579
MARANHÃO	72,863
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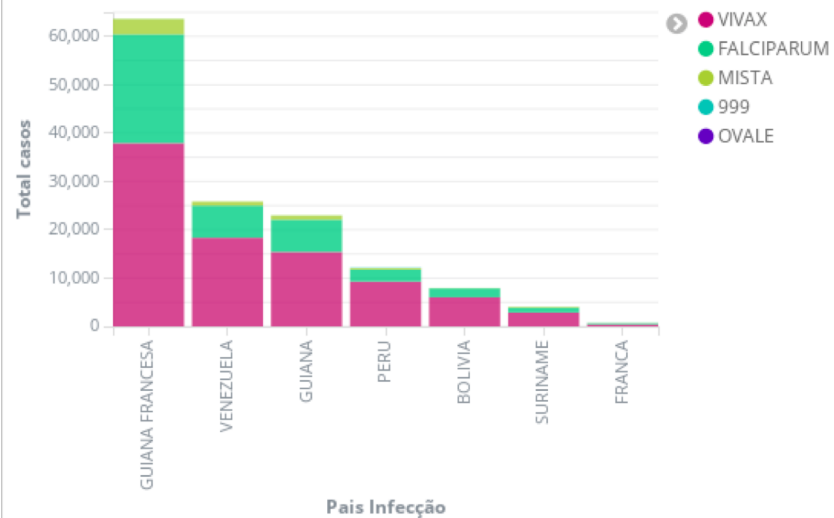
Total casos Autoctone Importados



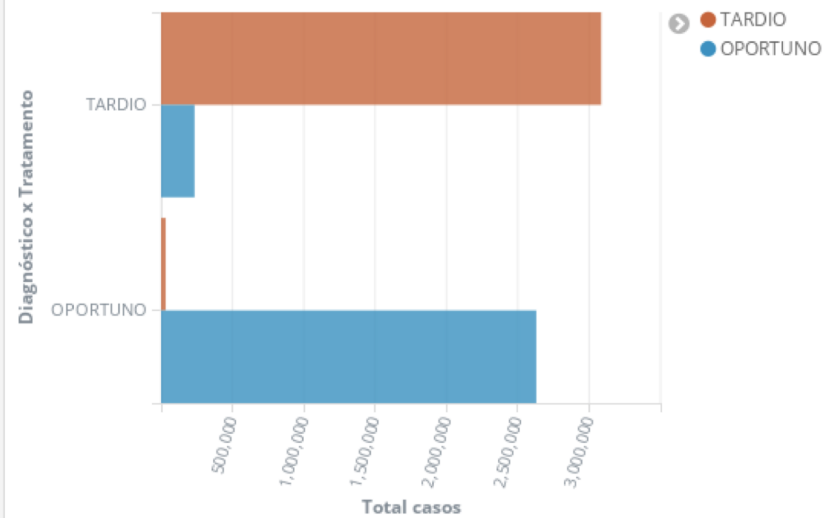
Total casos por sexo e faixa etaria



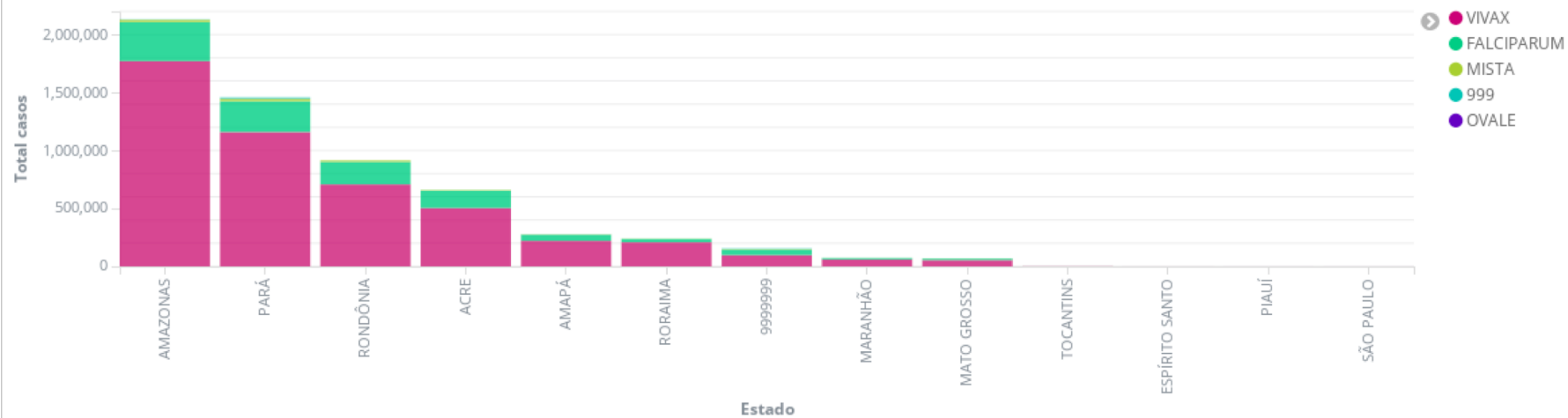
Total de casos por país de infecção e resultado exame



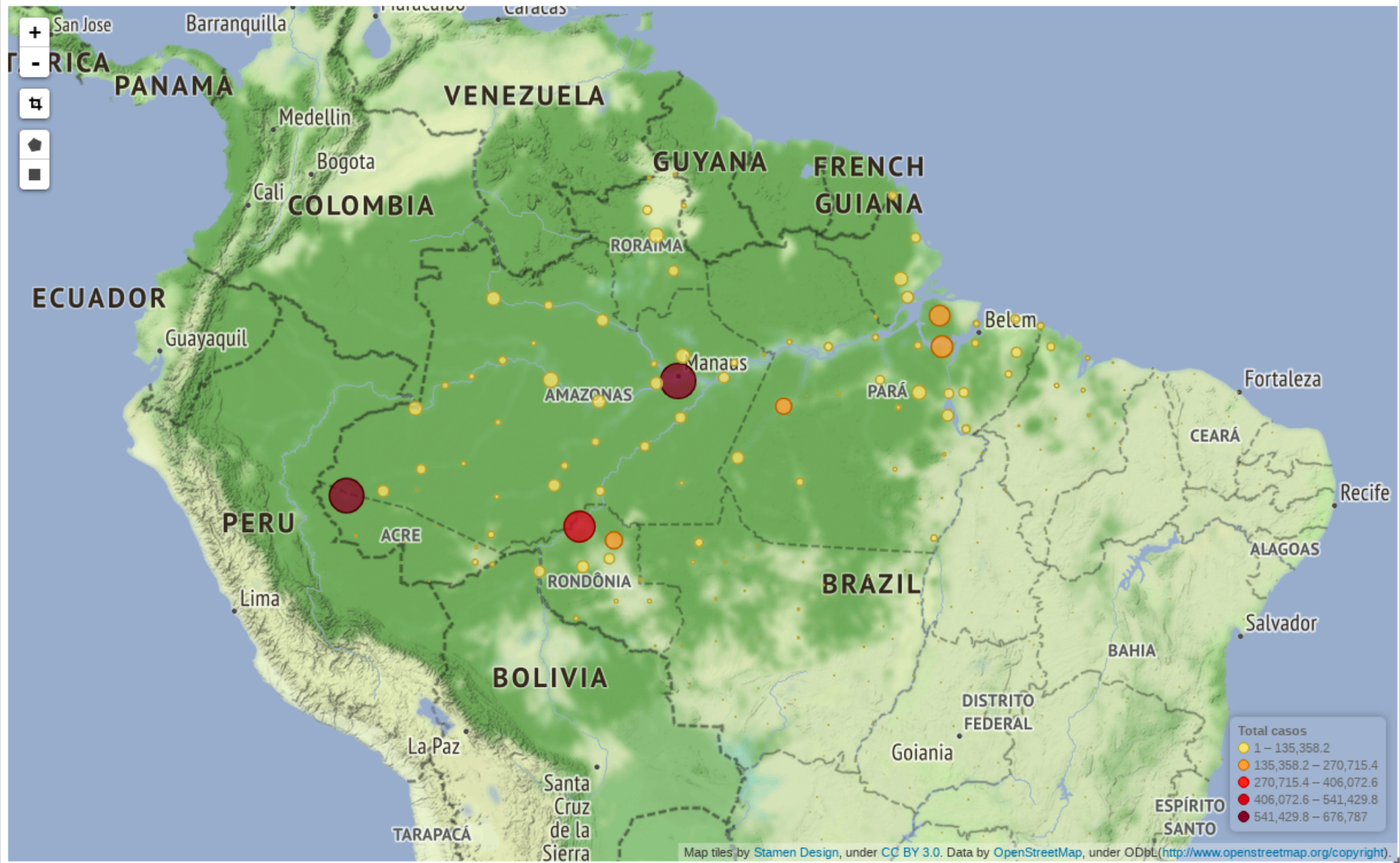
Total casos diagnostico e tratamento relativo



