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Mapping & Analytics for Health Activities | GIS GEOGRAPHICAL INFORMATION SYSTEM

Identifying priorities for improving Immunization programs

Limiting vaccine wastage by optimizing Health System support

An Integrated Study Workflow Using Bayesian Networks

Raphael Girod

BayesiaLab Conference - 11th of October 2019

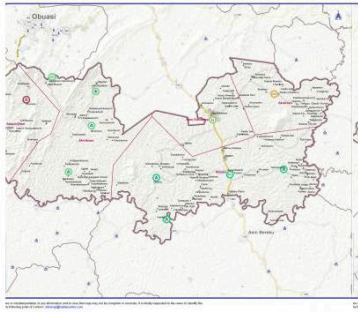
Static maps at district level

Adansi North | Adansi South | Afigya Kwabre | Afigya Sekyere | Ahafo Ano North | Ahafo Ano South | Amansie Central | Amansie West | Asante Akim Central Municipal | Asante Akim North | Asante Akim South | Asokore Mampong Municipal | Atwima Kwanwoma | Atwima Mponua | Atwima Nwabiagya | Bekwai Municipal | Bosome Freho | Bosomtwe -Atwima - Kwanwoma | Ejisu Juaben | Ejura Sekye Dumase | Kma | Kwabre | Mampong Municipal | Obuasi Municipal | Offinso Municipal | Offinso North | Sekyere Afram Plains | Sekyere Afram Plains North | Sekyere Central | Sekyere East

Ghana (Ashanti) - 150 maps

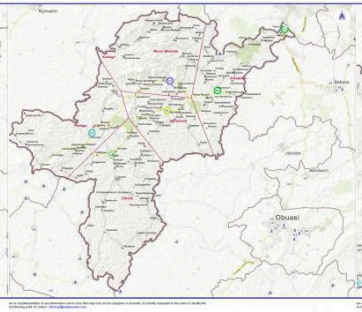
Sort by District | Type
Filter by basemap | catchment1km | catchment3km | catchment5km | reset filters

Region : Ashanti
District : Adansi South
Update 2018-12-18 **Format :** A3 **Type :** basemap



download show edit

Region : Ashanti
District : Amansie West
Update 2018-12-18 **Format :** A3 **Type :** basemap



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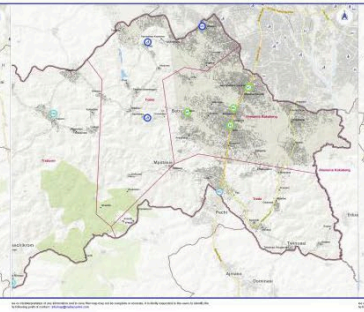
Region : Ashanti
District : Atwima Kwanwoma
Update 2018-12-18 **Format :** A3 **Type :** basemap



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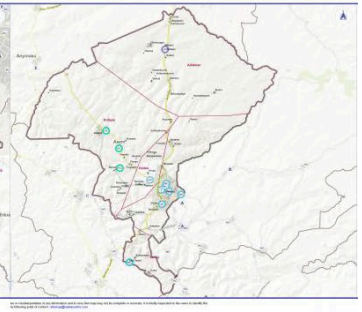
Region : Ashanti
District : Mampong Municipal
Update 2018-12-18 **Format :** A3 **Type :** basemap



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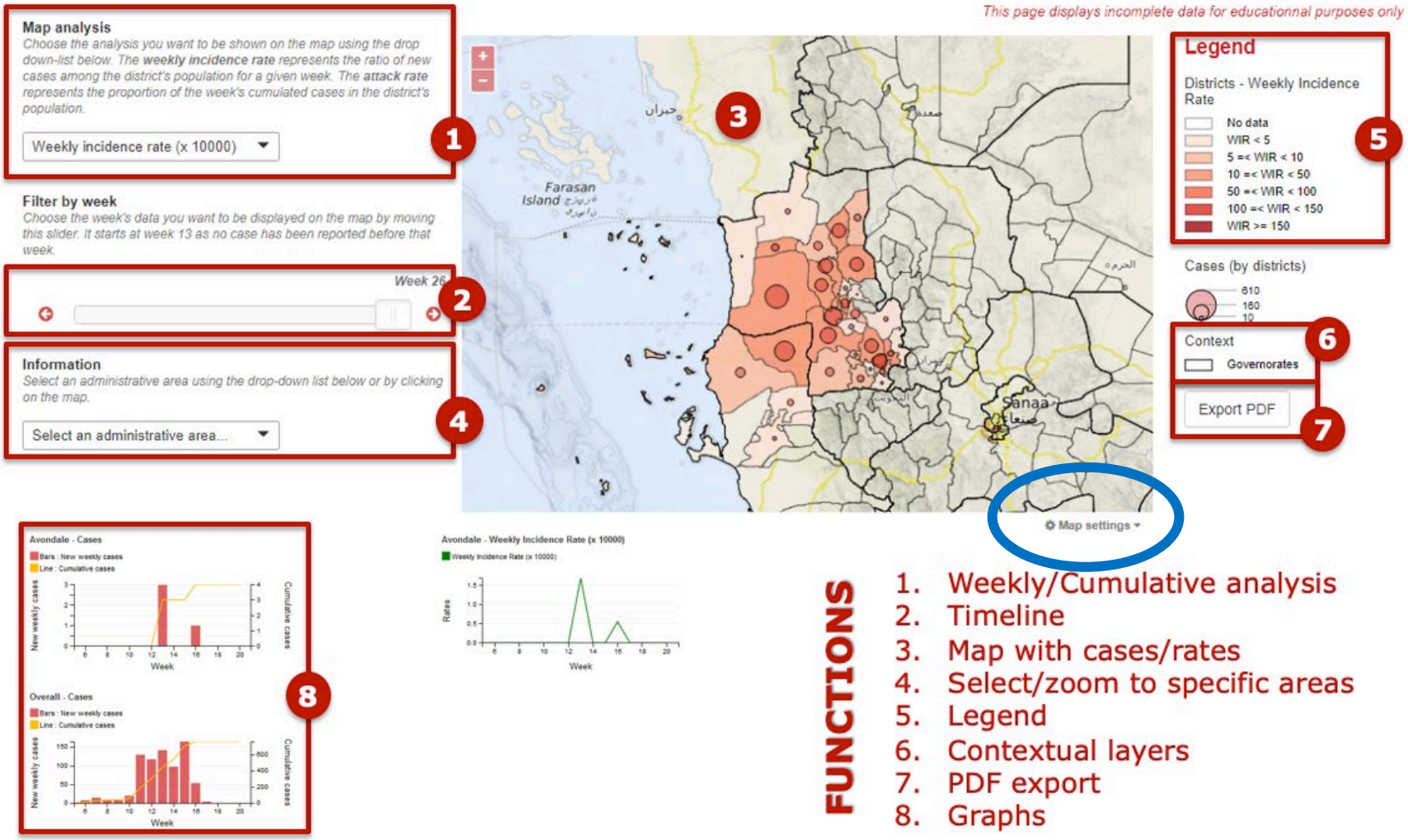
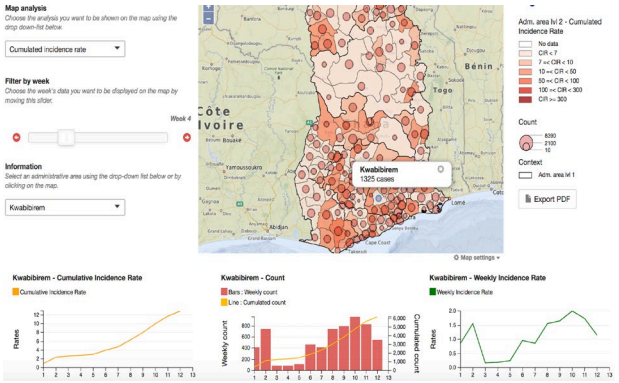
Flagship GIS application: Dynamic map

