**World Health Organization**

## Geospatial analysis with field validation to improve the accuracy of the operational population estimates of Bolivia for the benefit of its national immunization program.

### Wednesday, 5th February, 2025 | 14:00 - 15:30 CET

**Register here**

Please join PAHO and the WHO GIS Centre for Health for the first Knowledge Series of 2025, featuring a deep-dive on how geospatial analytics are being used to improve operational population estimates in Bolivia to support their national immunization programme. PAHO collaborated with Bolivia's National Immunization Program to estimate the total population of the country, with stratification by sex and 5-year age group in each catchment area, using multiple layers of open-source data from geospatial and population sources. These estimates were validated through a micro census in five municipalities. PAHO's estimates are used to improve the reach and effectiveness of vaccination operations in Bolivia.

**Adrienne Cox**
Unit Chief, Analysis and Equity Metrics, PAHO

**Ravi Shankar**
Head, HQ GIS Centre for Health DDI/DNA

**Thiago Hernandes Rocha**
Regional Advisor, Data Science, Evidence and Intelligence for Action in Health, PAHO

**Martha Velandia**
Advisor, Comprehensive Immunization (CIM), PAHO

**Silvana Zapata Bedoya**
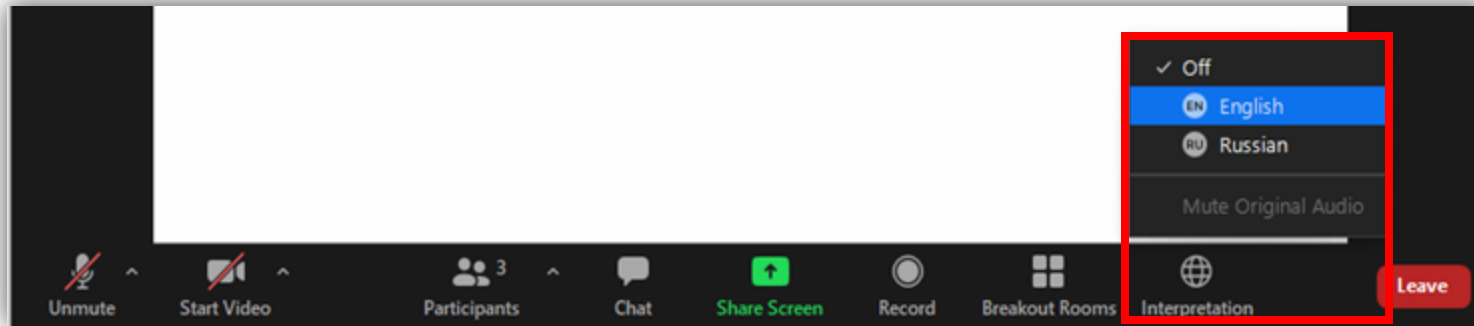International Consultant, Comprehensive Immunization (CIM), PAHO
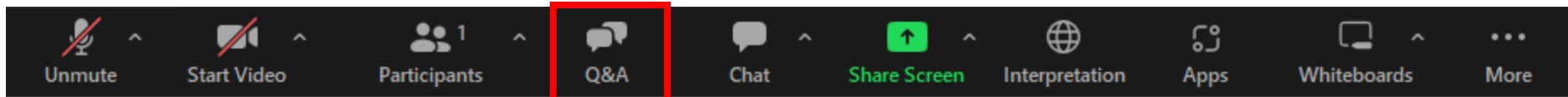
**Dr Carlos Echazu Torres**
National EPI Programme, Ministry of Health, Bolivia

# Zoom housekeeping

**Choosing the Language of audio and presentation**



**Ask your questions in the Q&A**

# Geo-enabled microplans for routine immunization

| Time (CET) | Title | Speaker(s) |
| --- | --- | --- |
| 14:00 | Welcome | Head of HQ GIS Centre for Health, DNA/DDI, Ravi Shankar |
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| 14:50 | Audience interaction and Q&A | Facilitated by GISC |
| 15:30 | Closing | Head of HQ GIS Centre for Health, DNA/DDI, Ravi Shankar |

# Today's speakers:

**Ms. Adrienne Cox**
*Unit Chief, Health Analysis and Equity Metrics, PAHO*

**Dr Martha Velandia**
*Advisor, Comprehensive Immunization (CIM), PAHO*

**Ravi Shankar Santhana Gopala Krishnan**
*Head, GIS Centre for Health*

**Dr Thiago Hernandes Rocha**
*Regional Advisor, Data Science, Evidence & Intelligence for Action in Health, PAHO*

**Ms. Silvana Zapata Bedoya**
*International Consultant, Comprehensive Immunization (CIM), PAHO*

**Dr. Carlos Echazú Torres**
*Epidemiologist, Vaccine-preventable Diseases, Ministry of Health, Bolivia*

**World Health Organization**

# Health Analysis and Equity Metrics, PAHO:

**Ms. Adrienne Cox**
*Unit Chief, Health Analysis and Equity Metrics, PAHO*

**Dr Thiago Hernandes Rocha**
*Regional Advisor, Data Science, Evidence & Intelligence for Action in Health, PAHO*

Adrienne Cox has more than 25 years of experience in global public health, working throughout countries in the Americas, Africa, and Asia in the areas of analysis; monitoring and evaluation; survey design, training, and implementation; laboratory coordination; and program management. She has served within PAHO for the past seven years as the Unit Chief for Health Analysis and Equity Metrics within the Pan American Health Organization (PAHO) Department of Evidence and Intelligence for Action in Health, providing technical support to monitor regional health trends and advise strategic direction and decision making within the Organization.

Thiago Rocha is a data scientist at the Pan-American Health Organization's Evidence and Intelligence for Action in Health Department. With a Ph.D. in policy assessment from the Federal University of Minas Gerais and Duke University, he specializes in enhancing public health through innovative evaluation methods.

Thiago harnesses geospatial analytics and artificial intelligence to drive impactful healthcare solutions. His expertise includes performance assessment, data mining, GIS, and mobile health (mHealth). Proficient in R, Python, and multivariate data analysis, he translates complex data into actionable insights.

# Comprehensive Immunization (CIM), PAHO:

## Dr Martha Velandia
*Advisor, Comprehensive Immunization, PAHO*

Dr Martha Velandia is an epidemiologist with over 20 years of experience in public health, with a strong focus on immunization across various settings. Since 2011, Dr Velandia has been working at the Pan American Health Organization (PAHO/WHO), providing technical and strategic support to strengthen routine national immunization programs across Latin America and the Caribbean. Her responsibilities include enhancing information systems and ensuring the accuracy and quality of immunization data and strategic information within PAHO's Immunization Program. Additionally, she serves as the editor of PAHO's *Immunization Newsletter*, a widely distributed publication that provides updates, technical guidance, and critical insights on immunization programs across the Americas and beyond.

## Silvana Zapata Bedoya
*International Consultant, CIM, PAHO*

Silvana Zapata Bedoya is an international PAHO consultant in data science and geographic intelligence, Special Program on Comprehensive Immunization (CIM). Silvana is a professional passionate about public health, with more than two decades of experience leading strategic projects in epidemiology, data analysis and implementation of surveillance systems in the region and geographic intelligence or modeling. Her work focuses on transforming data into life-saving decisions, integrating geographic intelligence tools, advanced analytics and effective public policies.

## Dr Carlos Echazú
Epidemiologist, Bolivia Ministry of Health
EPI Programme

Dr. Carlos Echazú Torres is an epidemiologist specializing in public health and disease prevention. Since 2023, he has been leading the epidemiological surveillance of vaccine-preventable diseases (VPD) under Bolivia's Extended Programme on Immunization (PAI), Ministry of Health. He previously managed vaccine safety monitoring as part of the COVID-19 response at the Madre Obrera Hospital in Potosí from 2021 to 2023. Dr. Echazú is a physician trained at the Universidad Mayor de San Andrés with postgraduate qualifications in medical emergencies, immunization program management, epidemiology, and HIV care. He is also currently pursuing a master's degree in epidemiology to further enhance his expertise in the field.

