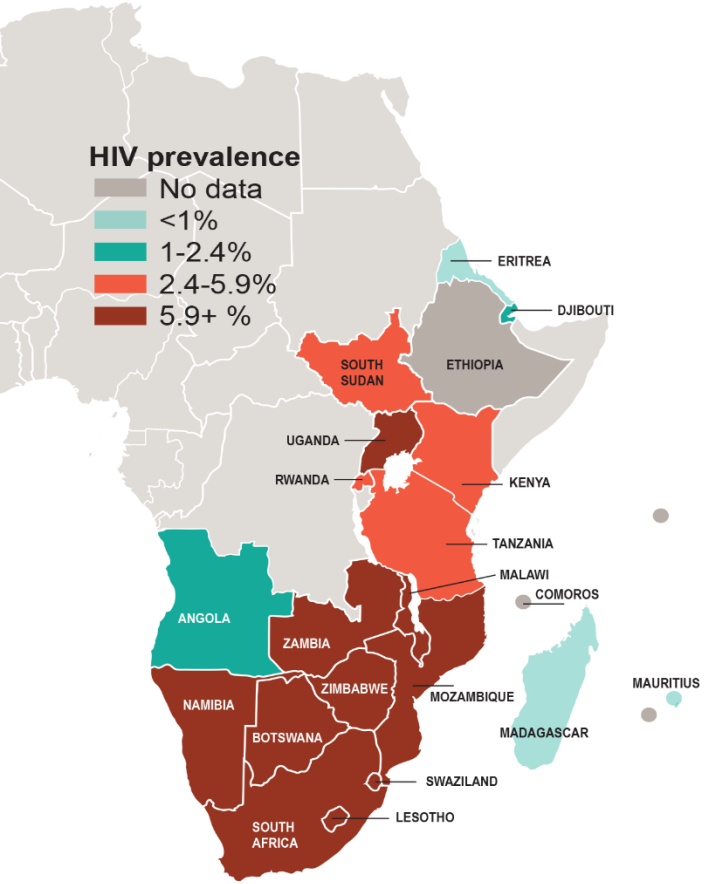
# A pragmatic approach to HIV hotspot mapping in a developing country

Thursday, July 13, 2017

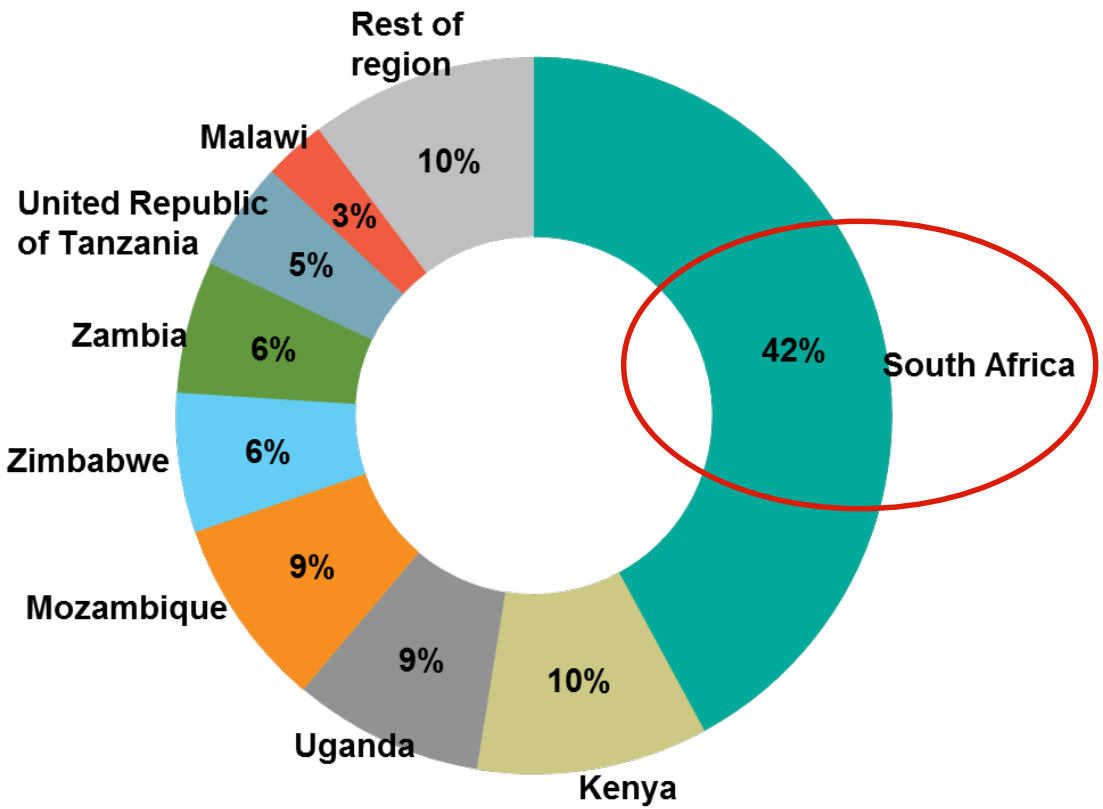
# Overview of HIV Epidemic
# Eastern and Southern Africa (ESA) 2016




| | |
|---|---|
| HIV prevalence (15-49 yrs): | **7.1%** [6.6 – 7.6%] |
| People living with HIV: | **19 million** [17.7 – 20.5 million] |
| Children (0-14 yrs) | **1 million** [930 000 – 1.2 million] |
| Women (15+ yrs) | **10.7 million** [9.9 – 11.5 million] |
| Young people (15-24 yrs) | **2.2 million** [2 – 2.4 million] |
| New HIV infections: | **960 000** [830 000 – 1.1 million] |
| AIDS related deaths: | **470 000** [390 000 – 560 000] |
| Coverage of ART: | **54%** [50 – 58%] |
| Coverage of PMTCT: | **90%** [82 - > 95%] |
| People receiving ART: | **10 252 400** |
| Mothers receiving PMTCT: | **861 624** |