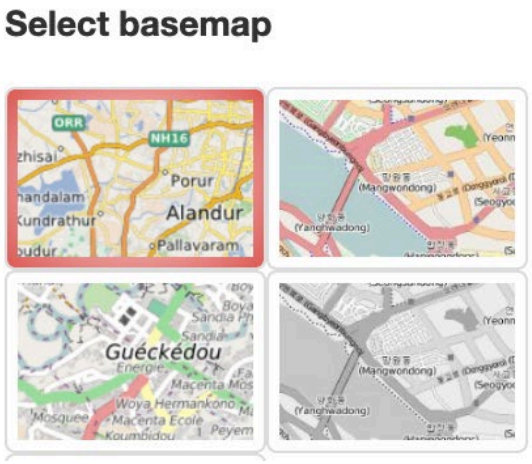


FUNCTIONS

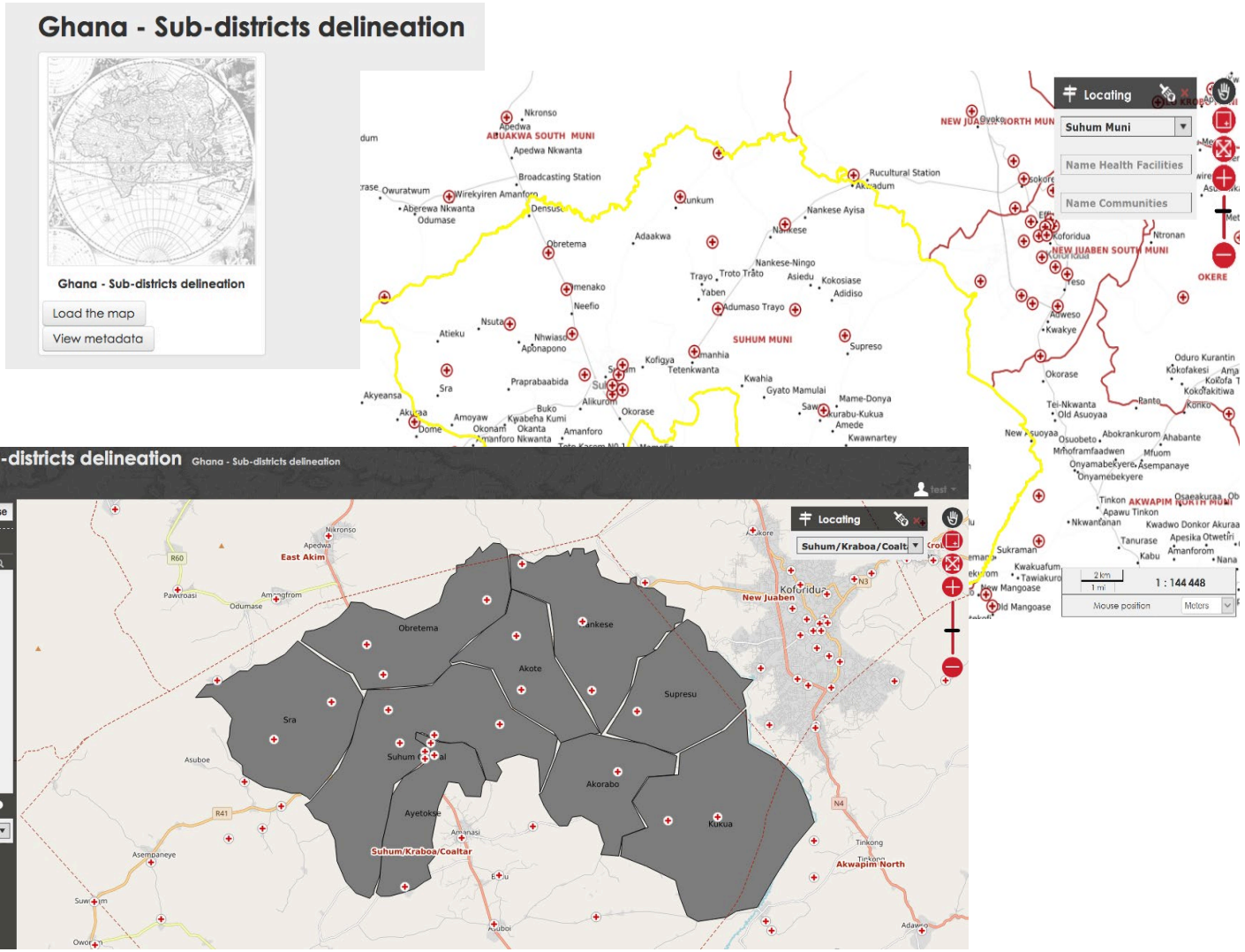
1. Weekly/Cumulative analysis
2. Timeline
3. Map with cases/rates
4. Select/zoom to specific areas
5. Legend
6. Contextual layers
7. PDF export
8. Graphs

Flagship GIS application: Dynamic map





Delineating sub-district boundaries



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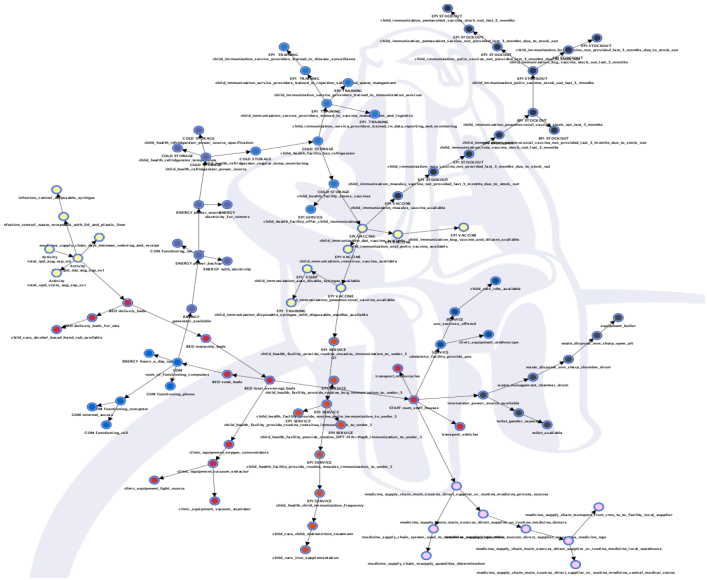
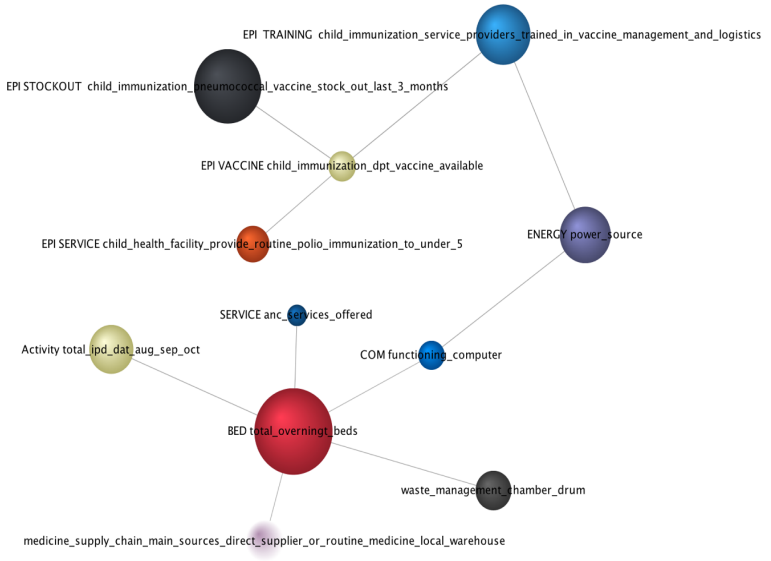
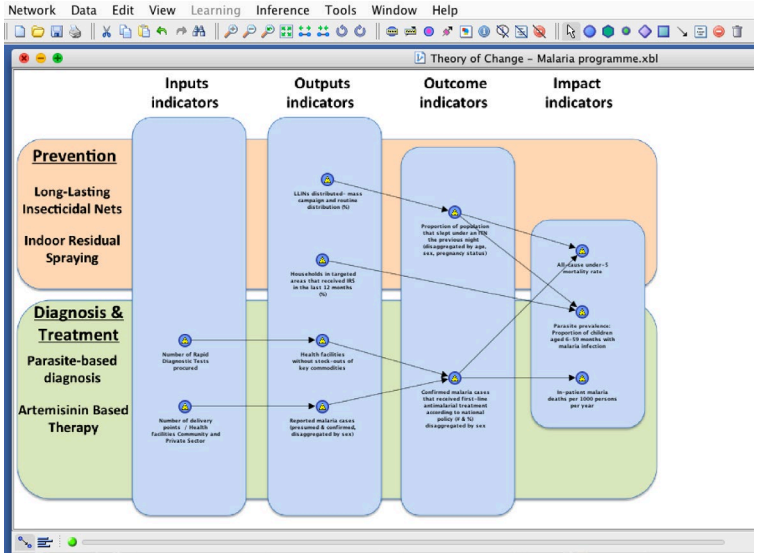
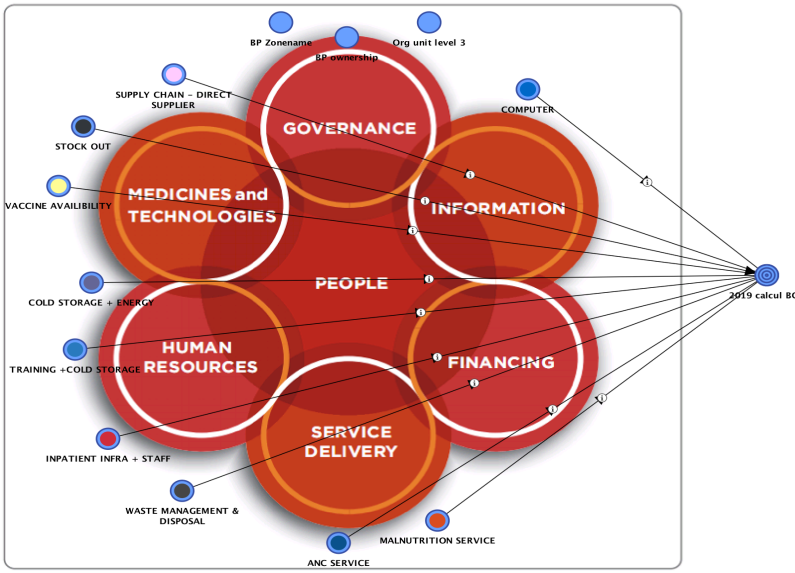
Bayesian networks make it possible to identify relevant drivers for Health System and establish priorities.





With this approach, public health researchers can quickly, generate clear recommendations for decision makers: Ministry of Health and funding organizations.