# What is the WHO GIS Centre?

**Advocacy**
- Bilateral meetings
- Key UN meetings
- Mission
- Conferences
- Events
- Presence

**Service**
- Technical Assistance
- Maps
- Projects
- Request
- Conceptualization
- Definition
- Planning
- Execution

**Capacity Development &**
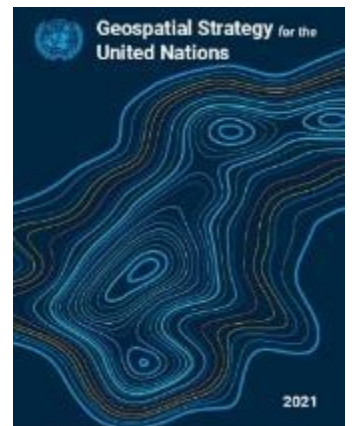- Workshops
- Training – online, face-to-face
- Webinars
- Events
- Office hours
- Mentoring
- Missions

*With a **vision** to connect maps, apps, data, and people, the WHO GIS Centre for Health is dedicated to helping countries make informed public health decisions faster.*

GIS Centre for Health Strategy
Version 1.0
World Health Organization

Geospatial Strategy for the United Nations
2021

# Meet the WHO GIS Centre for Health team



**Ana** — GIS specialist, project facilitator

**Anare** — GIS specialist

**Annette** — GIS specialist

**Antoni** — Information management officer

**Asela** — GIS specialist and data expert

**Bodour** — Project facilitator

**Brian** — Geospatial expert

**Cam** — GIS specialist

**Catherine** — Project facilitator

**Daniel** — GIS server expert

**Denise** — Monitoring and evaluation

**Francis** — GIS specialist

**Gédéon** — GIS specialist

**Heritier** — Information management officer & GIS specialist

**Ian** — GIS specialist

**Inge** — Training and capacity development specialist

**Iqbal** — Information management officer & GIS specialist

**Jaouad** — GIS specialist, project facilitator

**Jerome** — Information management officer

**Jing** — Product evangelist

**Jo** — GIS specialist

**Jon** — Partnerships

**Juan** — GIS specialist

**Julia** — Geospatial data assistant

**Kerry** — Geospatial health specialist

**Kshitij** — Web and IT specialist

**Luis** — Information management officer

**Kt** — Cartographer

**Michele** — Information management officer & GIS specialist

**Mona** — Project facilitator

**Mwenya** — Secretariat support

**Nadika** — Geospatial health analyst

**Nomsa** — Business analyst

**Oluwaseun** — GIS specialist

**Onur** — Health data analyst

**Prashant** — GIS specialist, project facilitator

**Ravi Shankar** — GIS team lead

**Reut** — GIS specialist

**Ronald** — GIS specialist

**Ryan** — GIS specialist

**Samuel A** — GIS specialist, project facilitator

**Samuel O** — GIS Specialist, project facilitator

**Sanjay** — GIS specialist, project facilitator

**Tamer** — GIS specialist, project facilitator

**Yamiko** — GIS specialist

**Ye Lin** — GIS specialist

**World Health Organization**

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# Geospatial analysis with field validation to improve the accuracy of the operational population estimates of Bolivia for the benefit of its national immunization program

TETANUS

COVID-19

MEASLES

POLIO

H

INFLUENZA

GET UP-TO-DATE

#EACHVACCINECOUNTS

DIPHT

# Objectives and goals

## Objectives

- Estimate the size of the population who lives in the catchment area around each vaccination site located within the national territory of Bolivia.

- Validate the accuracy of population estimates generated by PAHO by comparing them with the results of a house-to-house micro census that was conducted within 5 municipalities selected by the Ministry of Health.

## Goal

- Provide an accurate estimate of the population size of Bolivia, with stratification by sex and age group, to improve the reach and performance of the national immunization program.

# Necessary data

## Available online

- Satellite images of the entire national territory
  - META, WorldPop, GRID³, Global Human Settlement Layer (GHSL)
- Demographic data of the population, all ages.
  - National census
- Road network
  - OpenStreetMap

## Contributed by the Ministry of Health

-  Geographic coordinates of each vaccination site.
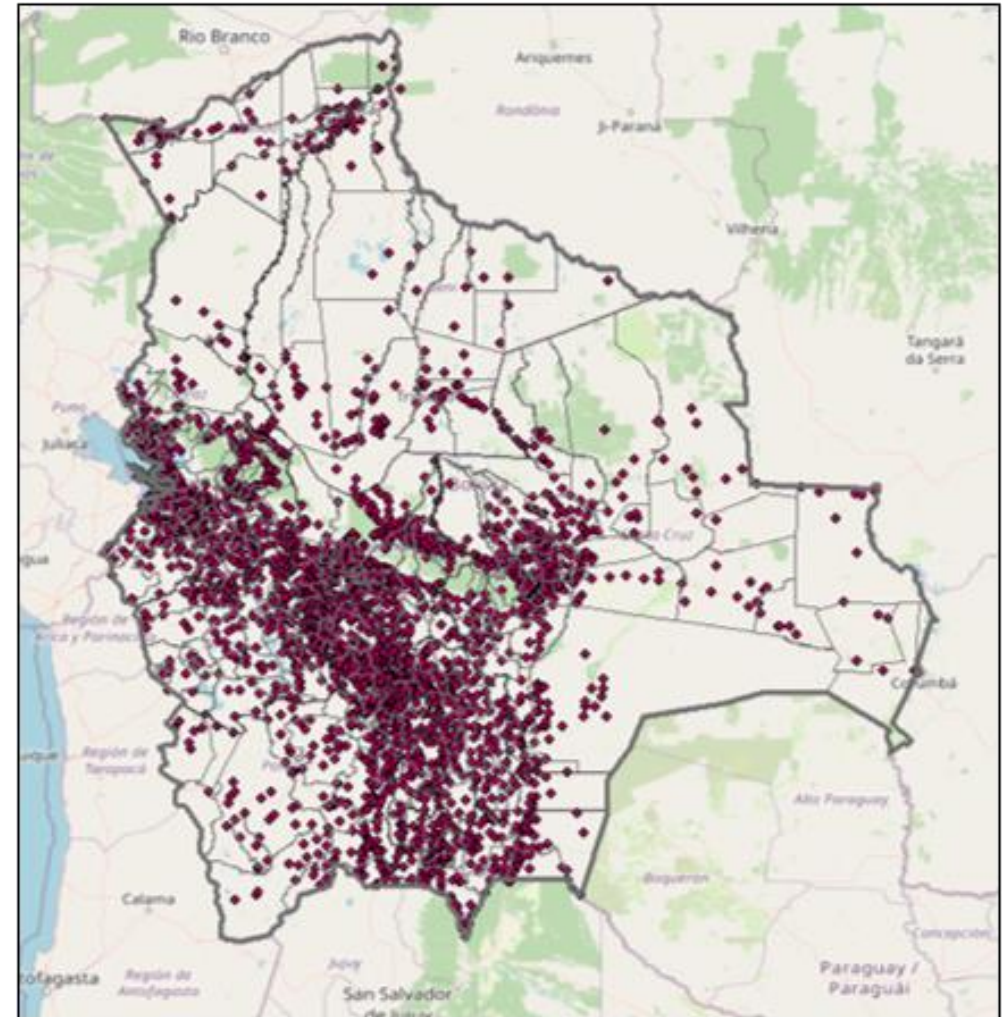
# Methodology