*Source: UNAIDS Estimates 2016*

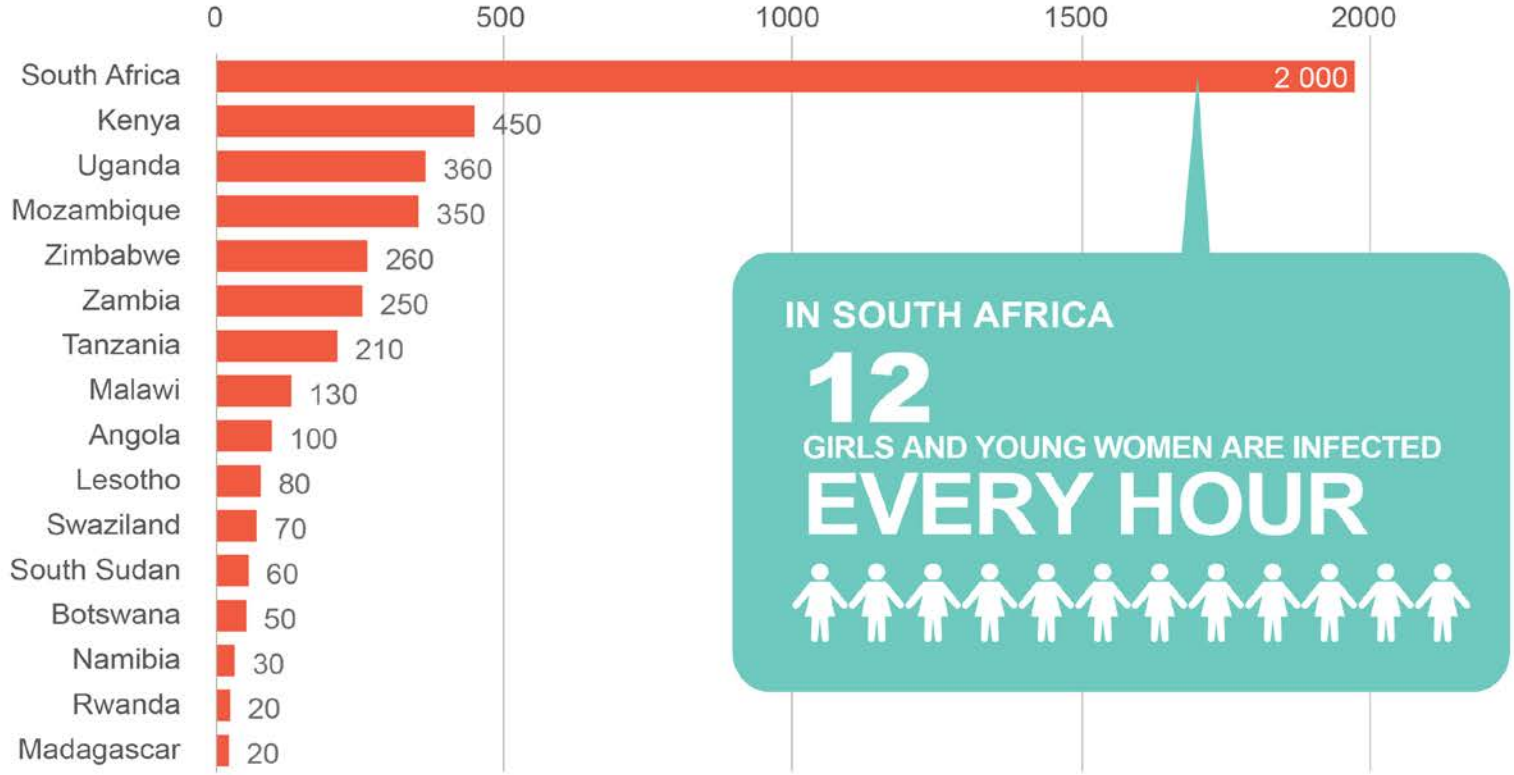
# Distribution of new HIV infections ESA 2015




*Source: UNAIDS estimates 2016*

# Adolescent girls and young women accounted for 25% of new HIV infections among adults (15+y) in the ESA region: about 4500 weekly