International context

Sustainable Development Goals

3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all

3.8.1 Coverage of essential health services (defined as the average coverage of essential services based on tracer interventions that include reproductive, maternal, newborn and child health, infectious diseases, non-communicable diseases and service capacity and access, among the general and the most disadvantaged population)

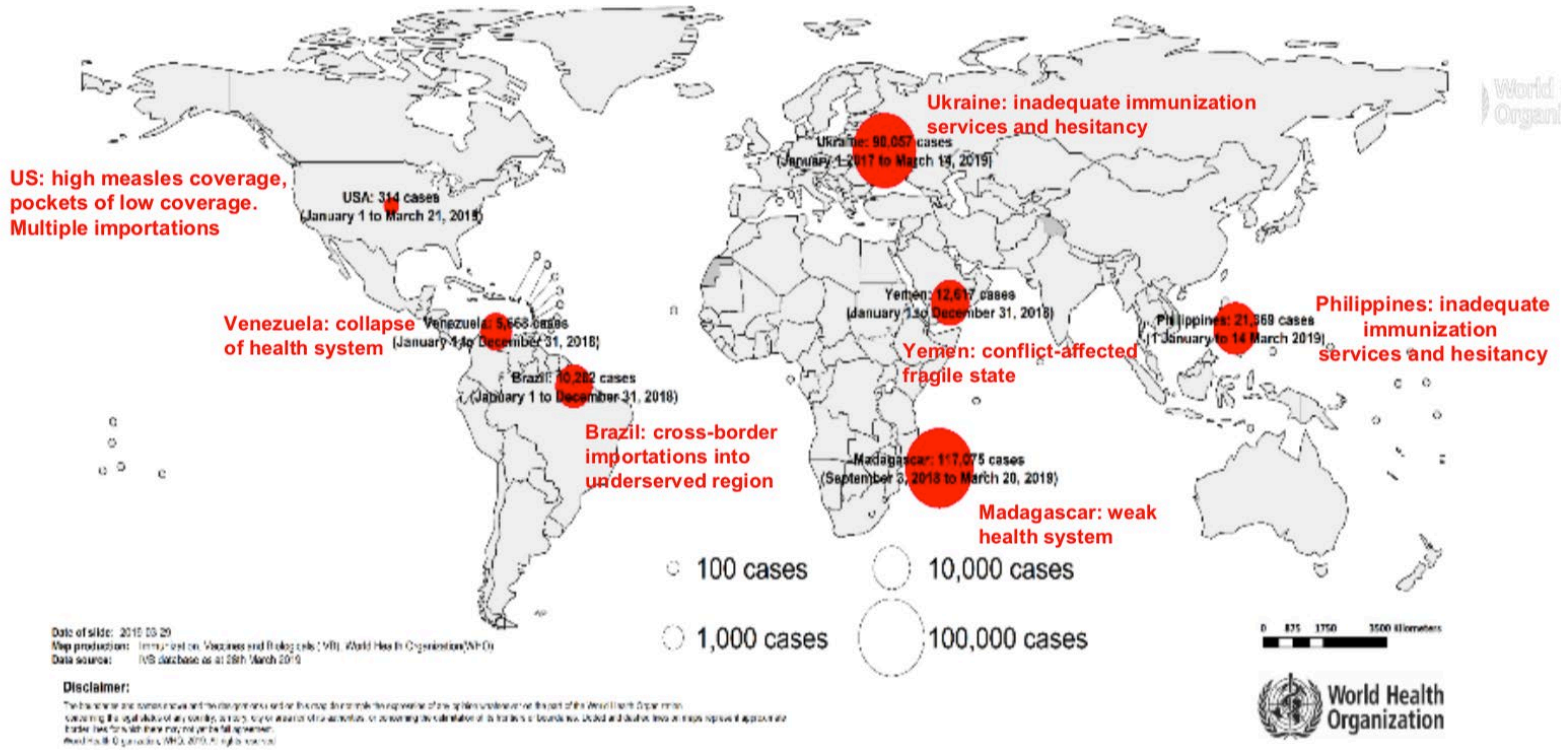
3.8.2 Proportion of population with large household expenditures on health as a share of total household expenditure or income

300% increase in measles cases worldwide

Measles outbreaks in all regions with increased size and frequency

World Health Organization

Same root cause: failure to vaccinate over many years



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Challenge

Complex and intertwined drivers of Expanded Programme on Immunization (EPI) performances

Solution

Theory of change + Bayesian Networks as Modeling Framework

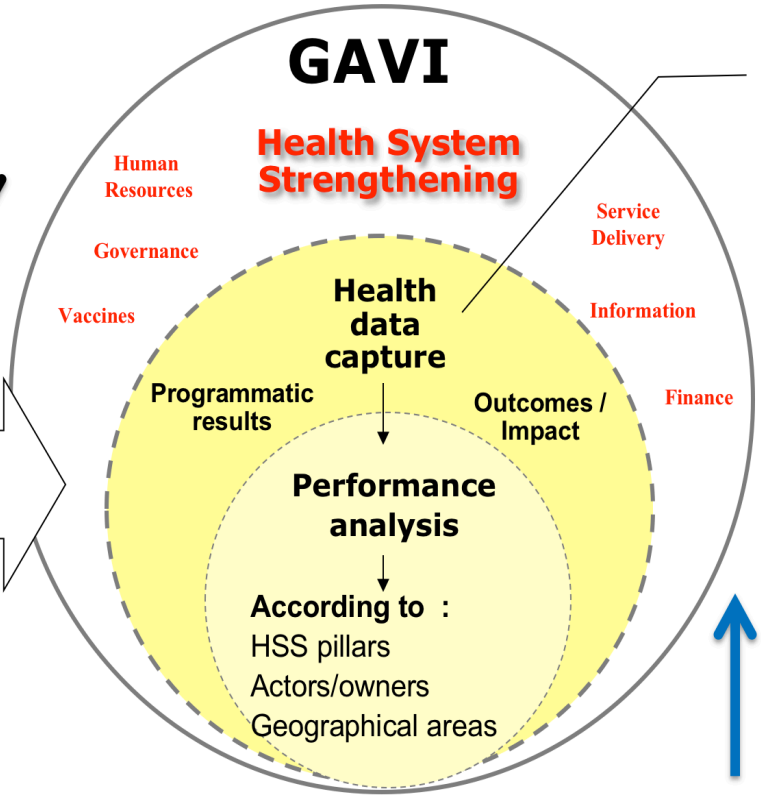
Overall approach

GAVI : The Vaccine Alliance

Assessing the current situation and needs of Health System Support & Strengthening for improving EPI program performances

***through* innovative analytical technique based upon modeling and data mining**

Top down qualitative based approaches through theory of change and interviews



Evaluation framework

Theory of change: EPI program + HSS

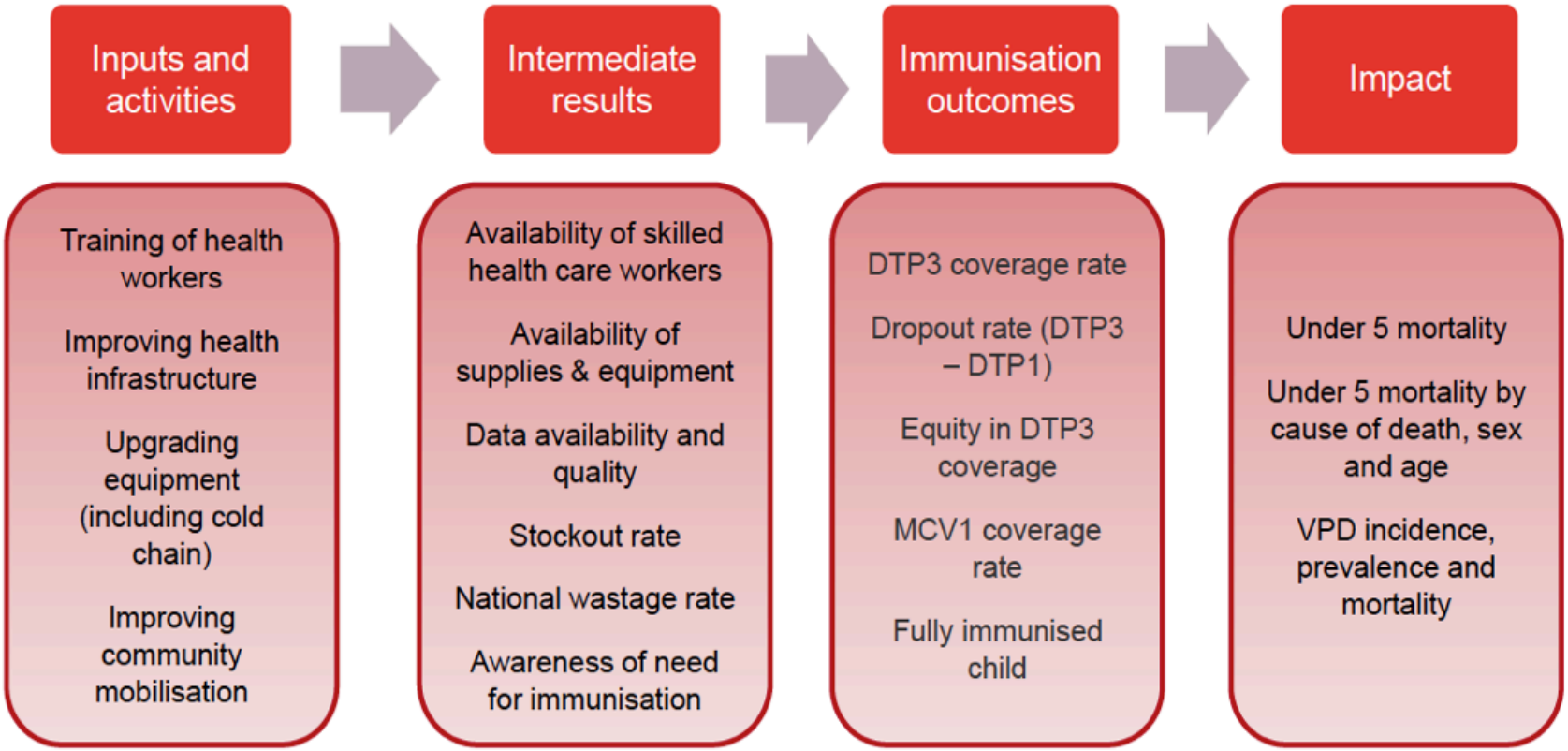
lay down through Bayesian network model

Gold mine repositories

- National surveys such as SARA
- Key performance indicators and corresponding database (DHIS2) disaggregated at granular level