1. Review and validate the list of vaccination sites.

2. Identify population distribution and densityusing satellite images.

3. Map all the roadways in the country (primary, secondary and tertiary roads).

4. Map all buildings.

5. Determine the closest distance between each building and the vaccination site, using the mapped roadways.
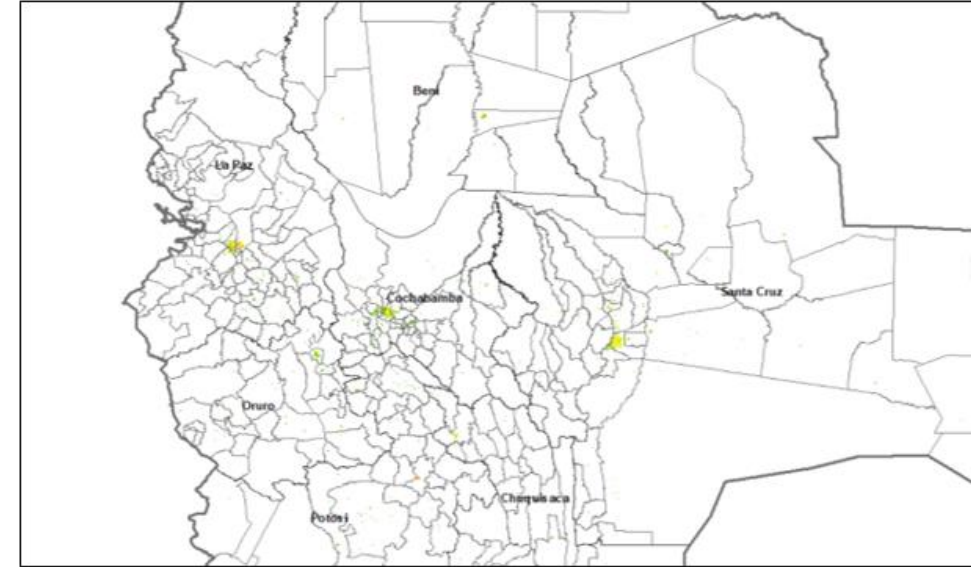
Road network
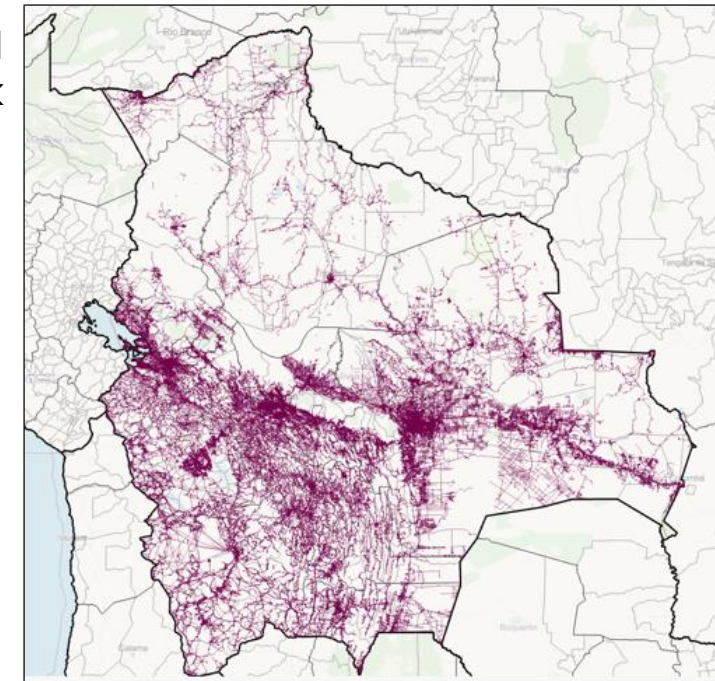
# Methodology

6. Define the catchment area around each vaccination site (≤5km) and estimate the size of the population residing in this area.

7. Prioritise catchment areas and their municipalities according to the vaccination coverage rate for children younger than 5 years.

8. Submit the list of 38 prioritized municipalities to the Ministry of Health, so 5 municipalities can be selected to implement the micro census.