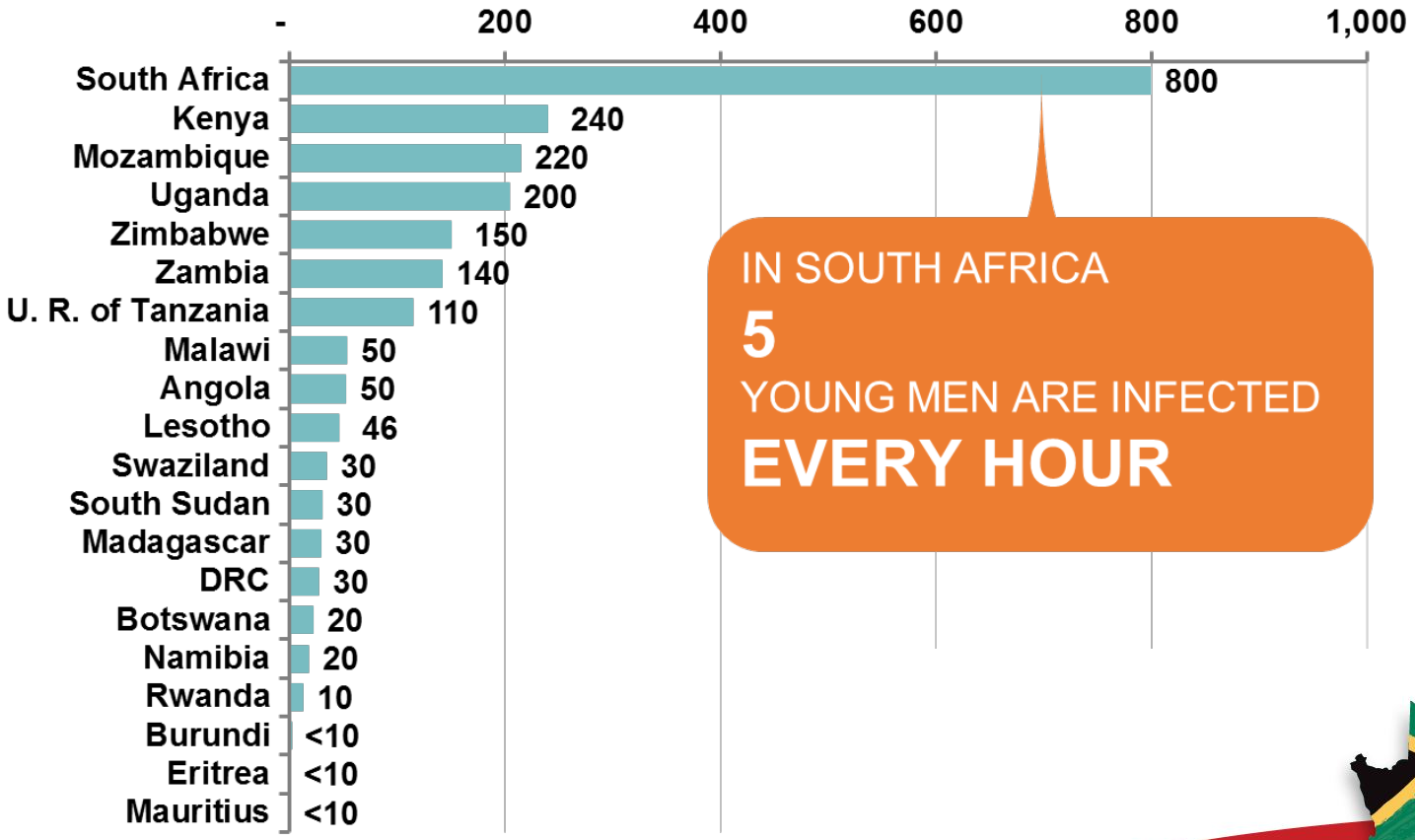
Estimated number of new HIV infections per week among females 15-24 years




*Source: UNAIDS estimates 2016*

# Adolescent boys and young men accounted for 12% of new HIV infections among adults (15+y) in the ESA region: about 2200 weekly

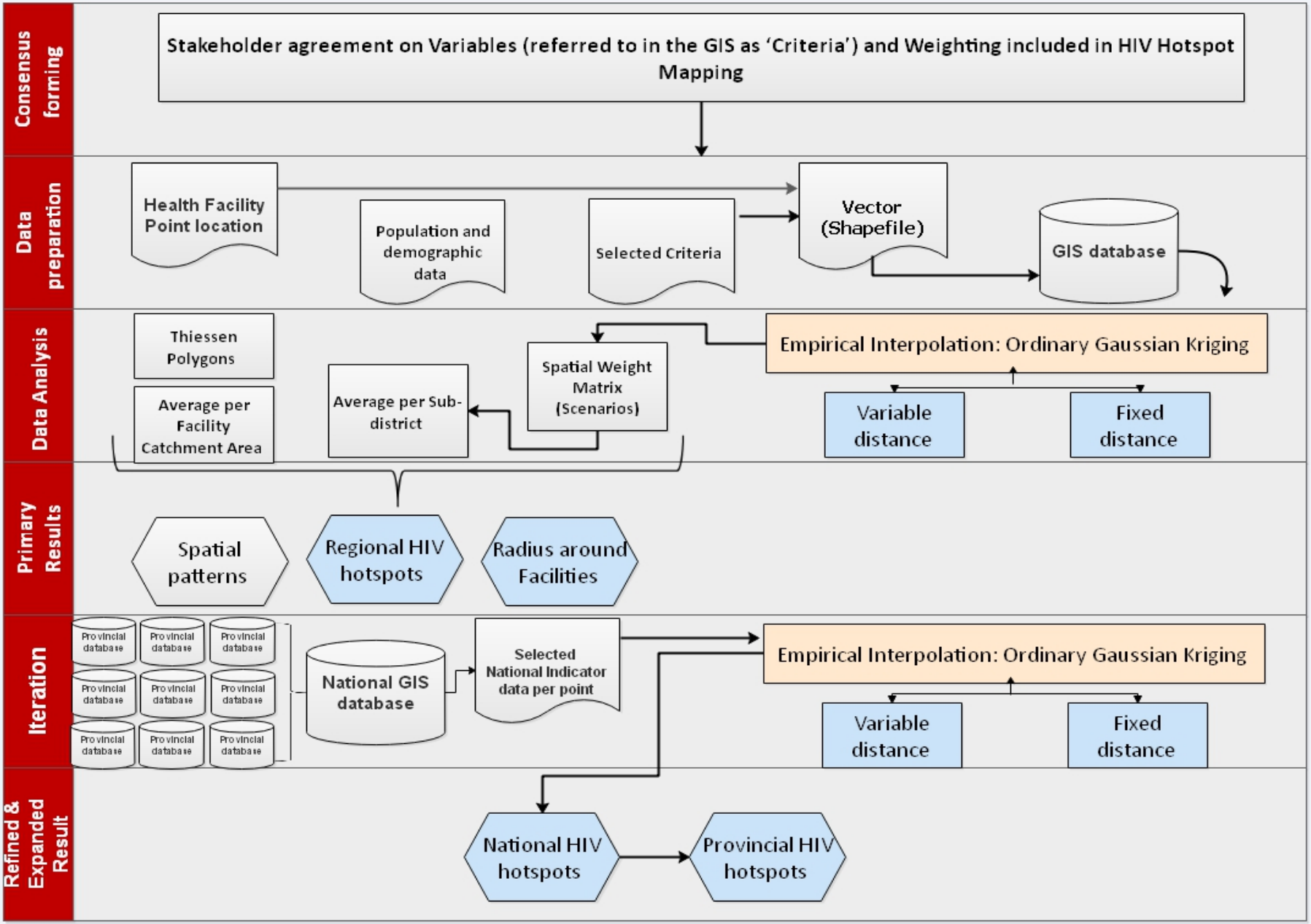
Estimated number of new HIV infections per week among males 15-24 years