Total de casos por Estado e resultado exame



Map of distribution of cases Malária

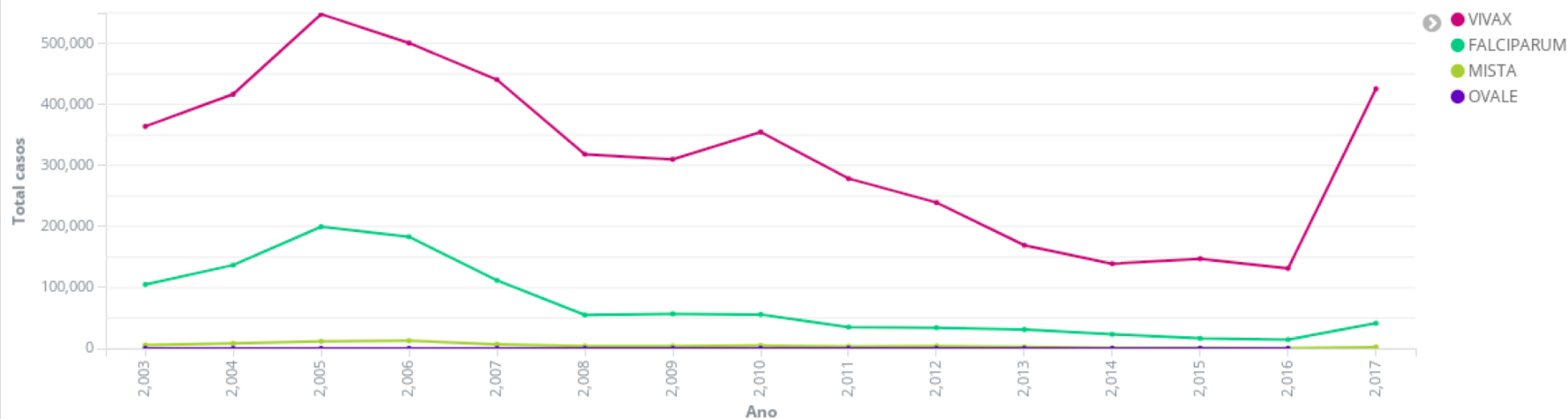


Distribuição de total de casos de malária por Município

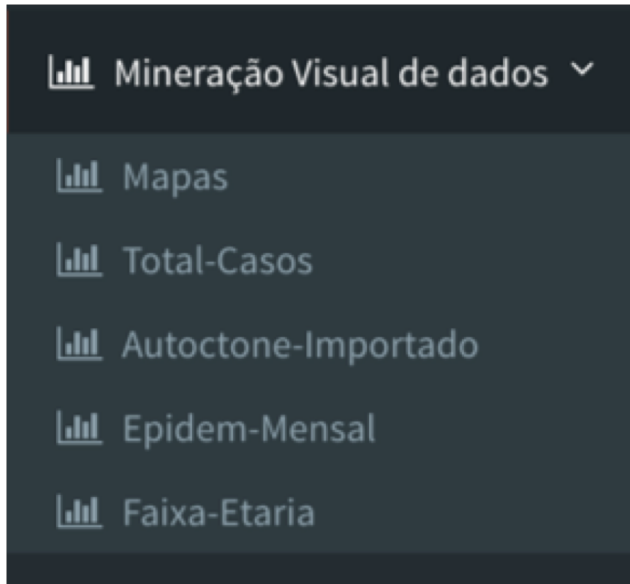


Total casos - Nome Município

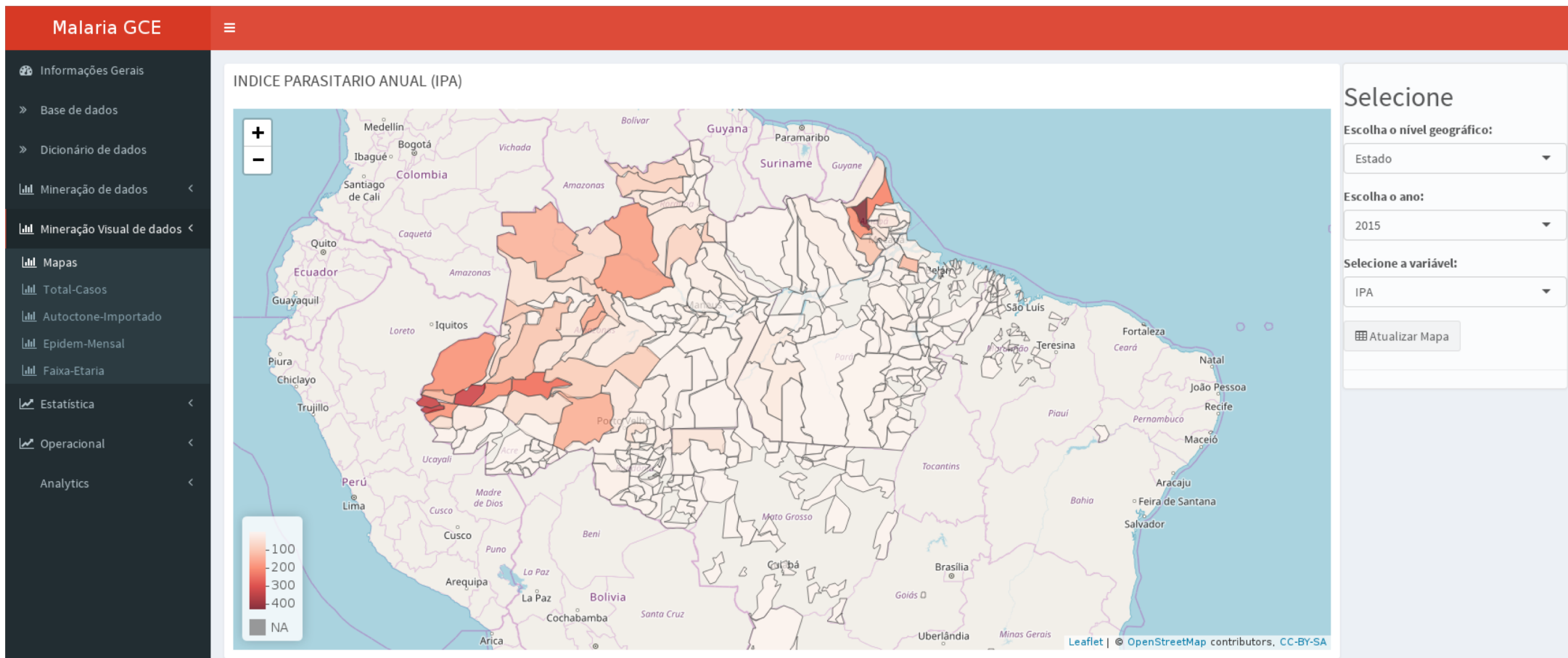
Total casos por ano e resultado exame



Visual analytics



IPA - Annual Parasitic Index





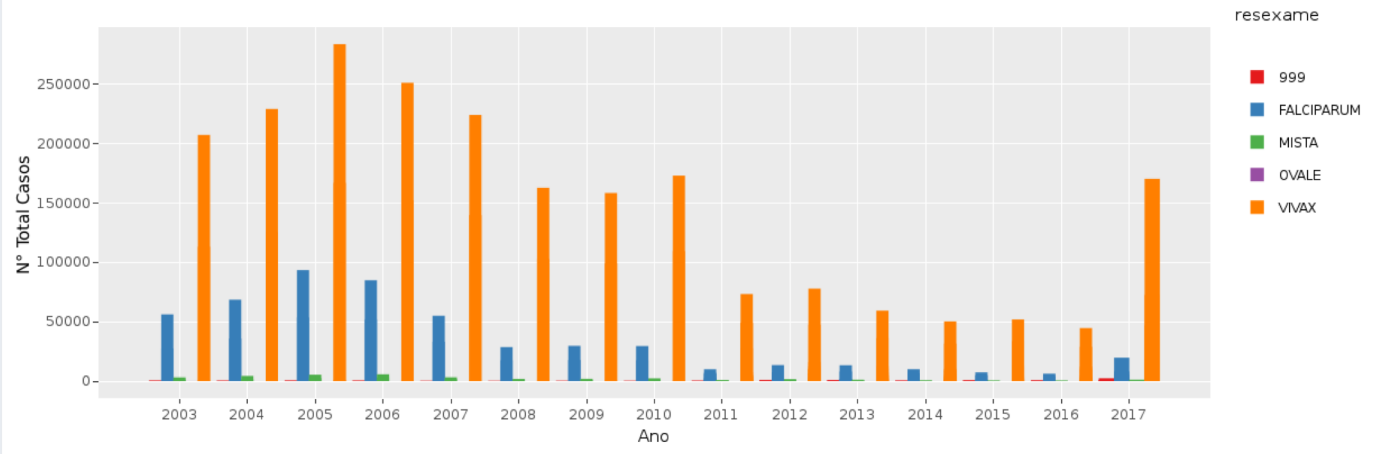
- 🏠 Informações Gerais
- » Base de dados
- » Dicionário de dados
- 📊 Mineração de dados <
- 📊 Mineração Visual de dados <
- 📍 Mapas
- 📊 Total-Casos
- 📊 Autoctone-Importado
- 📊 Epidem-Mensal
- 📊 Faixa-Etaria
- 📈 Estatística <
- 📈 Operacional <
- Analytics <

Inputs

Subtype:

- Resultado do exame
- Resultado do exame
- sexo
- raca