Catchment areas
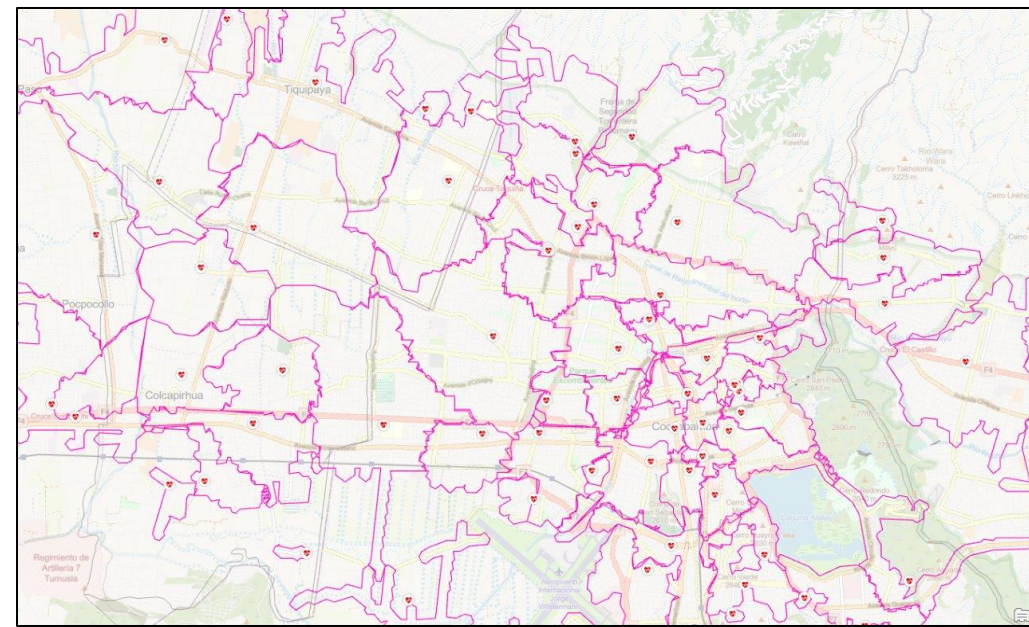


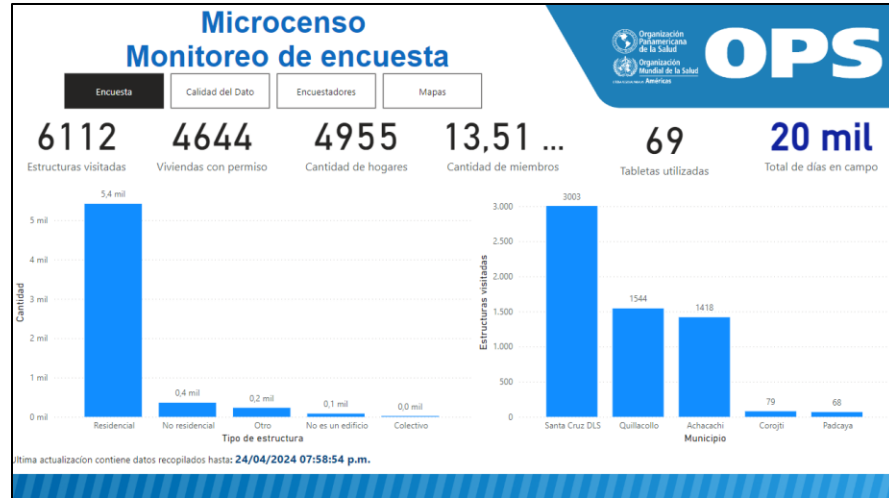38 priority municipalities that reported MCV2 and DPT1 coverage <90% in 2021.
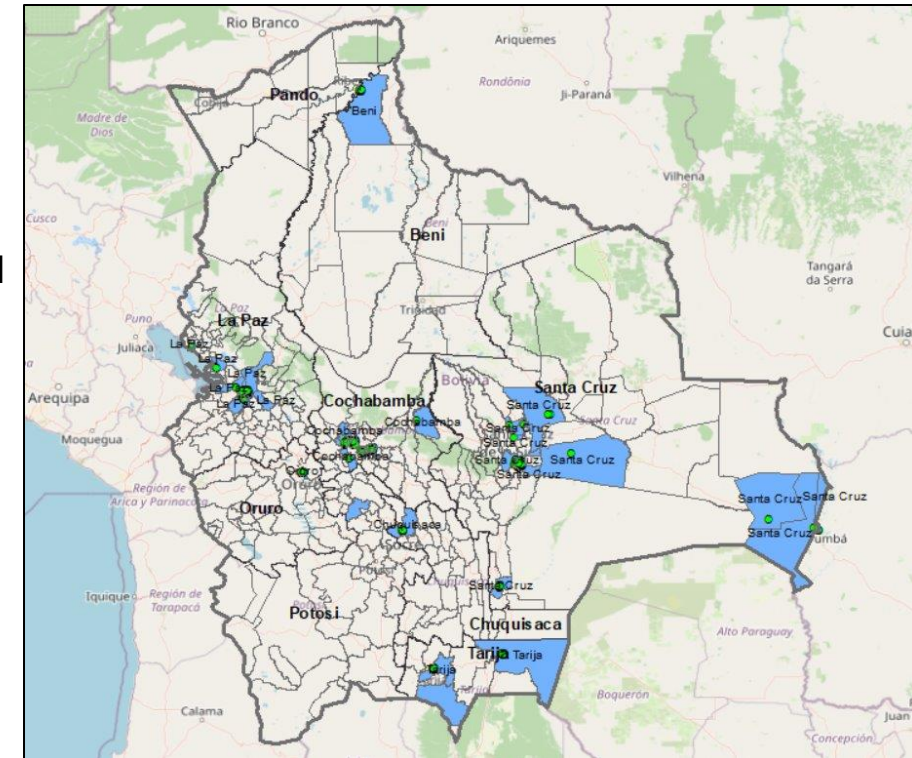
# Selected municipalities

| Administrative level 1 | Administrative level 2 | Estimated number of buildings to be visited | Estimated population totals | Estimated number of blocks to be visited | Number of field teams / days of data collection |
|---|---|---|---|---|---|
| Cochabamba | Quillacollo | 787 | 1227 | 16 | 9 teams de 3 persons / ~ 6 days in the field |
| Potosi | Pocoata_1 | 400 | 8 | 8 | 3 teams de 3 persons / ~ 3 days in the field |
| Potosi | Pocoata_2 | 518 | 75 | 10 | 5 teams de 3 persons / ~ 6 days in the field |
| Tarija | Padcaya | 50 | 25 | 1 | 2 teams de 3 persons / ~ 3 days in the field |
| Santa Cruz | Santa Cruz de La Sierra | 2000 | 2662 | 40 | 17 teams de 3 persons / ~ 7 days in the field |
| La Paz | Achacachi | 950 | 330 | 19 | 6 teams de 3 persons / ~ 6 days in the field |

The figures presented here in relation to the buildings and the estimated population may be adjusted during the micro census data validation process.

Proyecto piloto para mejorar las estimaciones demográficas en Bolivia, para apoyar el programa ampliado de inmunización (PAI) y otros programas de salud en el país a través de micro censo

Achacachi zonas delimitadas
Coordenadas de arranque:

-16.045 y -68.686
y
-16.051 y -68.686

ACHACACHI

La Paz    Achacachi

OPS

BOLIVIA

Achacachi

ZonasPriorizadas5_FINAL_BOL_CAMPO
Edificios5Muni_FinalCampo
DelimitacionManzana5Muni_Campo
Educativos5Muni_Campo
SitiosInteres5Muni_Campo

Cercanía puntos de vacunación
NEAR_DIST
Area Trabaj

0 0.015 0.03   0.06   0.09   0.12
Miles

---

Proyecto piloto para mejorar las estimaciones demográficas en Bolivia, para apoyar el programa ampliado de inmunización (PAI) y otros programas de salud en el país a través de micro censo

Area de trabajo 1 y única:
Coordenadas:
Entre: -18.728, -66.110 y -18.730, -66.110
Total sectores o manzanas 9

Area_Corojti_0001

Area_Corojti_0002

Potosi          Pocoata

Area_Corojti_0004

Area_Corojti_0003          Area_Corojti_0005

Area_Corojti_0006

COROJTI

Area_Corojti_0009   Area_Corojti_0008   Area_Corojti_0007

OPS

BOLIVIA

Pocoata

ZonasPriorizadas5_FINAL_BOL_CAMPO
Edificios5Muni_FinalCampo
DelimitacionManzana5Muni_Campo
Educativos5Muni_Campo
SitiosInteres5Muni_Campo

Cercanía puntos de vacunación
NEAR_DIST

0 0.005 0.01   0.02   0.03   0.04
Miles

POLIO
TETANUS
GET UP-TO-DATE
#EACHVACCINECOUNTS
INFLUENZA
RUBELLA

# Dashboard for data quality monitoring

# Satellite image processing



Total → 136

📁 1-Data_SIG_WORDPOP_2020_100Mts

📁 2-Data_SIG_GPW_V4_2020_1k

📁 3-Data_SIG_GRUMP_2000-2010_1K

📁 4-Data_SIG_GHSL_2025_100Mts

📁 5-Data_SIG_META_2020_HRSL

📁 6-Data_LandScan_POP_2022

📁 7-Data_SIG_Kontur_H3_400M

**Total**
**Sex**
**Age**
**Total**

**Total**

**Total**

**Total**
**Sex**
**Age**

**Total**

**Total**

# Descriptive results

| Departamento | Municipio | Localidad Seleccionada | Total de edificios visitados | Total edificios residenciales, colectivos u otros identificados | Total de edificios efectivos para encuestar | Total de edificios efectivos que aceptaron la encuesta | Tasa de respuesta en encuesta (residenciales ocupada) | Total Hogares | Promedio de personas por hogar |
|---|---|---|---|---|---|---|---|---|---|
| La Paz | Achacachi | Achacachi | 1415 | 1337 | 747 | 385 | 51,5 | 402 | 3 |
| Potosi | Pocoata | Corojti | 76 | 59 | 31 | 30 | 96,8 | 30 | 3 |
| Tarija | Podcaya | Padcaya-Localida | 68 | 45 | 37 | 33 | 89,2 | 49 | 2 |
| Cochabamba | Quillacollo | Quillacollo | 1543 | 1458 | 1295 | 1013 | 78,2 | 1407 | 4 |
| Santa Cruz | Santa Cruz de la Sierra | Redes este y Cen | 2975 | 2742 | 2395 | 1626 | 67,9 | 3025 | 3 |
| **Total general** | | | **6077** | **5641** | **4505** | **3087** | **68,52** | **4913** | **3** |

Of the 6,077 buildings identified in satellite images, 5,641 are residential.