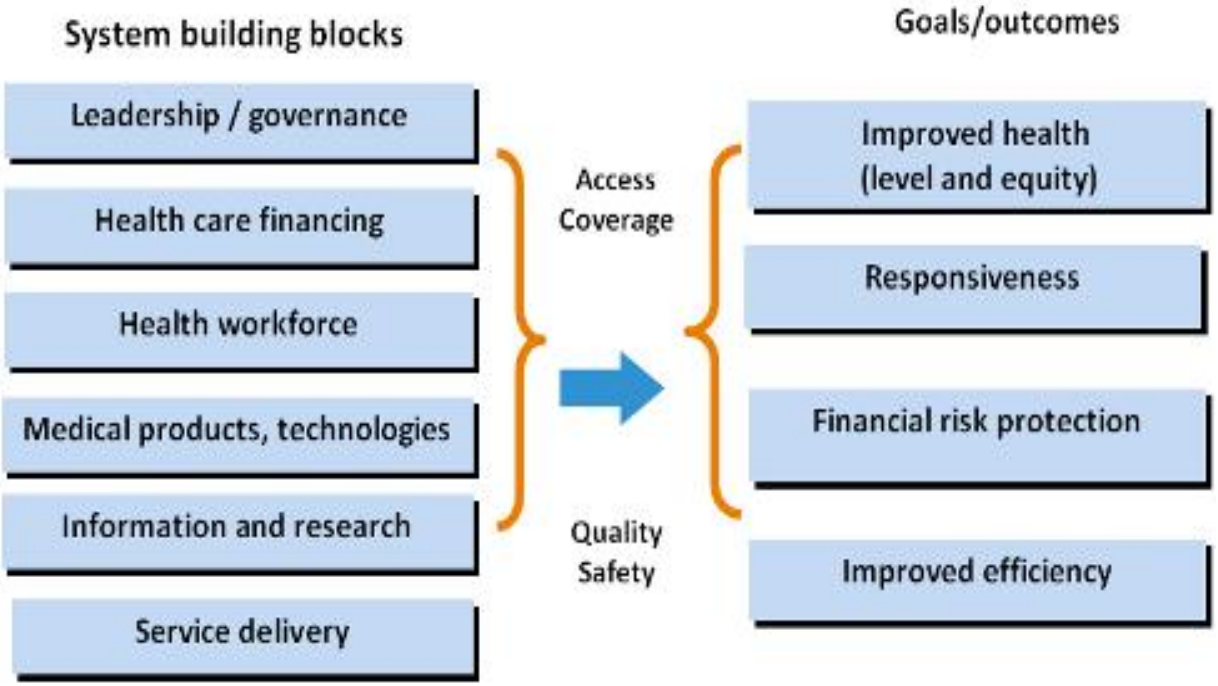
Bottom up quantitative based approaches through bayesian statistics and the use of large dataset

HSS Theory of change



Expert knowledge: causal linkages established

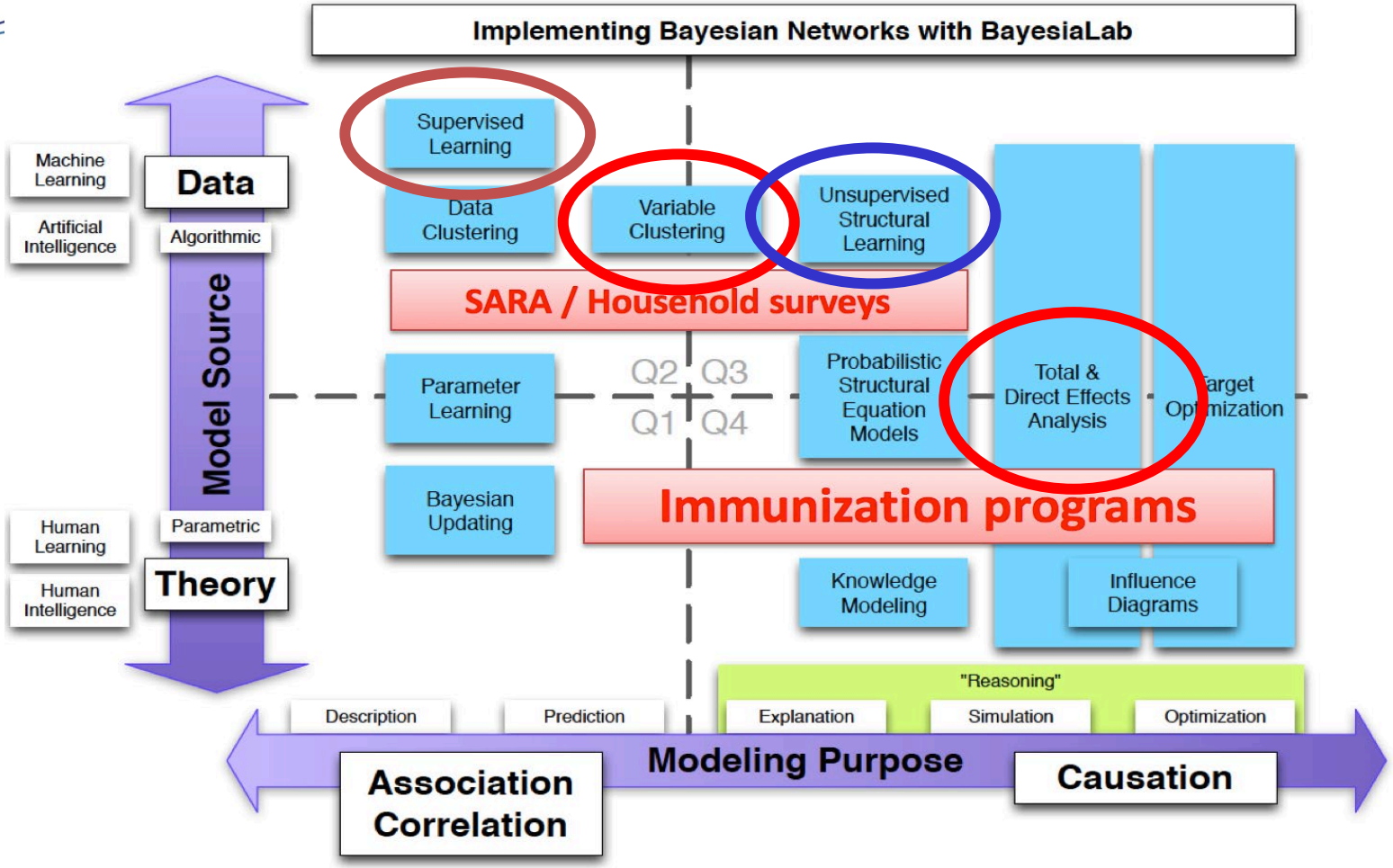
WHO Health Systems Framework



Aware of areas of strength and vulnerability

Ability to adapt structurally, functionally and socially

Bayesian Networks: Towards causation



Unsupervised learning to discover all the direct probabilistic relations
Variable clustering to induce “factors” made of highly connected variables
Supervised learning to characterize the targeted variables

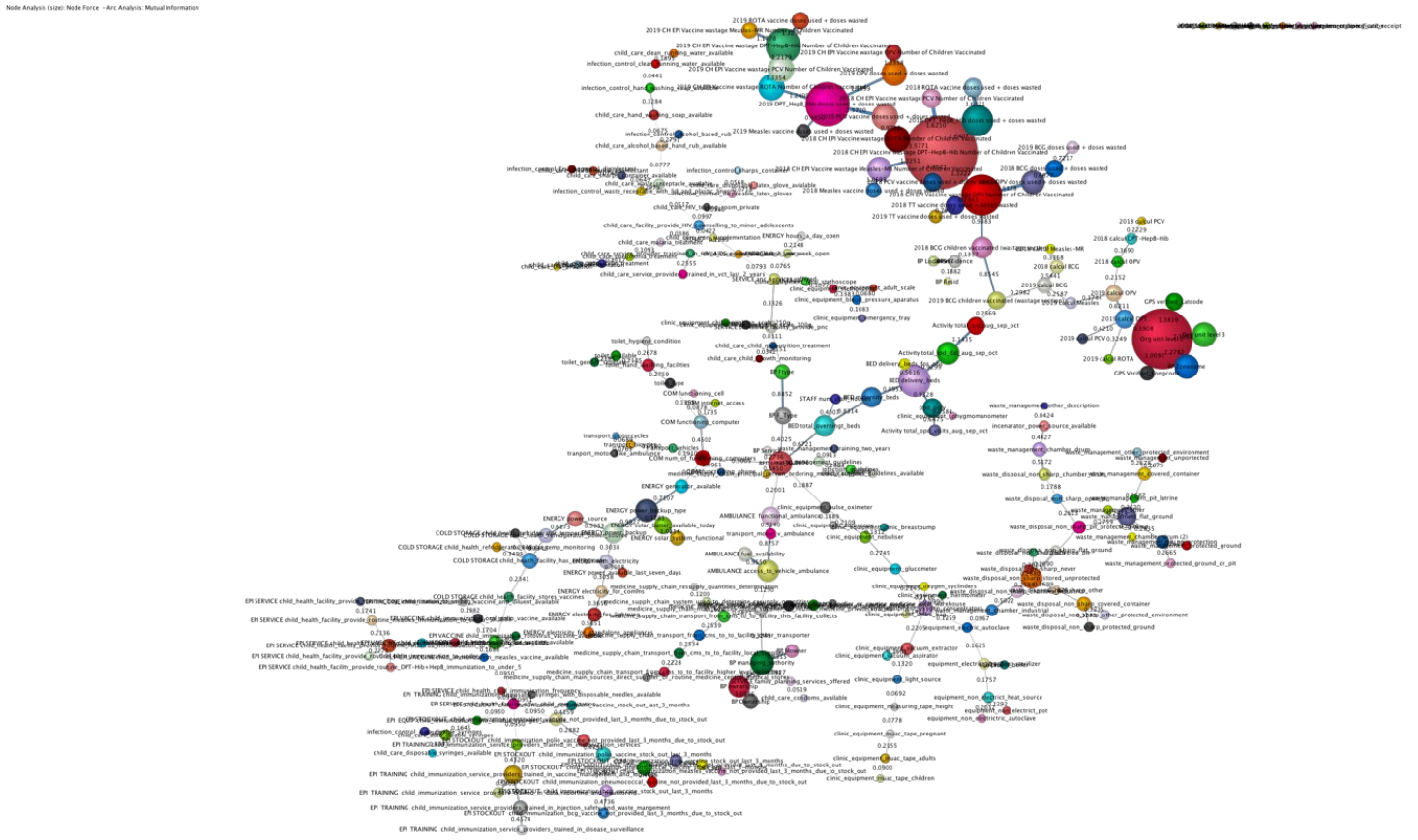
Data source

The SARA survey is designed to generate a set of core indicators on key inputs and outputs of the health system + Health Information System