BarPlot Graphics





- Informações Gerais
- » Base de dados
- » Dicionário de dados
- Mineração de dados <
- Mineração Visual de dados <
- Mapas
- Total-Casos
- Autoctone-Importado
- Epidem-Mensal
- Faixa-Etaria
- Estadística <
- Operacional <
- Analytics <

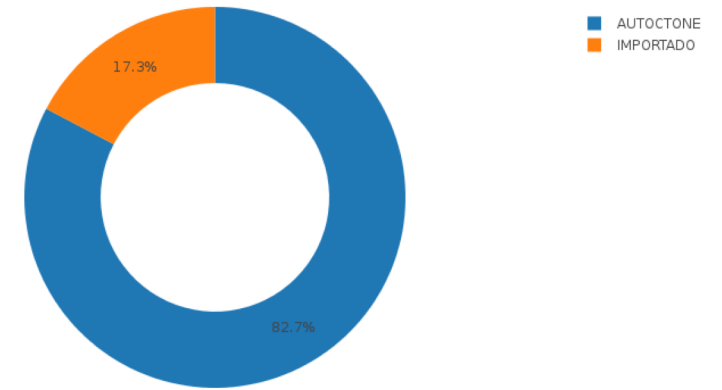
Inputs

Year:

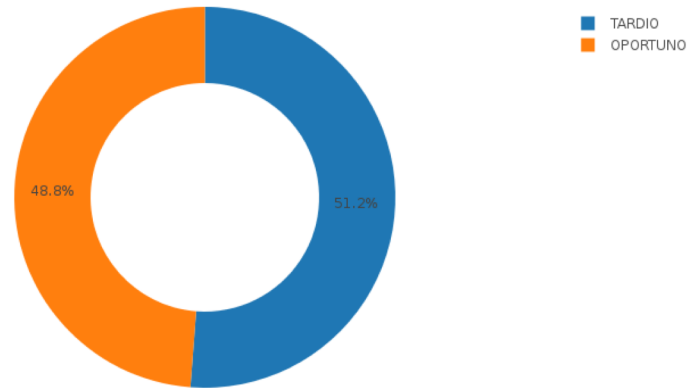
Resultado Exame:

Escolha Município:

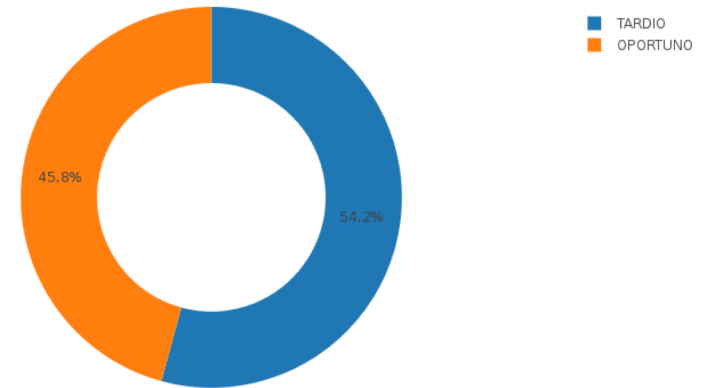
Autoctone / Importados



Tratamento Autoctone



Diagnostico Autoctone





- Informações Gerais
- » Base de dados
- » Dicionário de dados
- Mineração de dados <
- Mineração Visual de dados <
- Mapas
- Total-Casos
- Autoctone-Importado
- Epidem-Mensal
- Faixa-Etaria
- Estadística <
- Operacional <
- Analytics <

Input

Select the Variable:

Todas as Especies - Todas

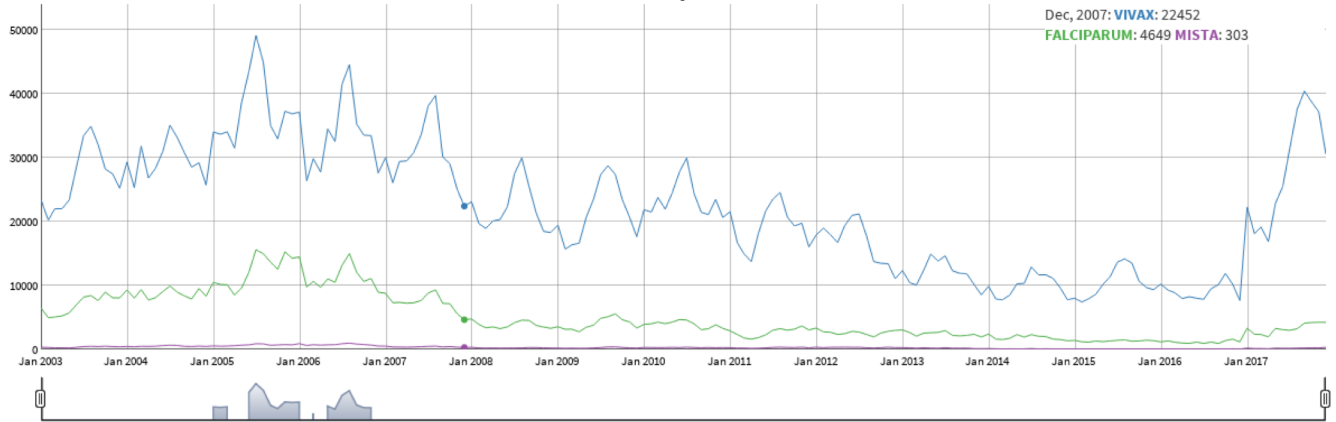
Escolha Município:

Digite o Nome do Município

Show Grid

Time Series

Análise Temporal



Click and drag to zoom in (double click to zoom back out).

Malaria GCE



Informações Gerais

» Base de dados

» Dicionário de dados

Mineração de dados

Mineração Visual de dados

Mapas

Total-Casos

Autoctone-Importado

Epidem-Mensal

Faixa-Etaria

Estatística

Operacional

Analytics

Inputs

Year:

2003-2017

Faixa Etaria:

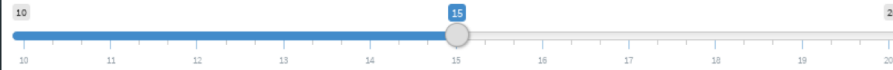
FAIXA_0-4

Group by:

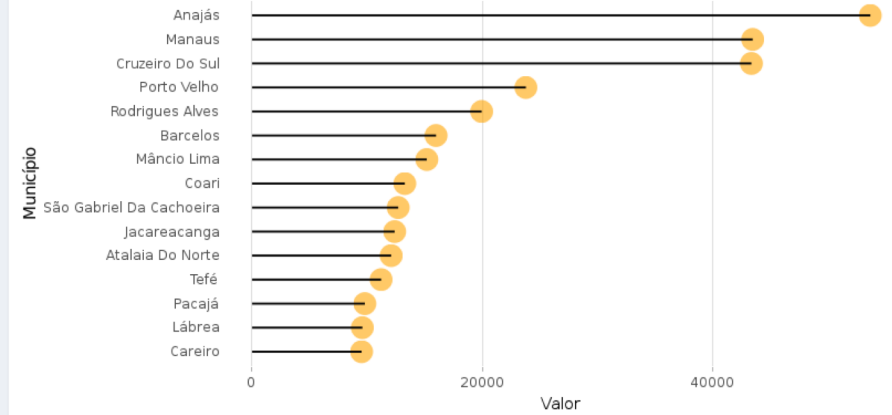
Município

Estado

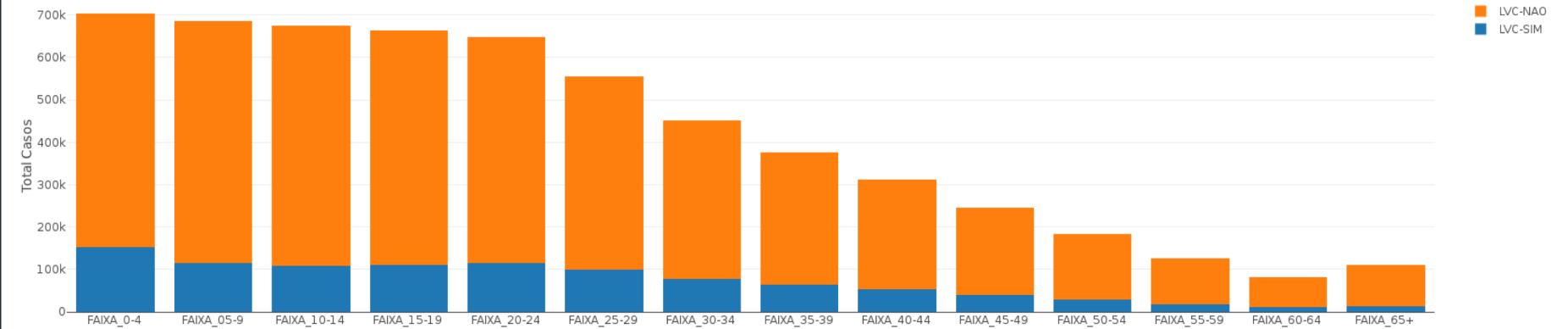
Number of Municipalities



Ranking



Bar Chart



Pilot study - Manaus (AM)



- Focusing on:
 - vector control
 - how to engage public health agents to improve data collection about vector-related data (laboratory, spraying zones, hotspots, and spas)
 - encourage other municipalities to do the same.

Pilot study - Manaus (AM)



Vector control (2016-2018)

- ✓ **Laboratory**
- ✓ **Records: 75**
- ✓ **Attributes: 11**

- ✓ **Hotspots**
- ✓ **Records: 325**
- ✓ **Attributes: 26**

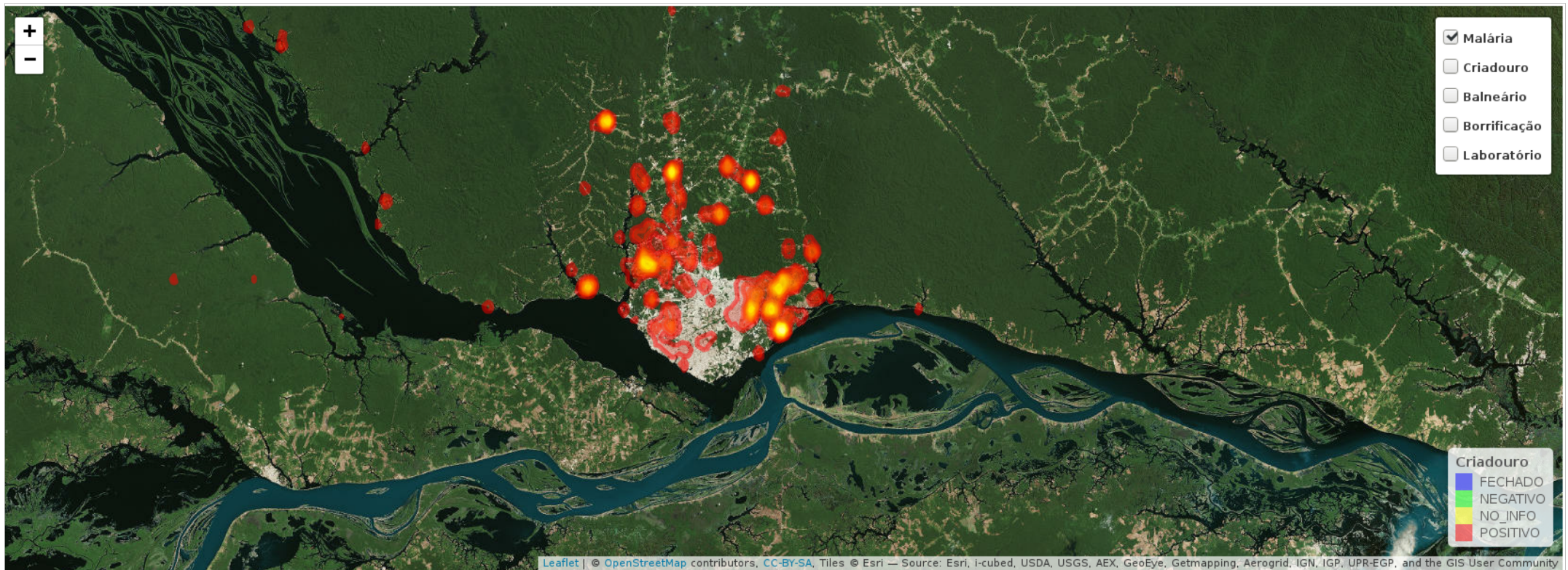
- ✓ **Spas**
- ✓ **Records: 45**
- ✓ **Attributes: 19**