Of these, 4,505 are currently occupied. Of those, 3,087 (68.52%) accepted to take the survey.

| Departamento | Municipio | Tipo de estructura Colectivo | | Tipo de estructura No es edificio | | Tipo de estructura No residencial | | Tipo de estructura Otra | | Tipo de estructura Residencia | | Total general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % | N | % | N |
| Cochabamba | Quillacollo | 6 | 30 | 13 | 16,7 | 72 | 20,1 | 40 | 17,4 | 1412 | 26,2 | 1543 |
| La Paz | Achacachi | 2 | 10 | 38 | 48,7 | 40 | 11,2 | 73 | 31,7 | 1262 | 23,4 | 1415 |
| Potosí | Pocoata | 0 | 0 | 17 | 21,8 | 0 | 0,0 | 4 | 1,7 | 55 | 1,0 | 76 |
| Santa Cruz | Santa Cruz de la Sierra | 11 | 55 | 10 | 12,8 | 223 | 62,3 | 109 | 47,4 | 2622 | 48,6 | 2975 |
| Tarija | Podcaya | 1 | 5 | 0 | 0,0 | 23 | 6,4 | 4 | 1,7 | 40 | 0,7 | 68 |
| **Total general** | | **20** | **0,33** | **78** | **1,28** | **358** | **5,89** | **230** | **3,78** | **5391** | **88,71** | **6077** |

# Overall results



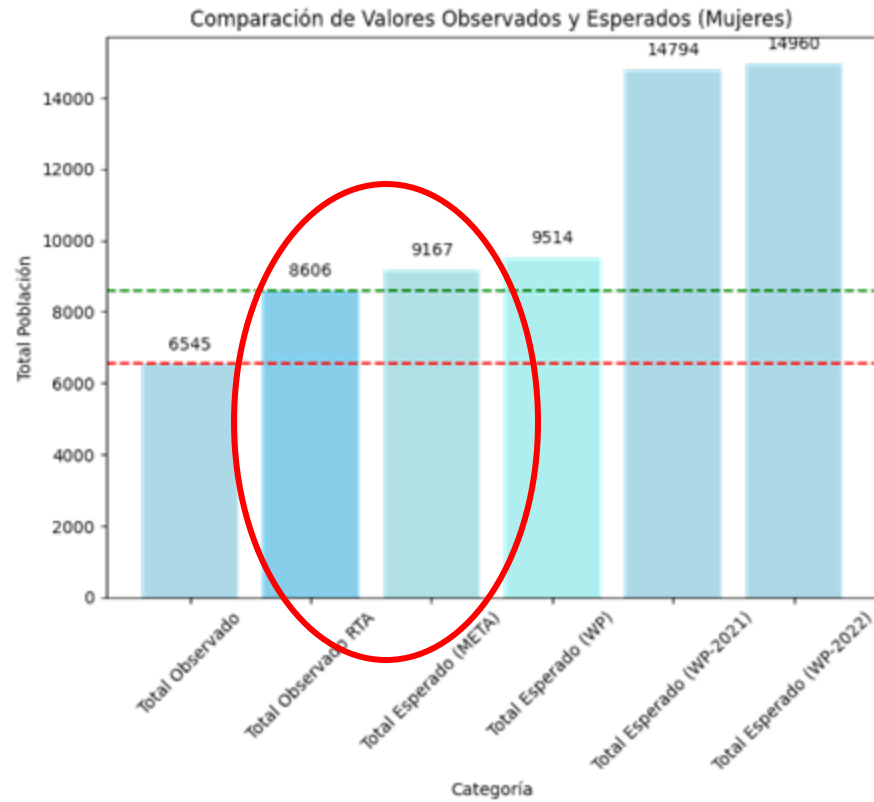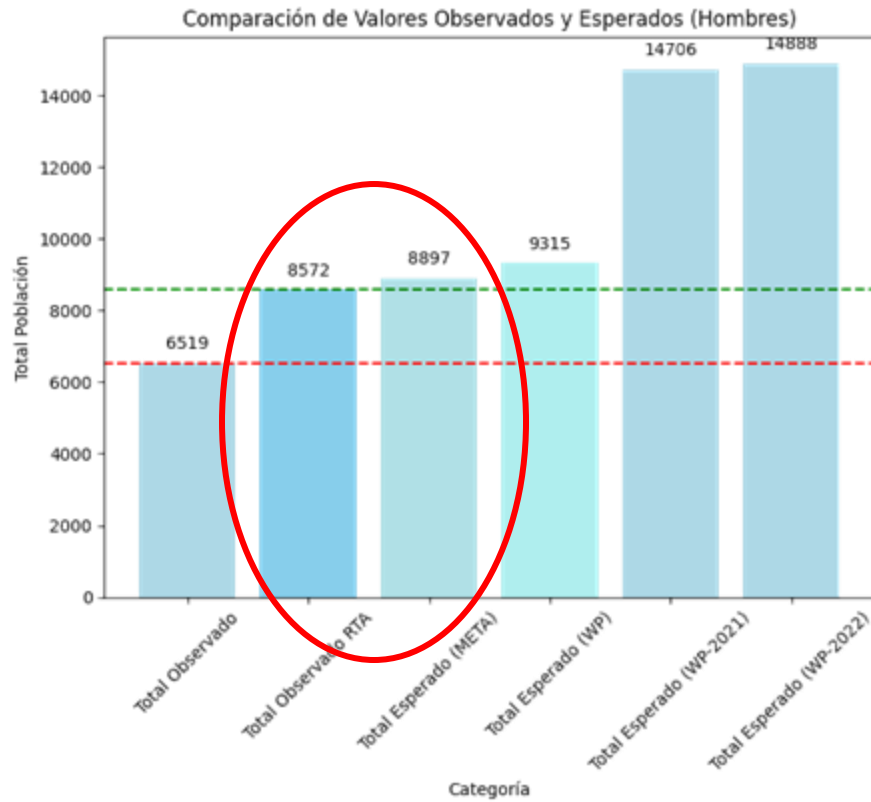Comparación de Valores Observados y Esperados para datos en en campo VS Imágenes de Satélite
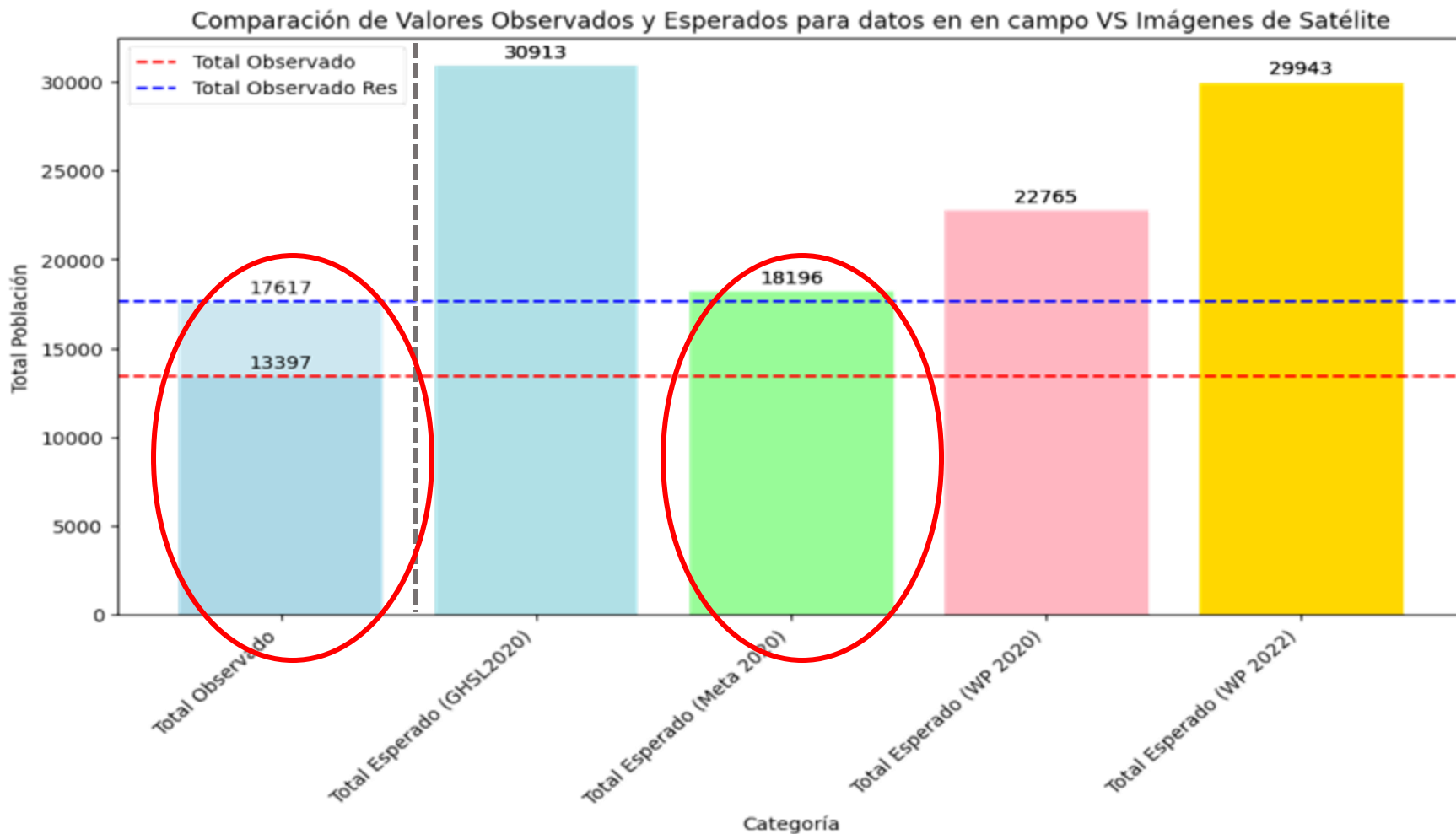
17,617 persons were expected and 13,397 were enumerated.