Data selection

Group of columns or surveyed questions which refer specifically to the Immunization program and corresponding building blocks

Original SARA dataset : 480 columns and 1,242 rows -→ 245/…

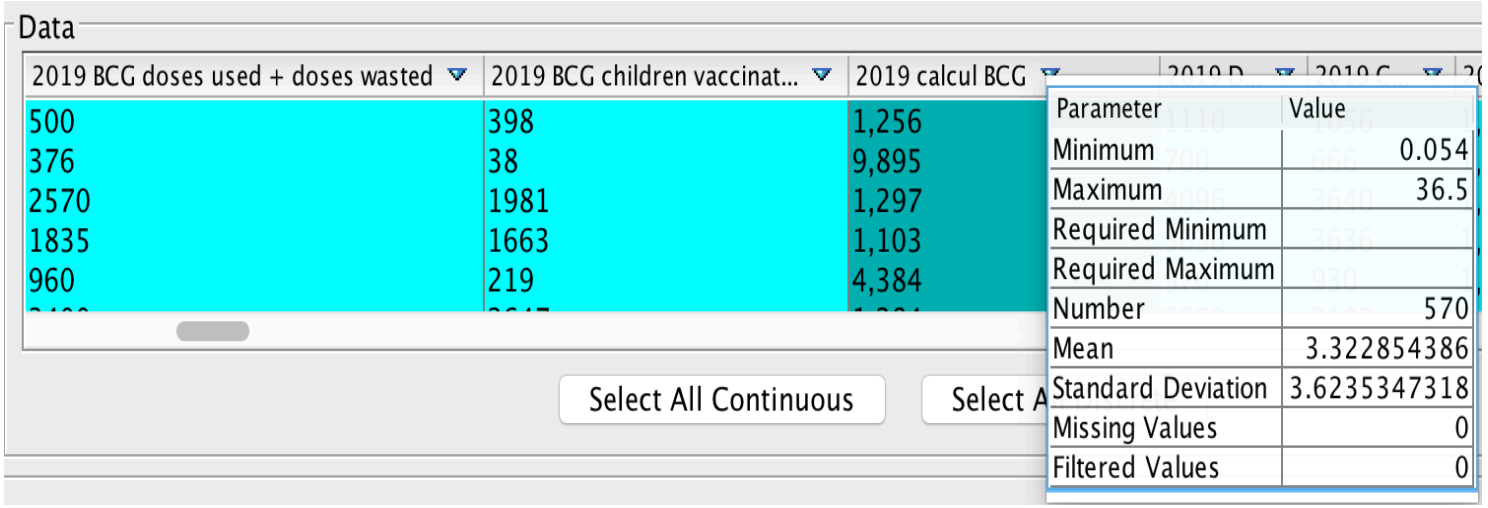


Data selection / broad categories

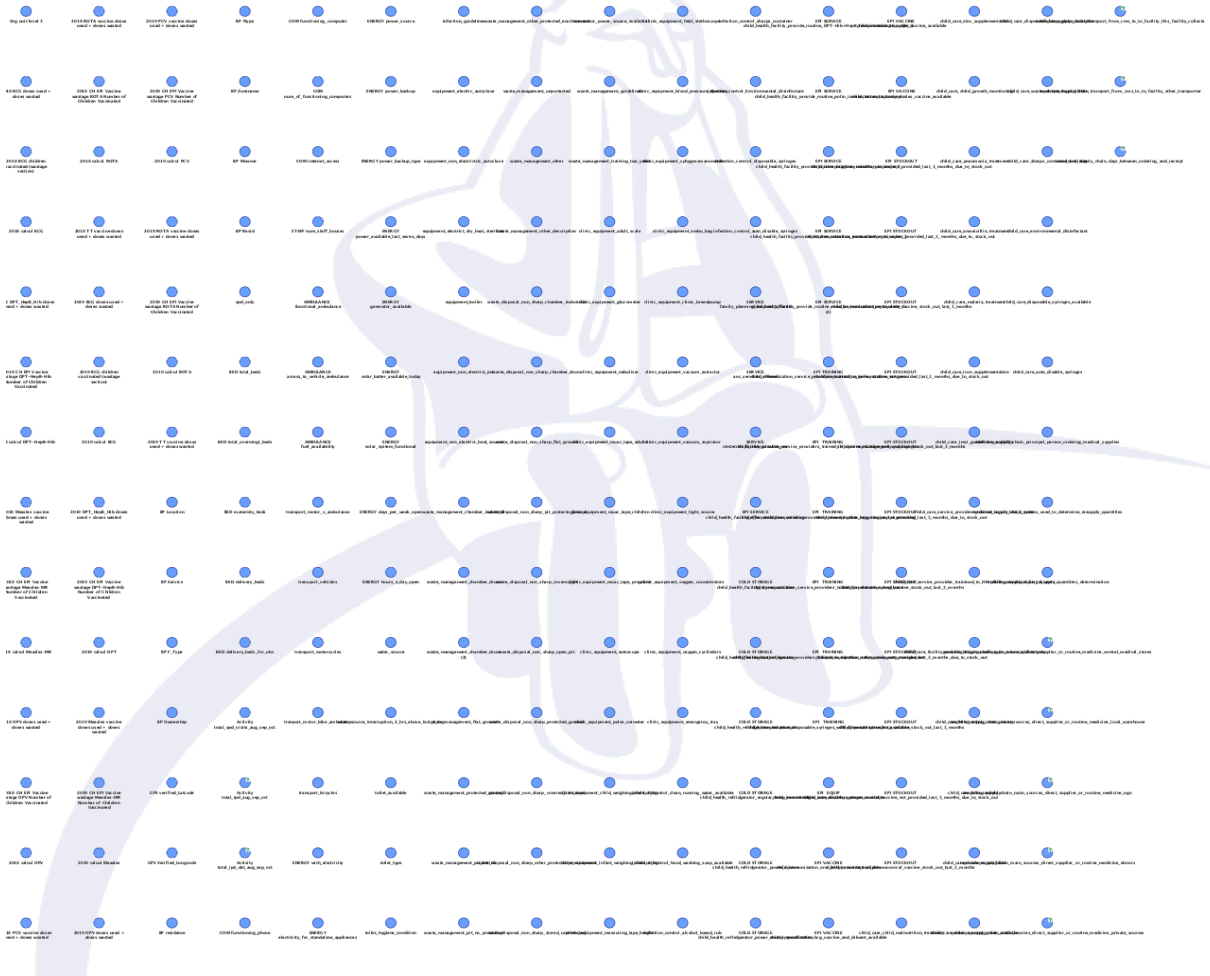
TRANSPORTATION
POWER SUPPLY - GENERATORS
BASIC CLIENT AMENITIES
WATER SOURCES, SANITATION AND HYGIENE
INFECTION CONTROL
PROCESSING OF EQUIPMENTS FOR REUSE
EQUIPMENT PROCESSING
HEALTH CARE WASTE MANAGEMENT
BASIC EQUIPMENT_GENERAL
OUTPATIENT SECTION
INFECTION CONTROL PRECAUTIONS
REPRODUCTIVE, MATERNAL AND NEWBORN HEALTH
ANTENATAL CARE SERVICES
PREVENTION OF MOTHER-TO-CHILD
CHILD AND ADOLESCENT HEALTH - *CHILD IMMUNIZATION*
CHILD PREVENTATIVE AND CURATIVE CARE SERVICES
HIV TREATMENT
HIV CARE AND SUPPORT
SEXUALLY TRANSMITTED INFECTIONS
SURGICAL EQUIPMENT AND SUPPLIES
MALARIA
MEDICINES AND COMMODITIES
SUPPLY CHAIN MANAGEMENT
ROLES AND RESPONSIBILITIES IN FACILITIES
USE OF INFORMATION SYSTEMS/DATA MONITORING
LEADERSHIP