- ✓ **Spraying zones**
- ✓ **Records: 80**
- ✓ **Attributes: 15**

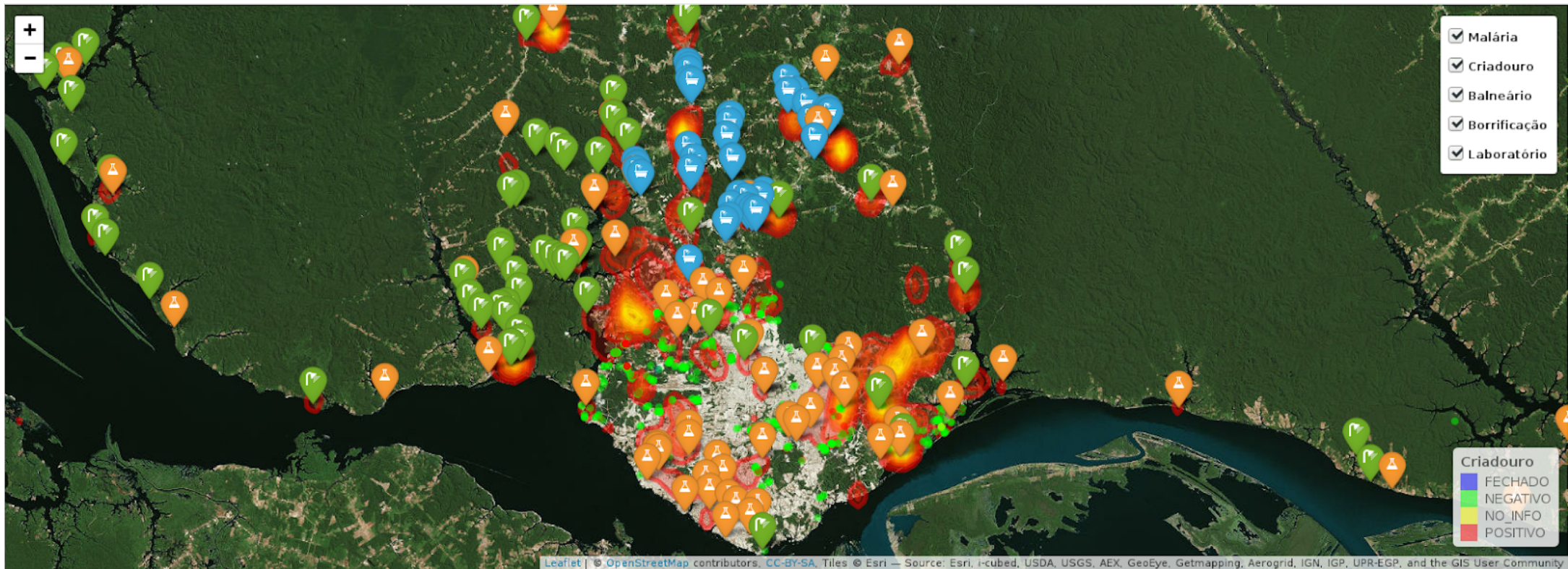
Example: hotspots (breeding sites)

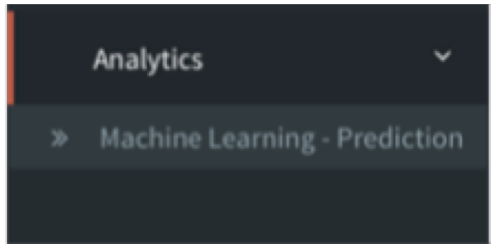
	LATITUDE	LONGITUDE	COD_CRIADOURO	NOME_CRIADOURO	CLASSIFICACAO_CRIADOURO	CRIADOURUS	ZONA	NOME_CRIAD_CODIGO
1	-3.018670	-60.04771	31318001	PARAISO TROPICAL	99	NEGATIVO	OESTE	PARAISO TROPICAL - 31318001
2	-3.020630	-60.04932	31318002	SITIO DO DARLAN DOS PORCOS	3	NEGATIVO	OESTE	SITIO DO DARLAN DOS PORCOS - 31
3	-3.020610	-60.04888	31318003	SITIO DO DARLAN DOS PORCOS	1	NEGATIVO	OESTE	SITIO DO DARLAN DOS PORCOS - 31
4	-3.023880	-60.03912	31318004	SITIO DIVBINOPOLIS	13	NEGATIVO	OESTE	SITIO DIVBINOPOLIS - 31318004
5	-3.022930	-60.03882	31318005	SITIO DO AUCILIO	99	NEGATIVO	OESTE	SITIO DO AUCILIO - 31318005
6	-3.023840	-60.03711	31318006	SITIO DO ZOTI	15	NEGATIVO	OESTE	SITIO DO ZOTI - 31318006
7	-3.023840	-60.03711	31318007	SITIO DO ZOTI	15	NEGATIVO	OESTE	SITIO DO ZOTI - 31318007
8	-3.024320	-60.03688	31318008	SITIO DO GILTON	15	NEGATIVO	OESTE	SITIO DO GILTON - 31318008
9	-3.007430	-60.05455	31614001	CACHOEIRA ALTA	9	NEGATIVO	OESTE	CACHOEIRA ALTA - 31614001
10	-3.007470	-60.05457	31614002	CACHOEIRA ALTA	9	NEGATIVO	OESTE	CACHOEIRA ALTA - 31614002
11	-3.007890	-60.05367	31614003	CACHOEIRA ALTA	1	POSITIVO	OESTE	CACHOEIRA ALTA - 31614003
12	-3.007740	-60.05361	31614004	CACHOEIRA ALTA	9	NEGATIVO	OESTE	CACHOEIRA ALTA - 31614004
13	-3.008350	-60.05425	31614005	CACHOEIRA ALTA	15	POSITIVO	OESTE	CACHOEIRA ALTA - 31614005
14	-3.008450	-60.02375	31614006	CACHOEIRA ALTA	99	NEGATIVO	OESTE	CACHOEIRA ALTA - 31614006
15	-2.982180	-60.05055	31501001	SITIO DO PAPA	99	NEGATIVO	OESTE	SITIO DO PAPA - 31501001
16	-2.982170	-60.05054	31501002	SITIO DO PAPA	99	NEGATIVO	OESTE	SITIO DO PAPA - 31501002
17	-2.982970	-60.05072	31501003	SITIO DO LABIBI	99	NEGATIVO	OESTE	SITIO DO LABIBI - 31501003