The expected number of people matches almost exactly the META estimate (green column), and matches quite closely the WorldPop estimate (pink column) .

# Results by sex



Comparación de Valores Observados y Esperados (Hombres)

Comparación de Valores Observados y Esperados (Mujeres)

For both men and women, the META estimate matches very well to the enumeration in the field.

The WorldPop estimate can be used with confidence as well.

# Results by urban/rural area



Urban area

Rural area

--- Total Observado   --- Total Observado Res

Comparación de Valores Observados y Esperados (Achacachi)
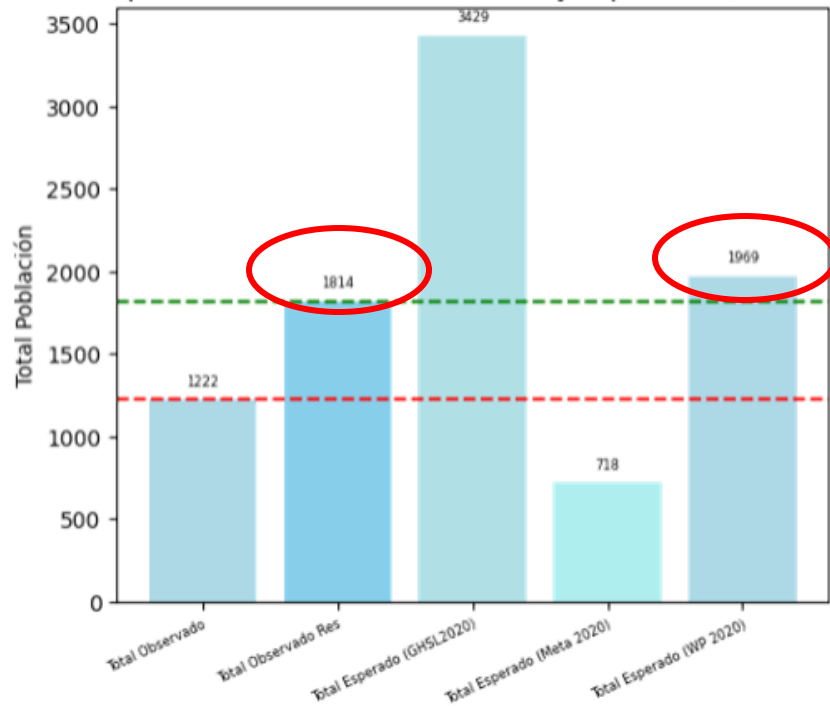
Comparación de Valores Observados y Esperados (Pocoata)
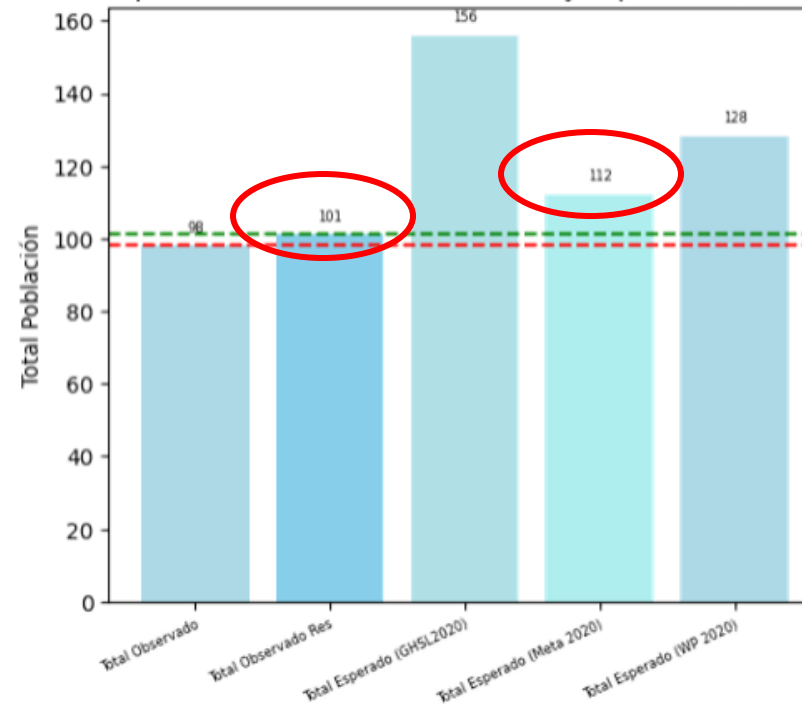
In rural areas, the META estimate agrees well with the field enumeration.

In urban areas, the WorldPop estimate agrees well with the field enumeration.

