Using mapping and mobile data to tackle the next outbreak

Prof. Andy Tatem
Controlling, eliminating malaria

- What volume of chemicals do we need?
- How many in the spray team for how long?
- How to measure coverage and make sure we’ve covered everywhere?

Maps of all settlements and residential buildings
Eliminating polio

- How much vaccine do we need?
- How many vaccinators?
- What routes should they take?
- How can we be sure to reach required coverages?

Detailed maps of where the under 5 year old children are
Responding to outbreaks

- How significant an outbreak is this?
- Where might it have originated?
- Where might it spread next?
- How best to control it?

Maps, data on denominators, population travel patterns
Settlement and population maps

Maps of population characteristics

Maps of population dynamics
1984
Immunization coverage

>95%
Cell Phone Ownership Surges in Africa

Adults who own a cell phone

Note: U.S. data from Pew Research Center surveys.
Source: Spring 2014 Global Attitudes survey. Q68.

PEW RESEARCH CENTER
Data sandwich

Thinking in ‘grids’

Grids: consistent and comparable format and a framework for integrating differing data types.

100 x 100m gridded estimates of population density.

Administrative unit population totals.

Comprehensive Emergency Obstetric and Neonatal Care (CEmONC) Facilities overlaid on grid of women of childbearing age.

Percentage of women of childbearing age per woreda within 50km of a CEmONC.

Grids: flexibility in summarization to any administrative unit level.

Grids: flexibility in analysis and data integration.

Population totals.
How can we use this monster gridded data sandwich?
Settlement and population maps

Maps of population characteristics

Maps of population dynamics
Population Density Vietnam Administrative Unit Level 002

Red = Urban Built
Orange = Non-Urban Built

> 30 People Per Ha

0
Global Human Settlement Layer 2014 for Vietnam
NOAA Suomi VIIRS-derived Lights at Night 2012 for Vietnam
Population Density Vietnam Administrative Unit Level 002

- Red = Urban Built
- Orange = Non-Urban Built

> 30 People Per Ha
China Population, 2010

Number of people per pixel

High: 20
Low: 0

Beijing

Shanghai

Guangzhou

www.worldpop.org
+ missing populations
+ inaccuracies
+ incomplete
+ inter-censal changes
A Top down approach

Census population counts

Geospatial covariates

Population disaggregation

Spatial weighting layer created based on covariates, using dasymetric mapping

Gridded population

Wardrop et al (2018) PNAS
District Aggregation

Predicted Population Count vs. Observed Population Count
Nigeria population estimation

150 Microcensus “Training” Clusters and Validation Sets in Kano State

Weber et al (2018) Rem Sens Env
Population estimates per 90x90m grid square
OK. But how do we get to those population characteristics?
Settlement and population maps
Maps of population characteristics
Maps of population dynamics
Poverty mapping

• Poverty is highly heterogeneous, strong association with disease risk

• Poverty maps used to monitor development progress, allocate resources, design strategies

• Standard approach, small area estimation is reliant on census data

• Last census in Bangladesh = 2011
Wealth index

R² = 0.77

Vaccination coverage

• Clustering of low vaccination areas may allow for pockets of susceptibility that sustain circulation despite high overall coverage

• Subnational data collected, but often at coarse scales

• Linked with outdated census data leads to common phenomena of >100% coverage rates

• Can we use the same approach as poverty mapping?
Data integration

Mapping health and development indicators

- Probability of receiving postnatal care within 48 hours of delivery per district
- Percentage of population with access to sanitation per 1x1km grid cell
- Percentage of women who are literate per 1x1km grid cell

Bosco et al (J Roy Soc Int); Ruktanonchai et al (Plos ONE)
HOLD UP

WAIT A MINUTE

People move!
Settlement and population maps

Maps of population characteristics

Maps of population dynamics
Change of flow during Chinese New Year
<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>CHETTO</td>
<td>2014</td>
</tr>
<tr>
<td>TOTAL POPULATION</td>
<td>1928</td>
</tr>
<tr>
<td>UNDER ONES</td>
<td>58</td>
</tr>
<tr>
<td>UNDER FIVES</td>
<td>289</td>
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<tr>
<td>WOCBA</td>
<td>463</td>
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</tbody>
</table>
100 cases of malaria - out of a population of 100,000
Dynamic facility catchment populations