Example: heatmap



Example: multilayer visual mining

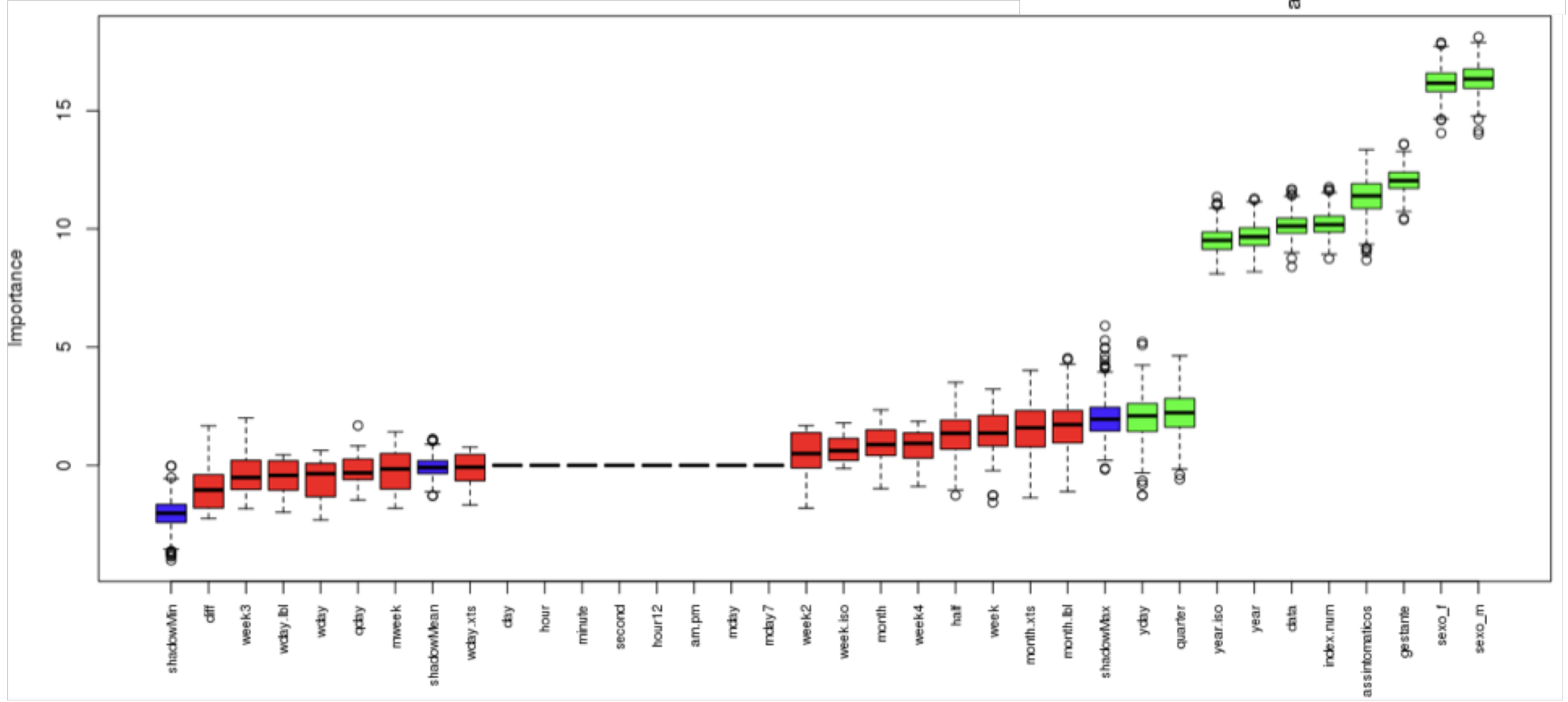




Predictive analytics

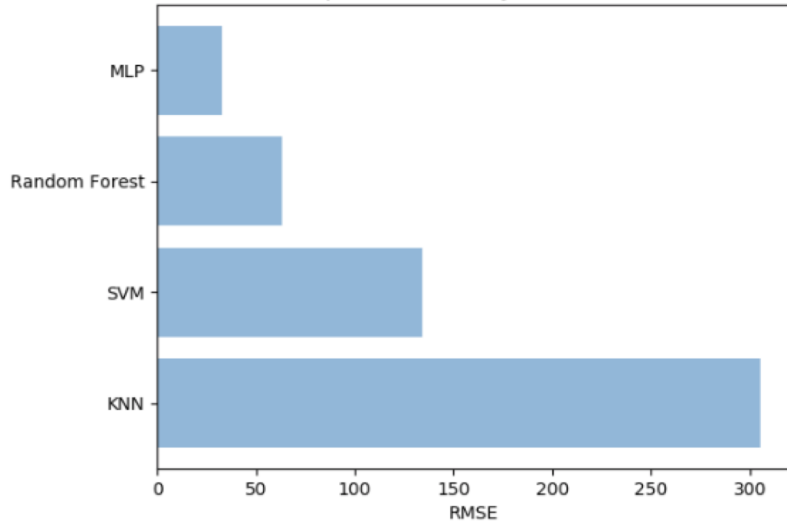
- Test ensembles of machine and deep learning algorithms over malaria data
- Predict the number of cases reported monthly by municipality to assist in surveillance and control actions
- Available attributes: Demographics / Environmental / Climate / Socioeconomic

Pilot study - Manaus (AM) - which predictors to use?