*Source: UNAIDS estimates 2016*

# Developing a spatial model for HIV hotspots

# HIV Hotspot mapping GIS Cross-Functional Process



# Reaching consensus


planning, monitoring and evaluation
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science & technology
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rural development & land reform
Department:
Rural Development and Land Reform
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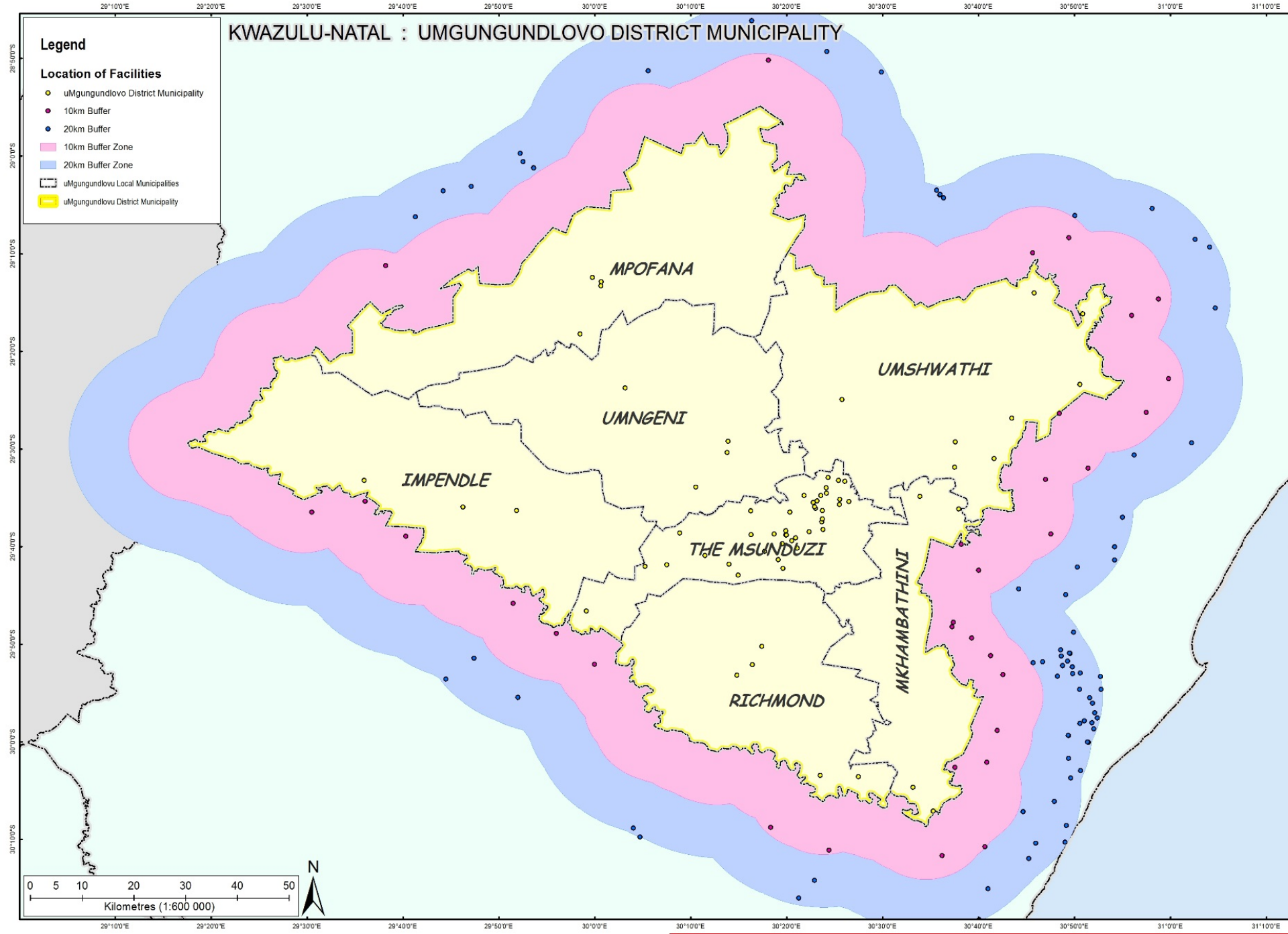
Office Of The Premier
PROVINCE OF KWAZULU-NATAL


Health Economics and Epidemiology Research Office
HE²RO
Wits Health Consortium
University of the Witwatersrand