# Results by sex and age group



Pirámide Poblacional Observada Rta y Esperada WP-2020
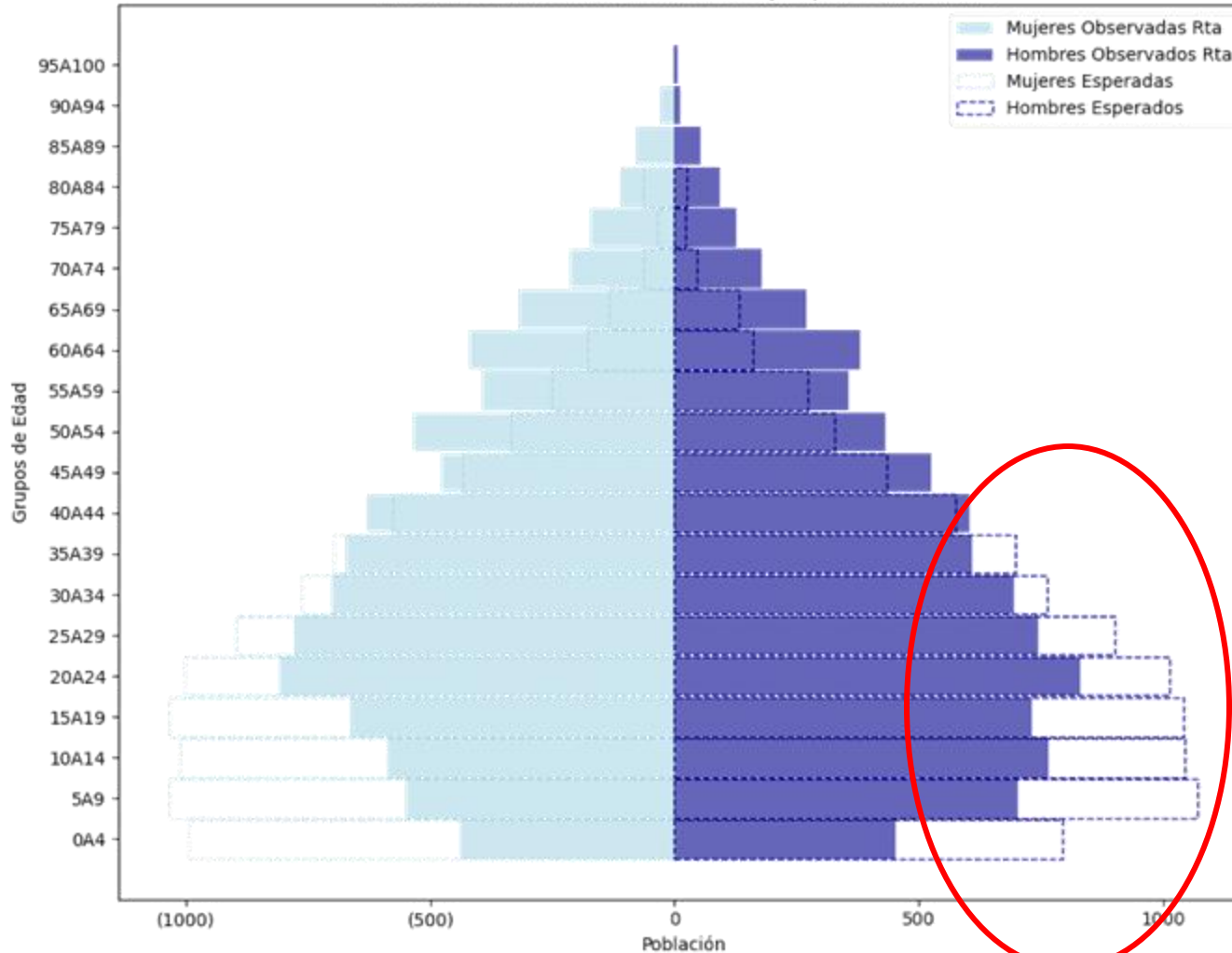
The field enumeration reports fewer young people (<30 years) than expected, and more elderly people (>60 years) than expected.

For the immunization program, this discrepancy between expected and enumerated children younger than 5 years is especially relevant.

The same trend is evident for males and females.

Estimated values by

world pop

# Conclusions

Satellite images from META and WorldPop 2020 were very **similar** to the enumeration results from the field.

META images have an excellent correspondence when analyzing by **sex** .

META is a better match for the enumeration in **rural areas**, while WordPOP is a better match in **urban areas**.

There are **fewer children younger than 5 years than estimated**, but very good matches for the other age groups.

Applying these results to the entire territory of Bolivia, we can **adjust** the population estimates according to the distribution by age, sex and geographic area.

# Application

## Question

I am the EPI manager and I want to use these results to find children **younger than 5 years** in **Murillo,** Bolivia. In this municipality, the vacination coverage rate for DTP3 is lower than 80% (target = 95%).

# Application



- **What**: QGIS training using the new geospatial layers of information provided by PAHO.

- **Who**: EPI officers and Information Systems officers (national-level and from the 9 departments)

- **When**: 14-18 October 2024

- **Where**: La Paz, Bolivia

- **Data sharing**
  - All geospatial layers used for the project have been transferred to the Ministry of Health of Bolivia.

- **Learning objectives**:
  - How to identify the appropriate type of satellite image based on specific needs.
  - How to use data points related to infrastructure, buildings, roads and environmental characteristics, so to identify barriers to accessing vaccination services.
  - How to use the QGIS application.
  - How to use the GeoDA application.
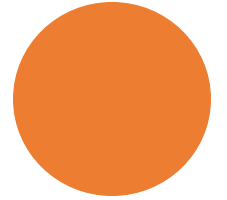
# Application
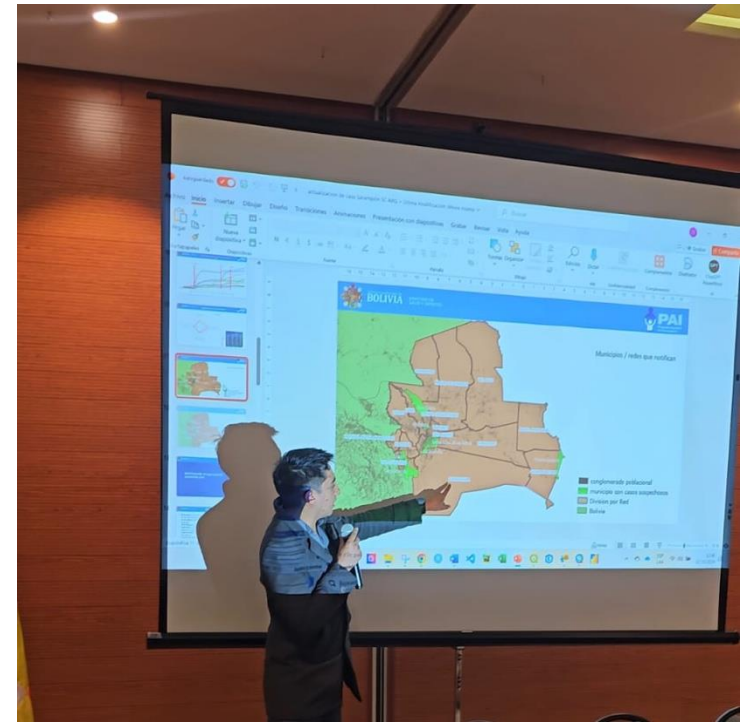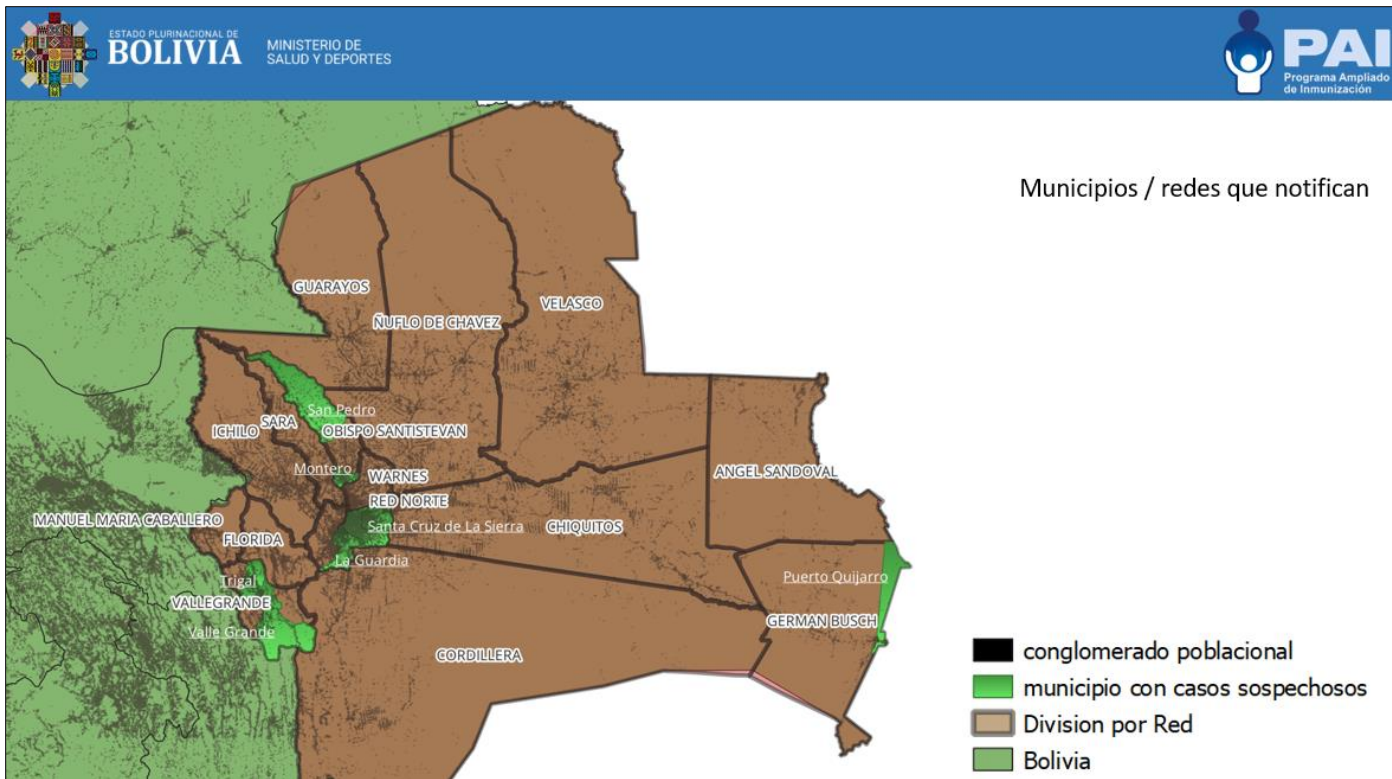