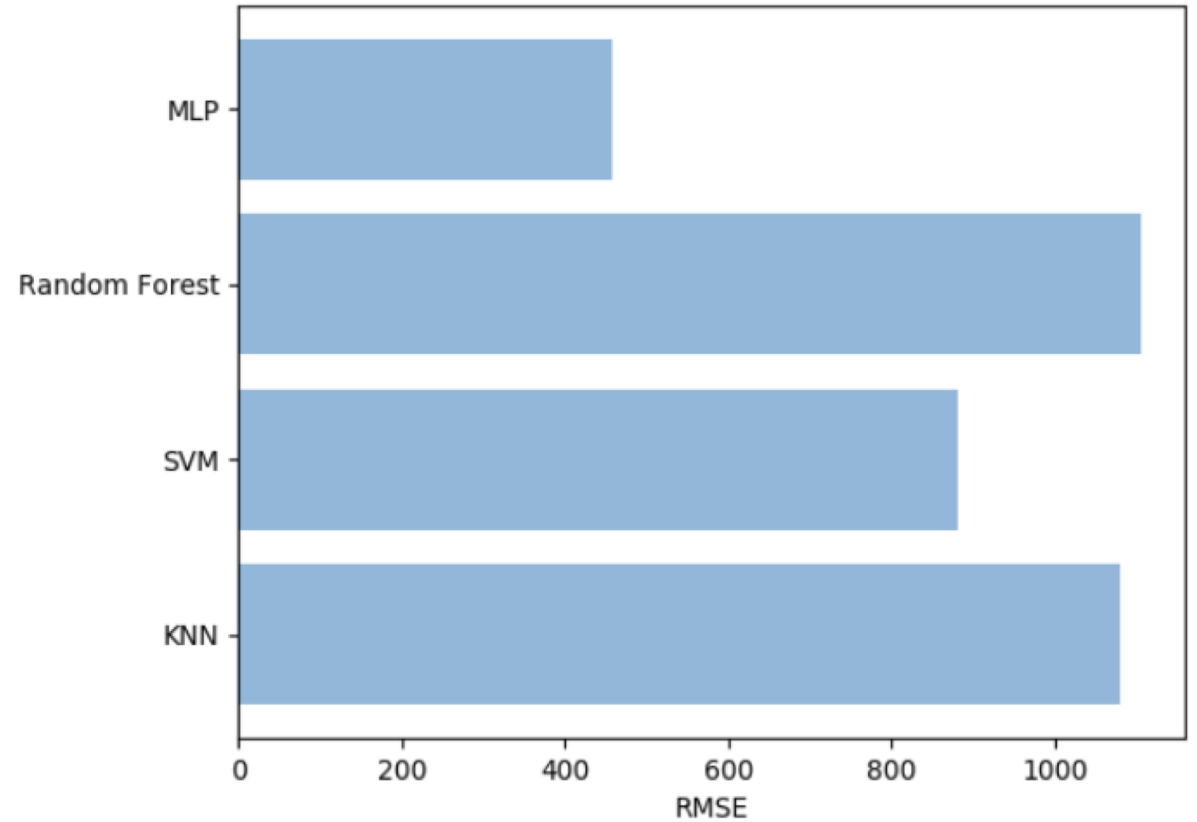


Pilot study - Manaus (AM)

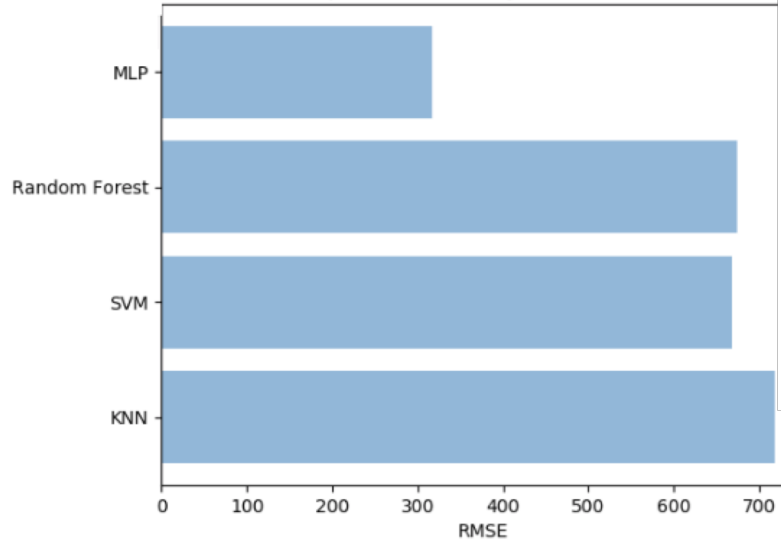
Comparacao accuracy - Careiro - AM



Comparacao accuracy - Manaus - AM

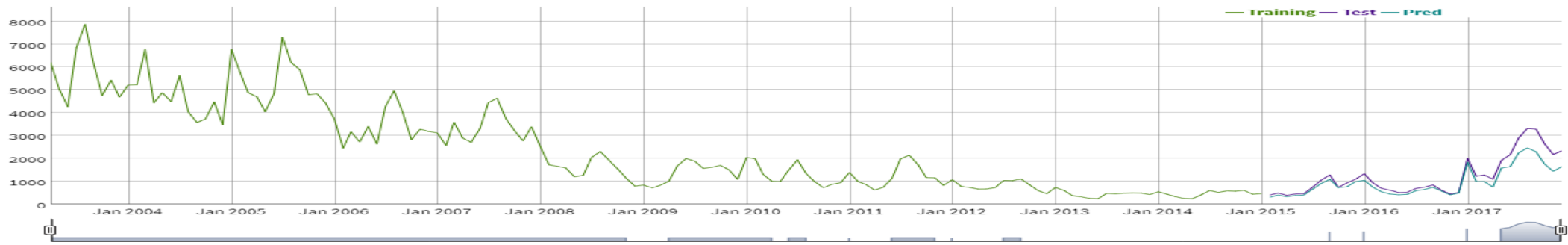


Comparacao accuracy - Barcelos - AM

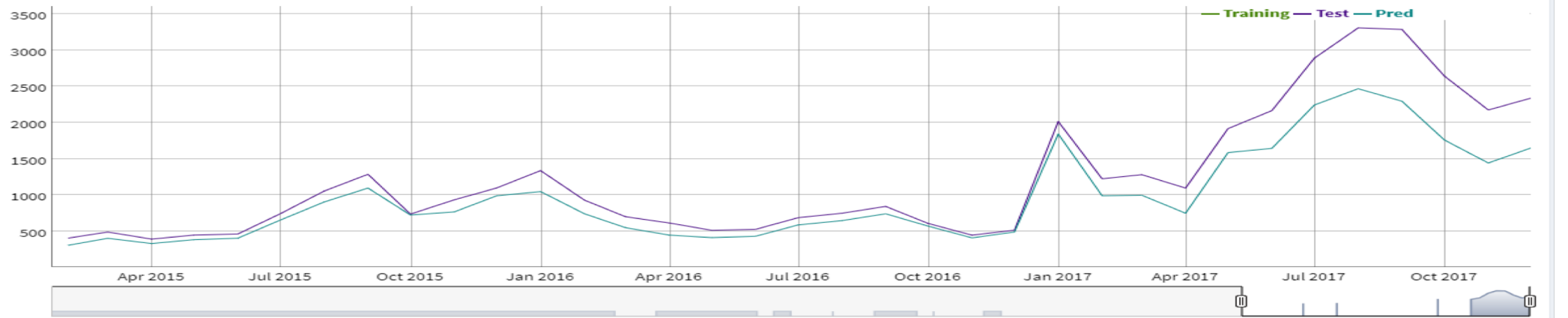


Pilot study - Manaus (AM) -


Manaus - Prediction of Number of Monthly Cases



Manaus - Prediction of Number of Monthly Cases



Existing results



MEDTROP
54º CONGRESSO DA SOCIEDADE BRASILEIRA DE MEDICINA TROPICAL
02 a 05 Setembro 2018 - Centro de Convenções de Pernambuco | Recife PE

INTEGRAÇÃO E MINERAÇÃO VISUAL DE DADOS PARA ESTUDO DA MALÁRIA NO BRASIL

ALBERTO SIRONI¹, JURACY BERTOLDO JUNIOR², MARCOS E. BARRETO¹, VANDERSON SAMPAIO², ANDRÉ SIQUEIRA³
¹ DEPARTAMENTO DE CIÊNCIA DA COMPUTAÇÃO, UNIVERSIDADE FEDERAL DA BAHIA (SALVADOR, BA), ² FUNDAÇÃO DE VIGILÂNCIA EM SAÚDE DO AMAZONAS (MANAUS, AM), ³ INSTITUTO NACIONAL DE INFECTOLOGIA EVANDRO CHAGAS (RIO DE JANEIRO, RJ)

International Journal of Population Data Science (2018) 3:3:453

International Journal of Population Data Science



Journal Website: www.ijpds.org

Linking surveillance and climate data to combat malaria

Sironi, A¹, Barreto, M¹, Bertoldo, J¹, Conceição, D¹, and Sampaio, V²



Título

INTERACTIVE DATA VISUALIZATION OF MALARIA USING R SHINY

Resumo

Data visualization consists in representing data in some systematic form including attributes and variables for the unit of information. A simple and quick information can highlight possible errors with data just as it helps uncover interesting trends. There are traditional and new approaches for visualization methods. Data coming from different sources (SIVEP, IBGE, NOAA, MDS) were considered and are potentially useful for the effective understanding of malaria in the Amazon region. Using data of malaria, we illustrated the process of exploratory analysis and traditional visualization tools that can make the evaluation of high dimensional data available and feasible. Exploratory analysis tools (univariate and bivariate) were used to enhance the data visualization techniques. We believe that data integration and the exploration of visualization tools, such as those available using R Shiny, can assist decision making, provide significant contribution for understanding several processes and make massive amounts of available data in several systems become useful.