Health Information Systems Program - SA



KWAZULU-NATAL : UMGUNGUNDLOVO DISTRICT MUNICIPALITY
Legend
Location of Facilities
uMgungundlovo District Municipality
10km Buffer
20km Buffer
10km Buffer Zone
20km Buffer Zone
uMgungundlovu Local Municipalities
uMgungundlovu District Municipality
MPOFANA
UMSHWATHI
UMNGENI
IMPENDLE
THE MSUNDUZI
MKHAMBATHINI
RICHMOND
0 5 10 20 30 40 50
Kilometres (1:600 000)
N
29°10'0"E
29°20'0"E
29°30'0"E
29°40'0"E
29°50'0"E
30°0'0"E
30°10'0"E
30°20'0"E
30°30'0"E
30°40'0"E
30°50'0"E
31°0'0"E
31°10'0"E
28°50'0"S
29°0'0"S
29°10'0"S
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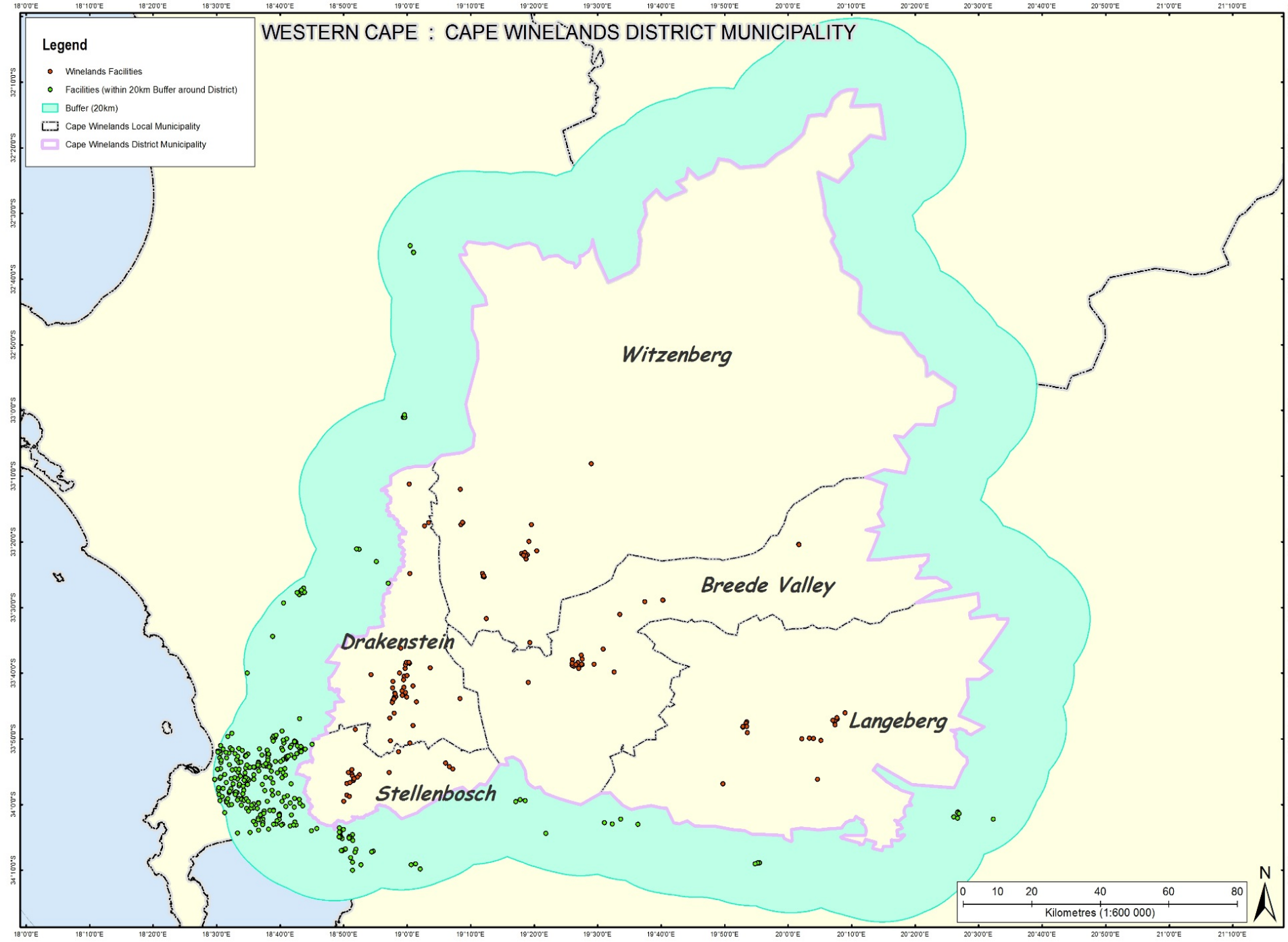
30°10'0"S


WESTERN CAPE : CAPE WINELANDS DISTRICT MUNICIPALITY
Legend
Winelands Facilities
Facilities (within 20km Buffer around District)
Buffer (20km)
Cape Winelands Local Municipality
Cape Winelands District Municipality
Witzenberg
Breede Valley
Drakenstein
Langeberg
Stellenbosch
0 10 20 40 60 80
Kilometres (1:600 000)
N

# Data Sources

- District Health Information System
  - TIER.net (Electronic HIV database) exports to DHIS
  - Aggregations form Antenatal registers
  - Routine health data at health facility level
- South Africa Census 2011 for population data

# Routine health indicators

- **Strengths**
  - Similar behaviour for collection, management and storage
  - Available for whole country
- **Limitations**
  - Can’t be disaggregated for sax and age
  - Mobile clinic data recorded as point not points on route