During the workshop, participants were able to use the geospatial layers and analysis software to plan response operations to an ongoing measles outbreak in the country, and reorient resources more efficiently to address the immunity gaps.

# Thank you!

Claudia Jhovana Carrizales, MoH BOL
Marcela Contreras, PAHO WDC
Margherita Ghiselli, PAHO WDC
Carlos Echazu Torres, MoH BOL
Thiago Hernándes, PAHO WDC
Leslie LaTorre, PAHO BOL
Yenny Neira, PAHO BOL
Javier Rodrigo Ojeda Ocampo, MoH BOL
Claudia Ortiz, PAHO WDC
Martha Velandia, PAHO WDC
Mariela Grisel Villalta Coro, MoH BOL
Silvana Zapata, PAHO WDC
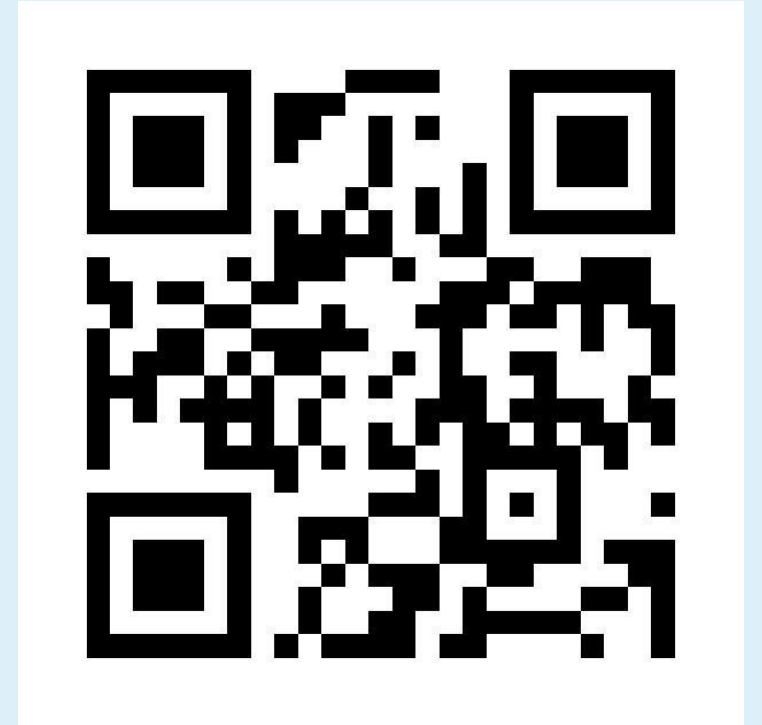Saul Santa Maria – Field Operator
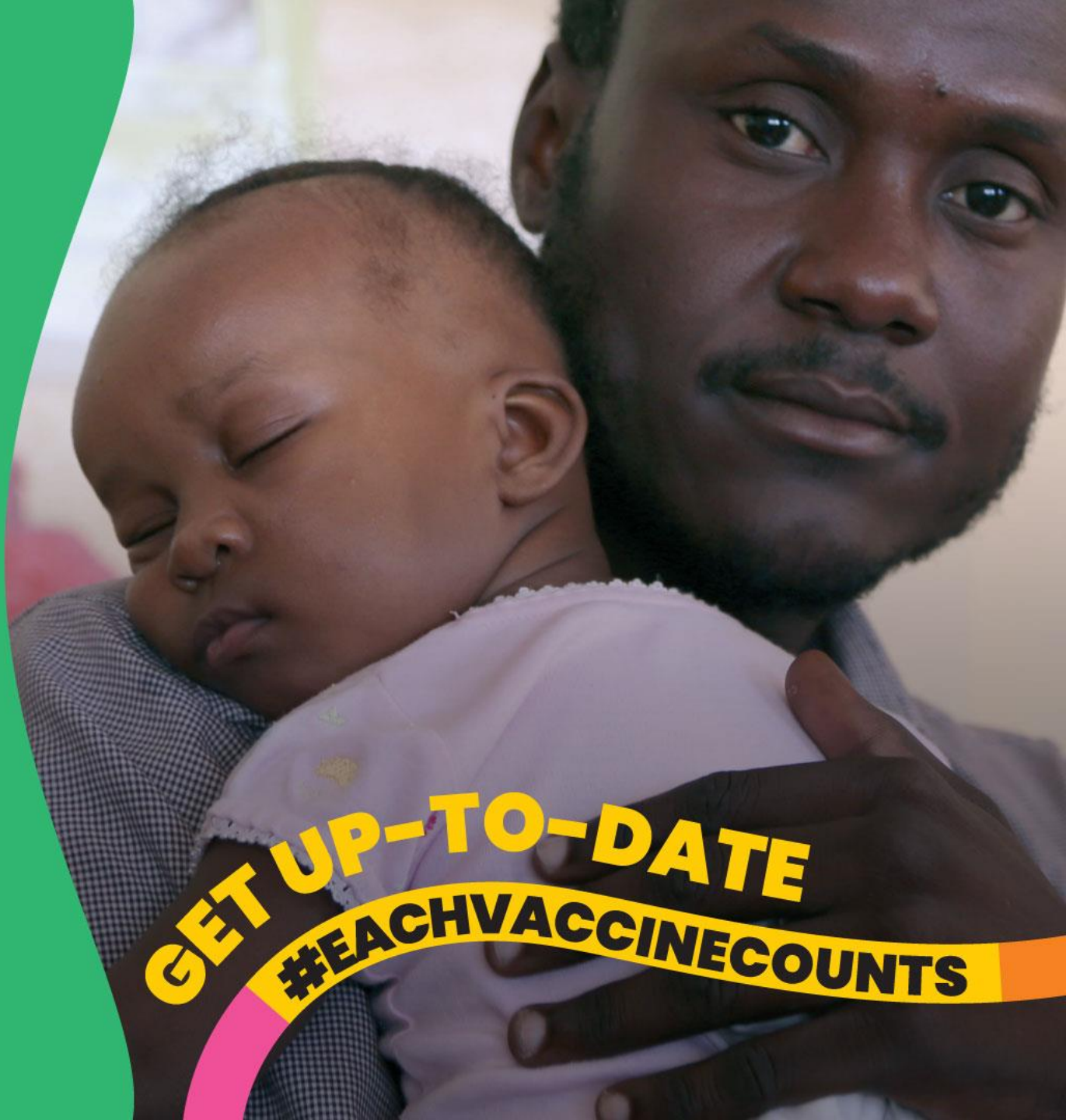
# Thank you for your participation!

# Please share your feedback:



https://arcg.is/raD4D0

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