Targeted variable

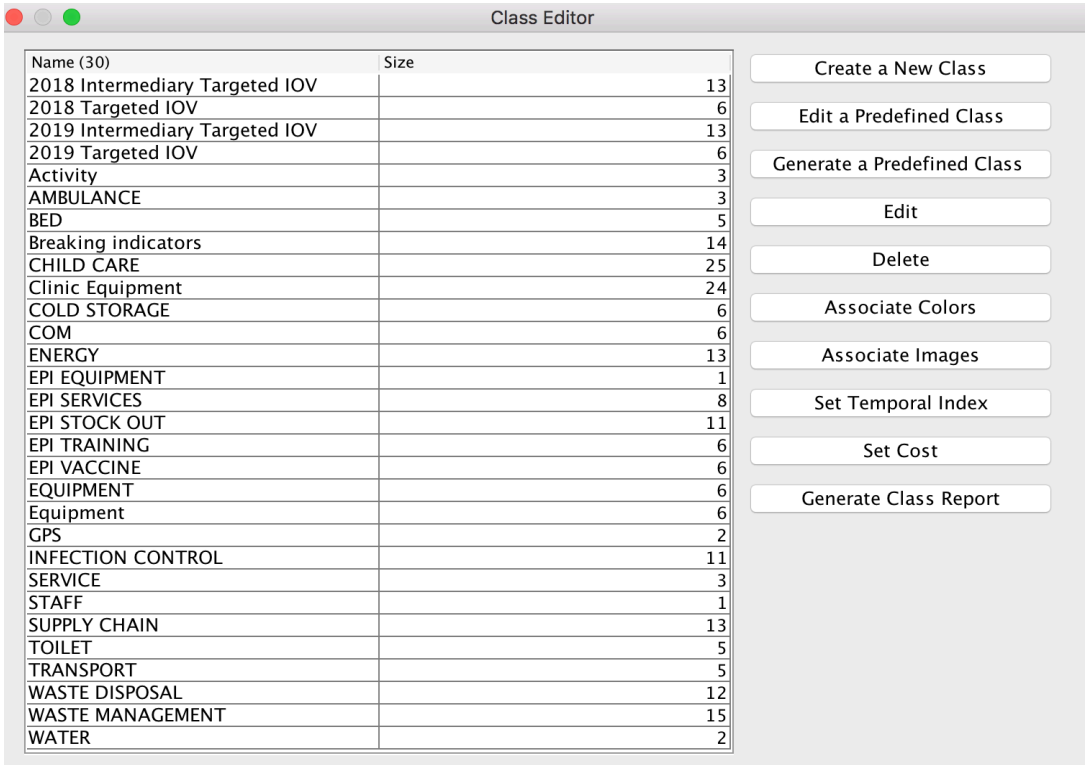
“Wastage rate” corresponding to the number of vaccine doses used + doses wasted DIVIDED by the number of children vaccinated for the antigen BCG



Unconnected network



Class indicator



The concept of classes allows to regroup nodes having common properties /features and to manage globally these properties in regards to the WHO building blocks

Example of contents of classes

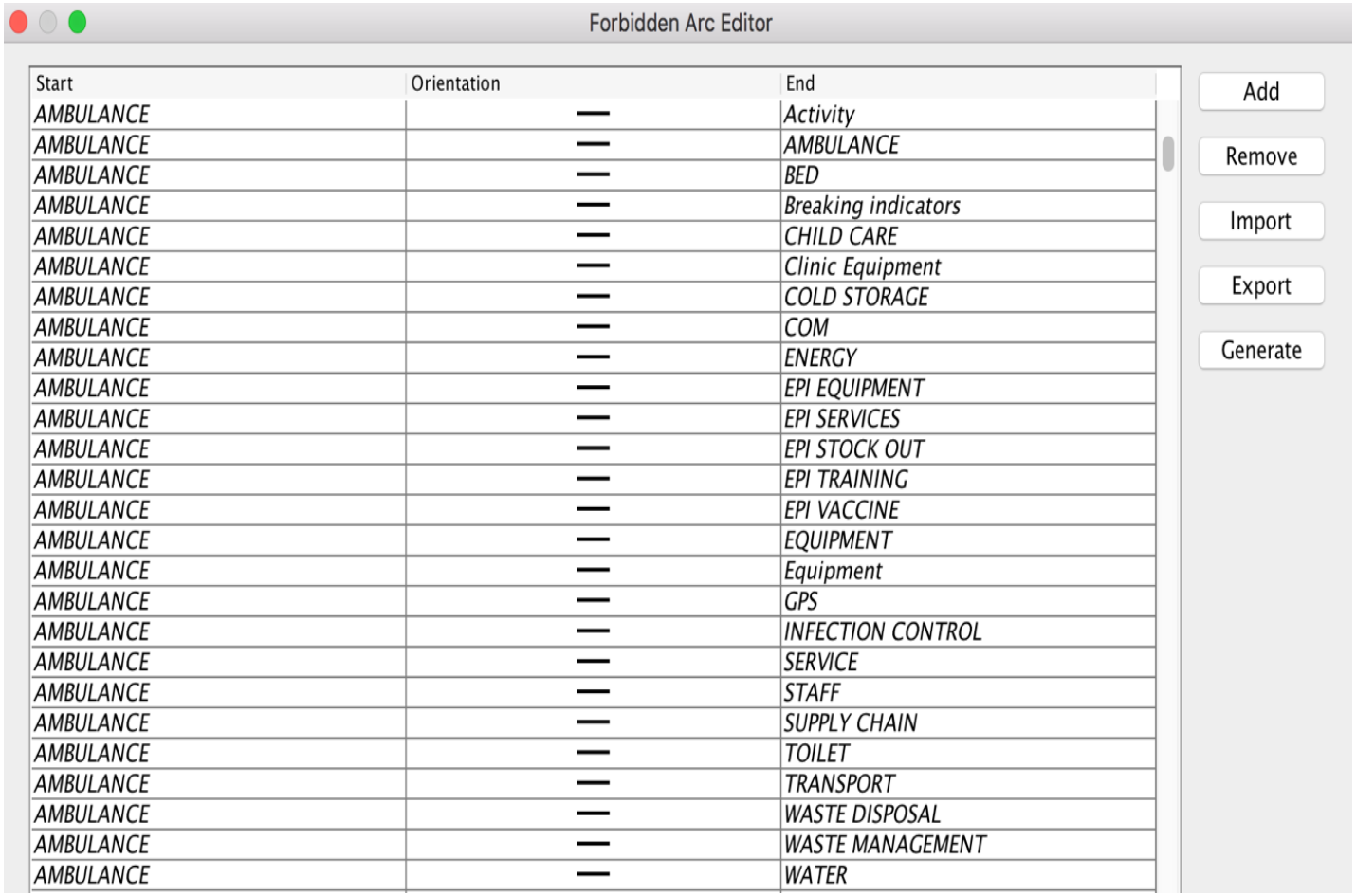
EPI SERVICE child_health_child_immunization_frequency
EPI SERVICE child_health_facility_offer_child_immunization
EPI SERVICE child_health_facility_provide_routine_bcg_immunization_to_under_5
EPI SERVICE child_health_facility_provide_routine_DPT-Hib+HepB_immunization_to_under_5
EPI SERVICE child_health_facility_provide_routine_measles_immunization_to_under_5 (2)
EPI SERVICE child_health_facility_provide_routine_measles_immunization_to_under_5
EPI SERVICE child_health_facility_provide_routine_polio_i
EPI SERVICE child_health_facility_provide_routine_rotavir

COLD STORAGE child_health_facility_has_refrigerator
COLD STORAGE child_health_facility_stores_vaccines
COLD STORAGE child_health_refridgerator_power_source_specification
COLD STORAGE child_health_refridgerator_power_source
COLD STORAGE child_health_refridgerator_regular_temp_monitoring
COLD STORAGE child_health_refridgerator_temperature

child_care_alcohol_based_hand_rub_available
child_care_amoxicillin_treatment
child_care_auto_disable_syringes
child_care_child_growth_monitoring
child_care_child_malnutrition_treatment
child_care_clean_running_water_available
child_care_condoms_available
child_care_disposable_latex_glove_avialable
child_care_disposable_syringes_available
child_care_environmental_disinfectant
child_care_facility_provide_HIV_counselling_to_minor_adolescents
child_care_HIV_testing_room_private
child_care_hand_washing_soap_available
child_care_imci_guidelines_available
child_care_iron_supplementation
child_care_malaria_treatment
child_care_ors_provision
child_care_pneumonia_treatment
child_care_provide_vit_a_supplementation
child_care_rdts_available
child_care_service_provider_trainined_in_HIV_AIDS_prevention_last_2_years
child_care_service_providers_trained_in_vct_last_2_years
child_care_sharps_container_available
child_care_waste_receptacle_available
child_care_zinc_supplementation

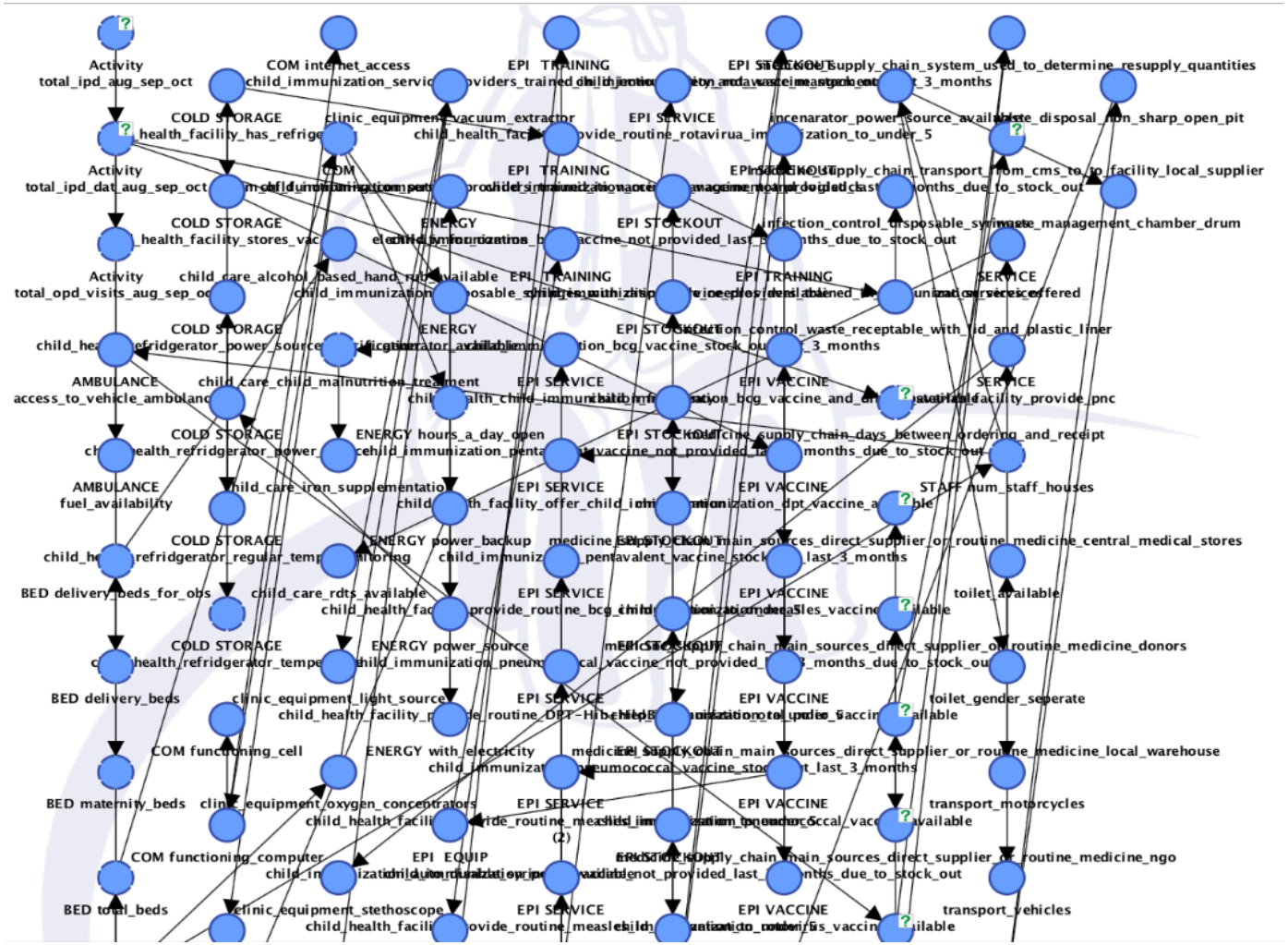
ENERGY days_per_week_open
ENERGY electricity_for_comms
ENERGY electricity_for_lightning
ENERGY electricity_for_standalone_appliances
ENERGY generator_available
ENERGY hours_a_day_open
ENERGY power_available_last_seven_days
ENERGY power_backup_type
ENERGY power_backup
ENERGY power_source
ENERGY solar_batter_available_today
ENERGY solar_system_functional
ENERGY with_electricity