# Workflow

- *Step 1:* Convert spreadsheet received into point shapefile. The following fields were used base the analysis on.
- Data is represented in the form of percentage of proportions of the tested population:
  - child 12-59 months; (HIVP1259)
  - child 5-14 years; (HIVP514R)
  - client 15-49 years (excluding ANC); assumed correct (HP_14_59)
  - client 50 years and older (excluding ANC); (no field)
  - antenatal clients; (ANCHIV1P)
  - PCR Tests (INFPCR2P)
  - Tests positive for infants - birth + at 6 weeks (TABPCRPR)

# Workflow

- *Step 2:* Apply an interpolation algorithm to each selected criteria, in this instance Ordinary Kriging (Gaussian option), using a Variable distance of 12 and cell and lag size of 0.0050
- *Step 3:* Apply an interpolation algorithm to each selected criteria, in this instance using Ordinary Kriging (with a Gaussian option), using a Fixed distance of 0.0050 (5 kms)
- *Step 4:* Visualise the modelling results as a data layer per criteria, for each of the Kriging types noted in Steps 2 and 3
- *Step 5:* Normalise the results by averaging the data per sub-district
- The final method used was Kriging, gaussian option, variable distance of 12 with cell size of 0.0050

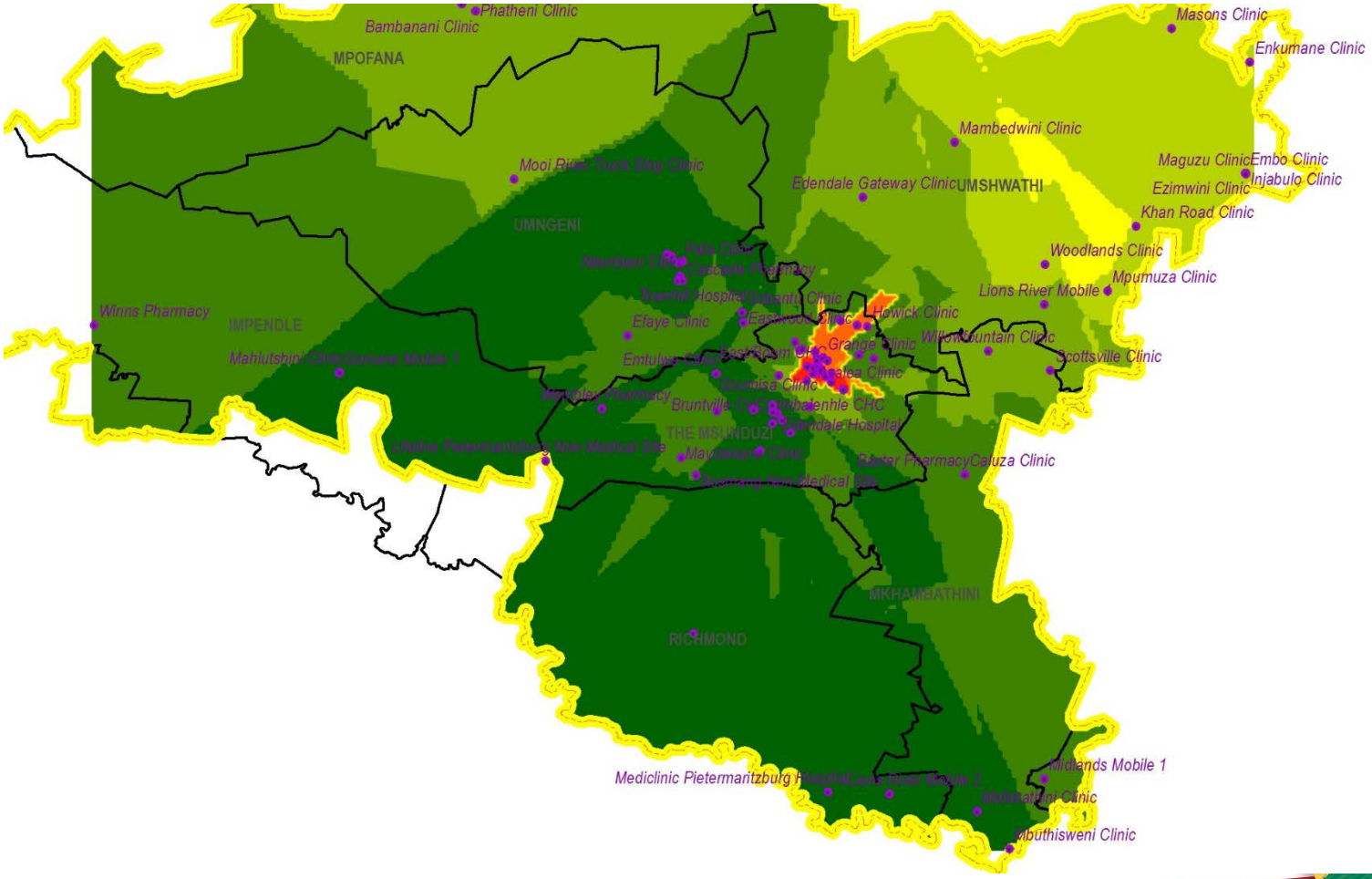
# Scenarios developed after initial modelling

- Where each of the criteria A to E each weighs 20% when overlayed (i.e. equal weighting to all);
- Where criteria C client 15-49 years weighs 60% while the remainder each weighs 10%;
- Where criteria E % of antenatal clients testing positive for HIV/AIDS weighs 60% while the remainder each weighs 10%;
- Where criteria A and B each weighs 30% while the remainder each weighs 10%;
- Where criteria C and E each weighs 30% while the remainder each weighs 10%;