Changes in incidence through accounting for catchment dynamics

December: Percentage change in incidence

Erbach-Schoenberg et al (2016) Pop Health Metrics
Mapping transmission foci

Cases: 27  Prevalence: 5.4%

Cases: 2  Prevalence: 0.2%

Cases: 5  Prevalence: 0.6%
Mapping transmission foci

Cases: 27
Prevalence: 5.4%
Measles epidemics in Niger

Measles outbreaks occur only during the dry season

The region is highly agriculturally dependent.

**Hypothesis**: Population density fluctuates seasonally and drives measles dynamics. People live in low density agricultural areas during the rainy season and high density urban areas during the dry season, sparking outbreaks.

Can we evaluate this hypothesis?

*Bharti, Tatem, Ferrari et al (2011) Science*
Bharti, Tatem, Ferrari et al (2011) Science
Mobility data driving models

Kathmandu daily exodus may reach 300,000 as residents flee chaos

More than 100,000 have already left the badly damaged capital of Nepal, heading for distant regions to escape the threat of aftershocks, landslides and disease.
The value of near-real time data

Aren’t these just crazy academic ideas that will never find real world use?
UNOSAT
Tropical Cyclone IRMA-17. Population exposure analysis in Caribbean 4 September 2017
Births at Risk of No SBA (per 1,000 live births)

High: 713.528
Low: 422.408

Open Health Initiative

using satellite and cell phone data to eliminate malaria in Namibia

Researchers use satellite and cell phone data to map how malaria spreads throughout Namibia and show where elimination efforts have the greatest impact.

Impact: identified and provided bednets to the 80,000 people most important to the malaria transmission cycle in 2013.

Tatem et al (2014) Malaria Jnl
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Pop density change: Nov-Dec 2014

Pop flows
Summary

• For disease outbreak response, control and elimination, reliable recent small-area data on population distributions, demographics and dynamics can be valuable.
• In many resource poor settings, such data are outdated, coarse resolution, inaccurate and sometimes lacking completely.
• Data from GPS-located surveys, satellites and cellphones can help fill some of these gaps.
• However, each is far from perfect....!
Summary

• Importance of validation, integration and measuring uncertainty.
• Such ‘new’ datasets should only be seen as a compliment to vital data from more traditional sources – census, surveys, surveillance, registries.
• Local ownership and engagement with users is key for sustainable uptake and use.
Further information

worldpop
FLOWMINDER.ORG

www.worldpop.org
@WorldPopProject

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INAUGURAL WORLDPOP SCHOOL ON SPATIAL DEMOGRAPHY
4-7 December 2018
https://wp-winterschool.org
How much vaccine do we need?
How many vaccinators?
Can we rely on health facility distribution?
Where to send vaccinators to ensure reaching all children?
How to reach mobile populations?
What time of year to vaccinate?

We need:
- Maps of where all the settlements are
- Maps of how many children are in each settlement
- Maps of vaccination coverage
- Maps of health facility locations, catchments and treatment seeking rates
- Maps of where mobile populations are and when

Disease control/elimination
Responding to an outbreak

Where did these cases likely come from?
How big a problem is this outbreak?
Development goals are increasingly focused on achievement ‘everywhere’: **Geography is important!**

‘Traditional’ datasources (e.g. census, surveys) remain vital to measuring, monitoring and mapping these goals.....

....but they can be outdated, incomplete and unreliable in many low income settings.

‘New’ datasources (e.g. satellites, GPS, phones) can help compliment traditional sources – but they are not perfect: **important to measure uncertainty.**

Local ownership and engagement with users is key for sustainable uptake and use.