Autores

André Alves Ferreira Mendes, Rosemeire Leovigildo Fiaccone, Leila Denise Alves Ferreira Amorim, Marcos Ennes Barreto, Juracy Bertoldo Santos Junior, Alberto Sironi, Marcos Aurelio Eustorgio Filho



Frontiers of Engineering for Development symposium:

Engineers as healthcare practitioners

**Ho Chi Minh City, Vietnam
30 October to 2 November 2018**

Next steps

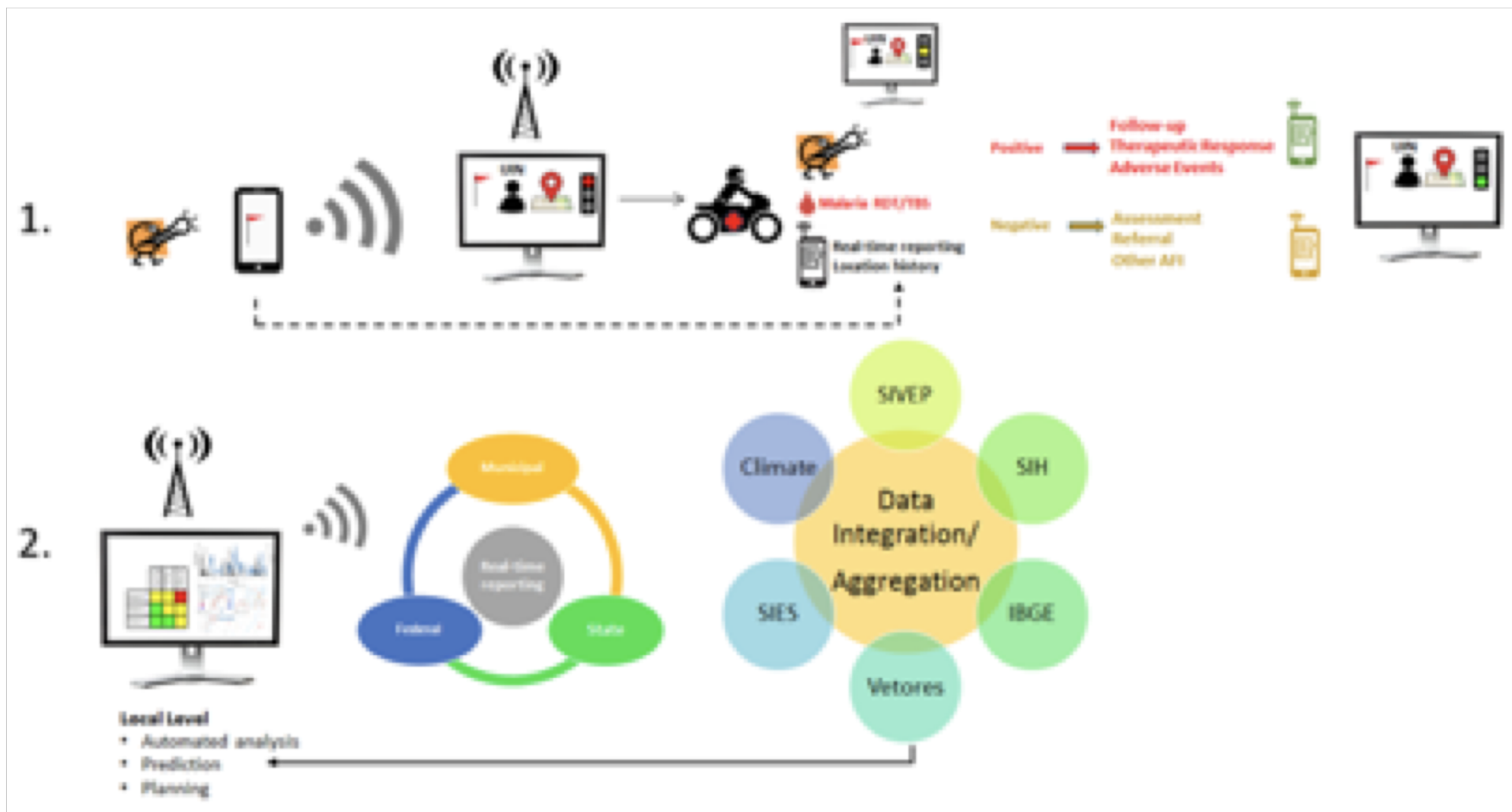
- ✓ Moving to Phase II: 2019-2020
- ✓ Focusing on a set of case studies to generate i) routine tools for malaria surveillance, and ii) evidences for policy making.
- ✓ Case study #1: real-time data collection + alert system (Red Flag)
- ✓ Case study #2: imported x autochthonous cases (Roraima state)
- ✓ Case study #3: evidence-targeted predictive analytics

Thank
You.



BILL & MELINDA
GATES foundation

Case study #1: real time data collection and alert system (Red Flag)





Malaria in Brazil, Colombia, Peru and Venezuela: current challenges in malaria control and elimination

Judith Recht^{1*}, André M. Siqueira², Wuelton M. Monteiro³, Sonia M. Herrera⁴, Sócrates Herrera⁴ and Marcus V. G. Lacerda^{3,5}

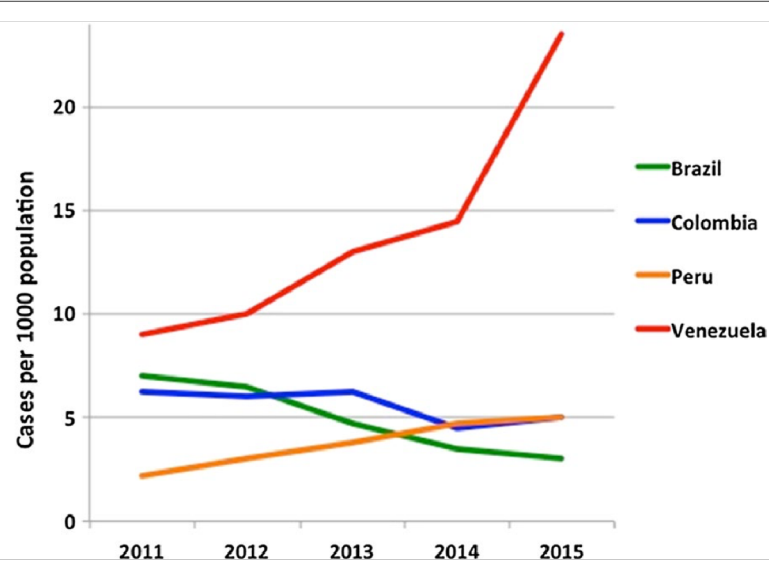


Fig. 2 Confirmed malaria cases 2011–2015. Number of confirmed malaria cases in Brazil, Colombia, Peru and Venezuela are shown per 1000 population Data from [1]