# Data analysis

- Literature review conducted to determine suitability of kriging to health statistics such as that which this project considers
- Discussions with experts on application of interpolation in general as well as kriging
- Empirical smoothing/interpolation was applied: among others, Inverse Distance Weighting (IDW) and Natural neighbour (NN) did not present suitable results; Kriging provided feasible representations
- Spatial weight matrix: methods tested and implemented
- Average per sub-district and facility catchment area (using Thiessen polygons) – not used in the final model

# Final deliverable for HIVP1259



# Important to remember

- Future developments - overlay budget distribution and programme intervention areas may reveal additional insights
- Catchment population in terms of age and sex (gender), using the Census data (STATSSA, 2011 or variants thereof) based on household surveys can be incorporated in the model at a later stage – it is not included at this time
- Modelling process is run on a flat unfeatured earth surface – Topographical features such as cliffs, rivers and steep valleys, as well as the location of densely populated area and different road classes is considered to have a major impact on the distribution and hot spot occurrence of HIV and AIDS – include in future modelling

# Important items to remember

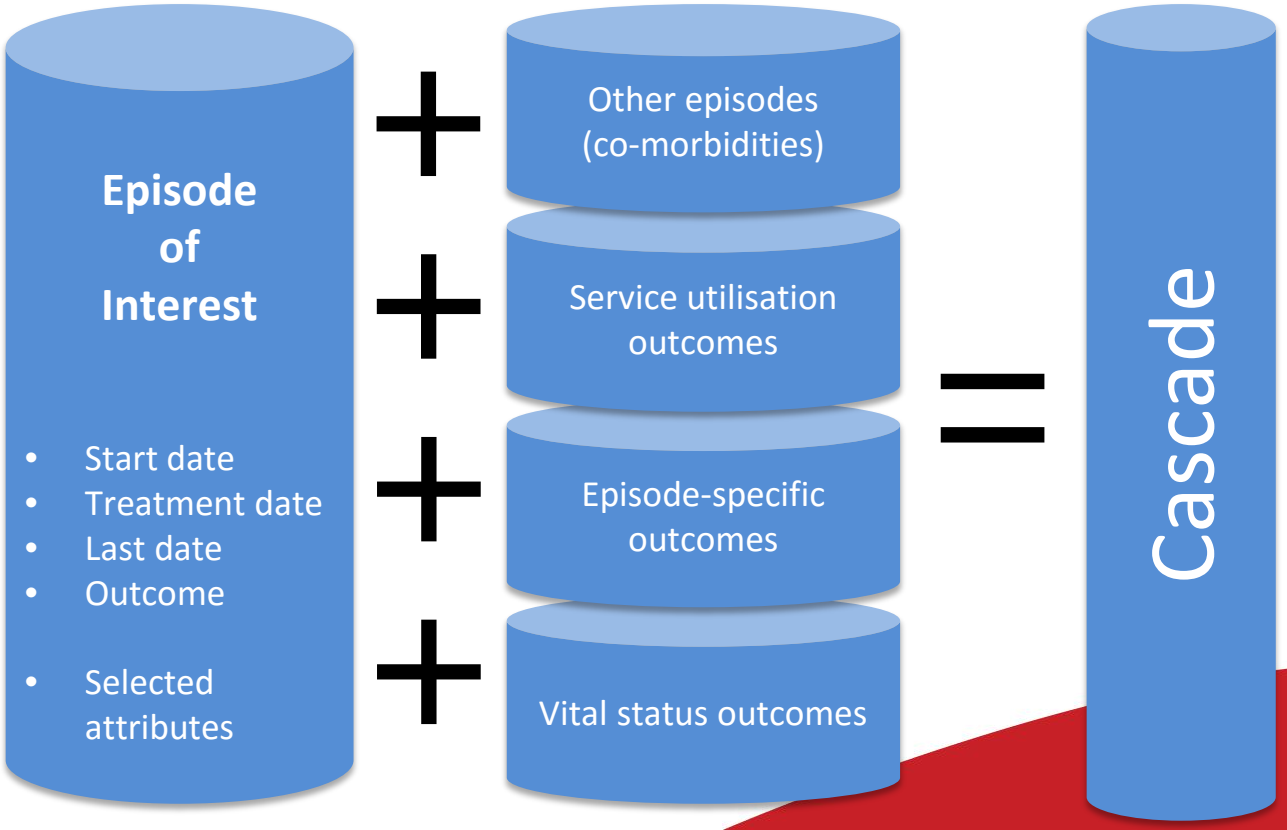
- While summation provides a wider-scale interpretation of the model, multiplication focus the importance of specific parameters in specific areas. Multiplication therefore enhances any outliers or data that has consistently high values across the set of criteria

# Alternate Data Sources

- Western Cape Province makes use of a **unique patient identifier** to link and harmonise individualised patient data
- Patient Master Index (PMI) has matured over last 20 years aligned to the **future strategy** for individualised health data in South Africa as a whole
- Ideal prototyping space for geospatially mapping the burden of HIV according to the **actual patient address**, rather than from assumptions around the primary health care facility. The PMI also includes **patient demographic info**
- PMI also allows for analysis of sub-groups, such as **Young Women & Girls (15 – 24 years)**

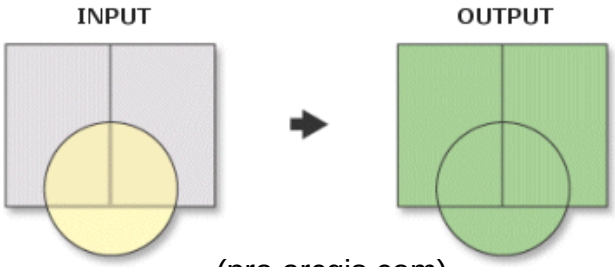
# Cascades

- Comprehensive patient level view of episodes, including key dates, evidence, outcomes and co-morbidities relevant for patient management
- Provides us with a cohort in the absence of complete registers
- Optimised for operational and management purposes
- Easily aggregated by region or attributes



# Workflow for Harmonised Geospatial Health Data using Street Postal Code

- Determine population estimates for postal code polygons:
  - Use the **Overlay Analysis** tool for the Small Area polygon layer and the Street Postal Code polygon layer using the **Union** operation
  - **Manual** method avoids mistakes where there are multiple distinct overlapping areas between a small area and a postal code
  - Create new area field in resultant layer and calculate area in required units ($km^2$) using **Summary Statistics** tool
  - Calculate the **proportional population** of the Small Area layer that resides within the postal code polygon layer




(pro.arcgis.com)

# Workflow for Harmonised Geospatial Health Data using Street Postal Code

- Map **HIV episodes** (PLHIV) by street postal code
  - Import data from Data Centre Server (Western Cape uses Microsoft stack) – 3 options:
    - Manual export from MS SQL and import to ArcGIS
    - Direct connection to database View of HIV episodes aggregated to street postal code
    - Semi-automation of most steps with an ArcGIS Model
  - Join street postal code polygon layer to the data table / view

# Workflow for Harmonised Geospatial Health Data using Street Postal Code

- Deal with patients with missing or invalid postal codes (10%)
  - Determine last PHC facility visited by the patient
  - Assume patient lives within that the health sub-district (municipal region) of the health facility
  - Follow similar workflow using the **Union** operation of the **Overlay Analysis** tool to proportionally assign patients from the sub-district layer to the postal code layer
- Add appropriate symbology, colour ramp with no more than 5 natural jenks for health managers
- Visualize:
  1. Absolute number of PLHIV per area
  2. Standardise by population for urban areas
  3. Standardise by area (density) for rural areas

# Workflow for Harmonised Geospatial Health Data using Street Postal Code

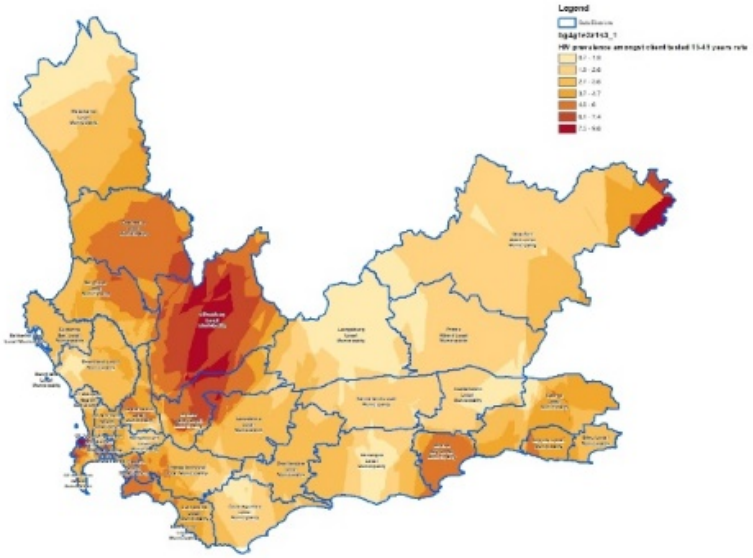
- **Limitations**:
  - Street postal code population will not contain SAL population where postal code polygons and SAL polygons did not overlap
  - Postal code does not cover the entire surface of the country, particularly in the rural and agricultural areas
- **Strengths:**
  - Fairly reliable in city / urbanised areas
  - Small Area Layer is small enough for the assumption of homogenous distribution of the population

# Comparison of results
# Facility level v Patient level

| Facility Level | Patient Level |
|---|---|
| • Anonymized Aggregated Facility Level Data<br>• Location: Facility location<br>• Sample size: Number of Health facilities<br>• Method: Raster maps utilizing the statistical method of interpolating facility level data through a standard Gaussian process | • Anonymized Single Patient data<br>• Location: Aggregated from patient addresses to postal code area<br>• Sample size: Number of postal areas<br>• Method: Thematic Map based on postal code aggregated data standardized according to rurality |

# Comparison of results
# Facility level v Patient level

- Two independent methods used to address a common problem
- Surprisingly similar outcomes
- Confirmation of common areas for focusing to achieve maximum impact



# Esri ArcGIS Desktop Advance

- Utilised to do the heavy lifting
  - Analyses
  - Transformations
  - Iterative evolution and presentation of data
- Tools used
  - ArcMap
  - Spatial Analyst
  - Kriging
  - Raster Clipping
  - Automation through modelling
  - Publishing of results

# Esri ArcGIS Advance Server

- Utilised to host and publish results
  - SQL Geo-spatial DB
  - Raster image server
  - REST API
- Integration into 3rd party software via API calls
- Flexibility

# Lessons learnt

- The value of the approach is realised when users find it useful for decision-making
  - Focus for Impact tool for coordination, monitoring progress and decision support
  - Inform policy and priorities – key approach in South Africa's National Strategic Plan for HIV, TB and STI 2017 to 2022
- Need to build local capacity to use/interpret the outcomes of the approach
- Data is not perfect but sufficient for pragmatic decision making

# Financial and in kind contributions

## Development

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

health
Department:
Health
REPUBLIC OF SOUTH AFRICA

The Global Fund
To Fight AIDS, Tuberculosis and Malaria

# Financial and in kind contributions

## Attendance of the conference

SOUTH AFRICAN NATIONAL AIDS COUNCIL
OUR ACTIONS COUNT

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PROVINCIAL TREASURY

KWAZULU-NATAL
GLOBAL FUND SUPPORTED PROGRAMME

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Health

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