Forbidden arcs

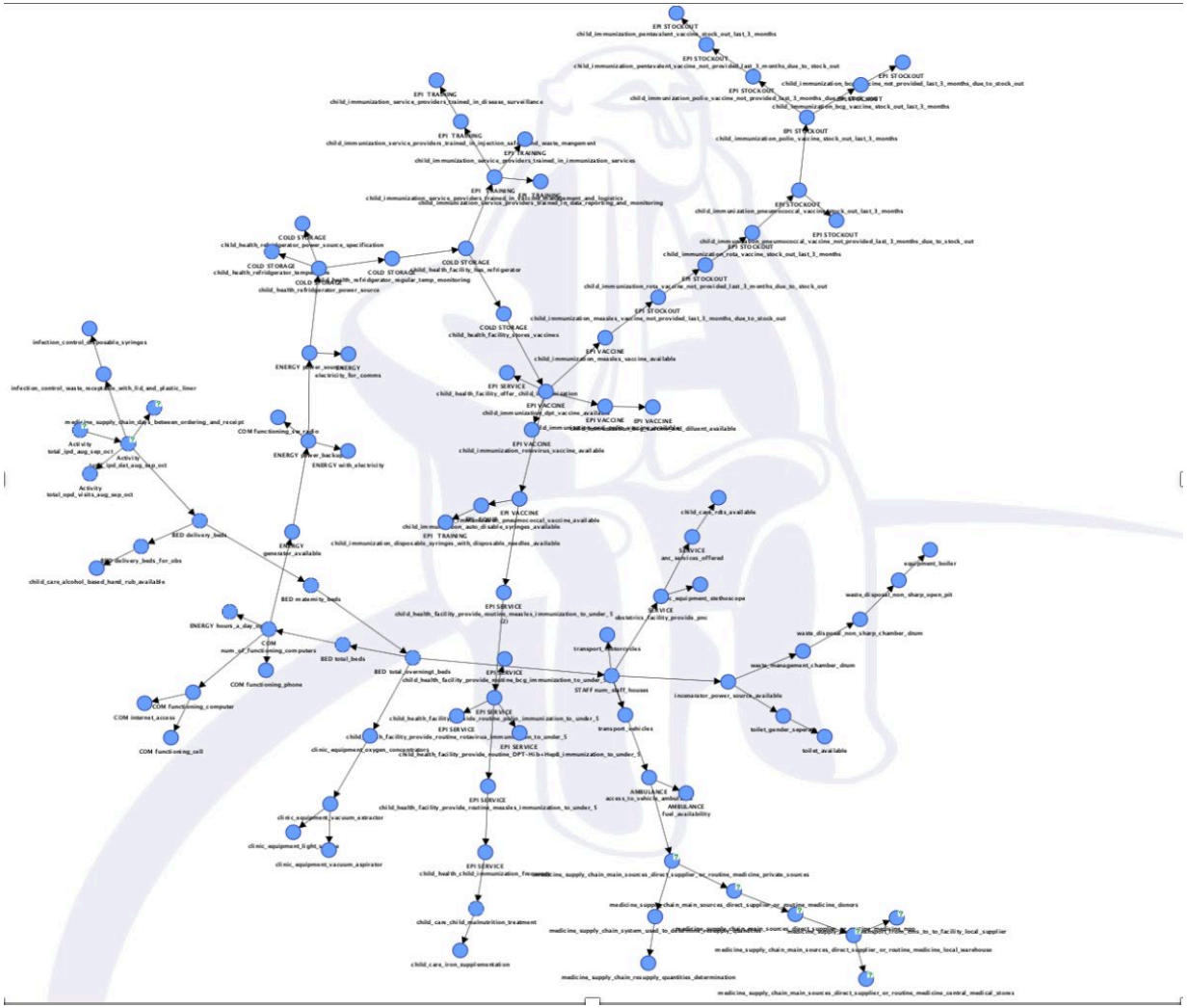


….to prohibit the addition of arcs between classes

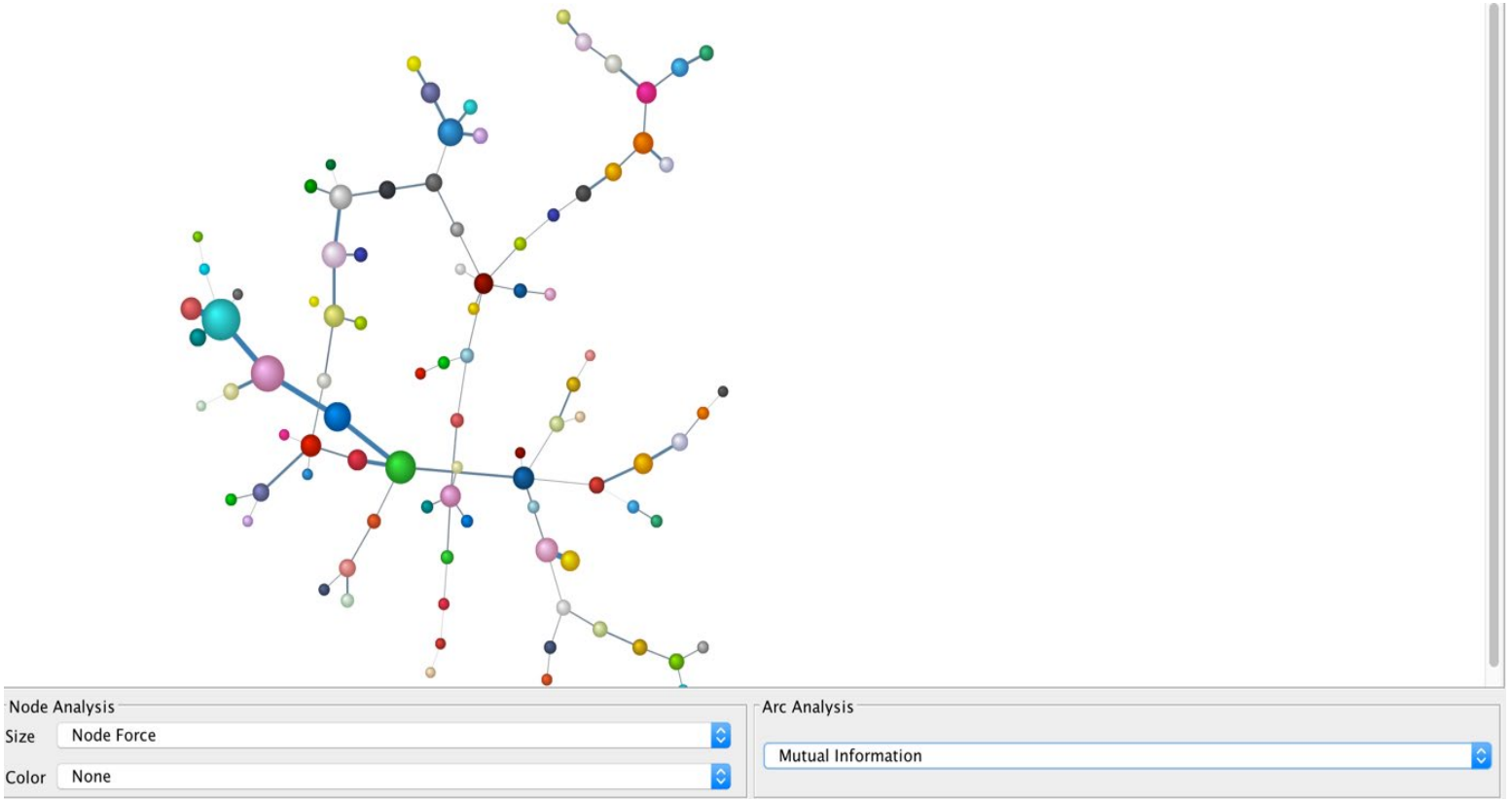
Unsupervised Structural Learning



Interpretable layout

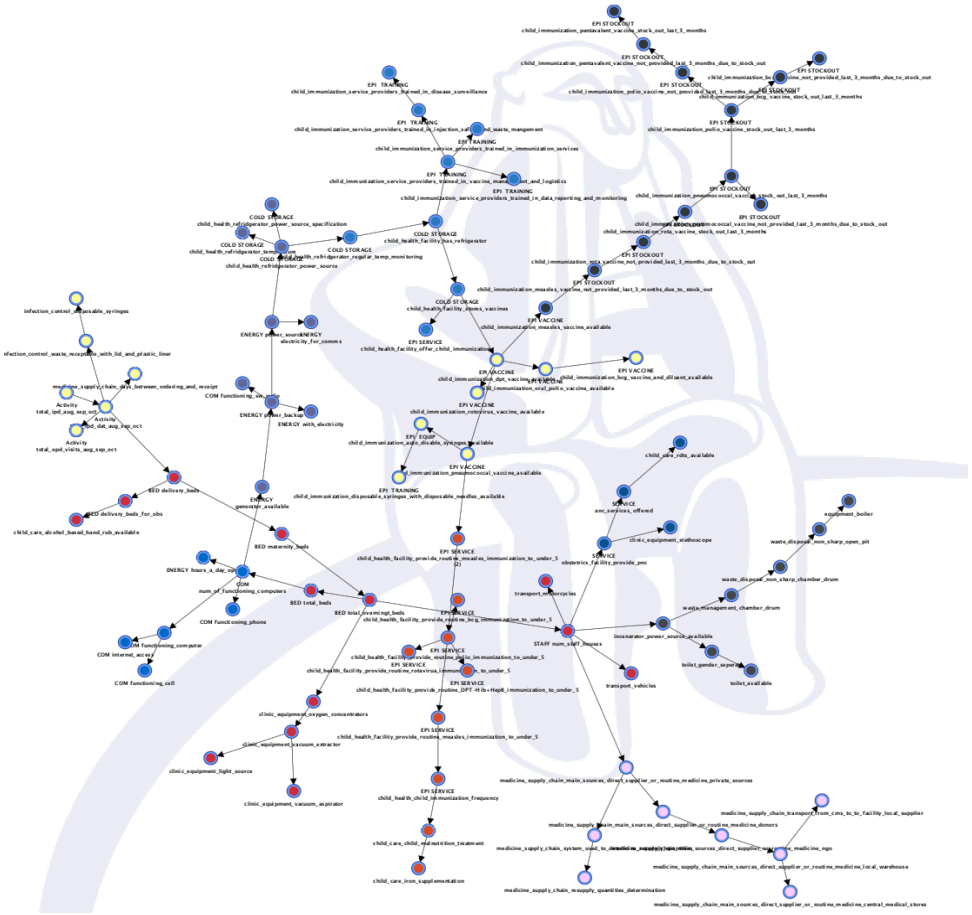


Mapping



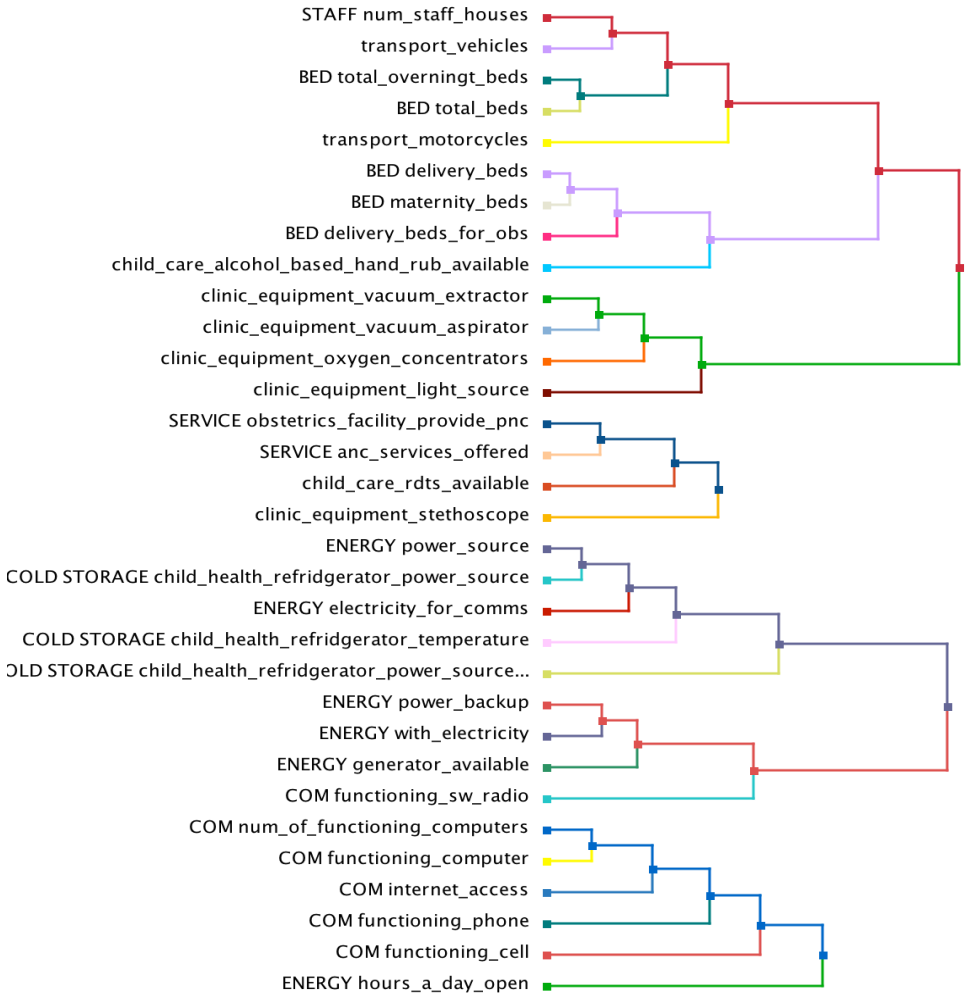
This visualization suggests that "vaccine stock out last 3 months", "service providers trained in vaccine management & logistics", "energy power source", "health facility provides routine polio immunization to under 5" or "total overnight beds" to mention a few

Variable Clustering



For setting up priorities… Still rather difficult !
Building blocks + grouping nodes into meaningful concepts

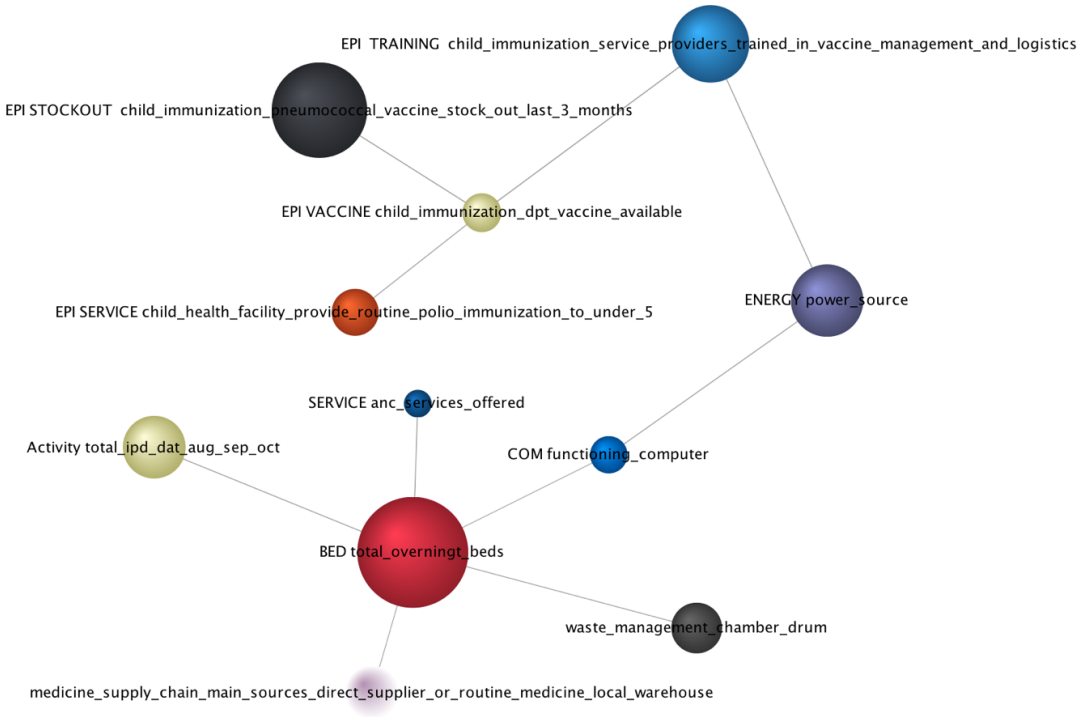
Dendrogram


STAFF num_staff_houses
transport_vehicles
BED total_overningt_beds
BED total_beds
transport_motorcycles
BED delivery_beds
BED maternity_beds
BED delivery_beds_for_obs
child_care_alcohol_based_hand_rub_available
clinic_equipment_vacuum_extractor
clinic_equipment_vacuum_aspirator
clinic_equipment_oxygen_concentrators
clinic_equipment_light_source
SERVICE obstetrics_facility_provide_pnc
SERVICE anc_services_offered
child_care_rdts_available
clinic_equipment_stethoscope
ENERGY power_source
COLD STORAGE child_health_refridgerator_power_source
ENERGY electricity_for_comms
COLD STORAGE child_health_refridgerator_temperature
OLD STORAGE child_health_refridgerator_power_source...
ENERGY power_backup
ENERGY with_electricity
ENERGY generator_available
COM functioning_sw_radio
COM num_of_functioning_computers
COM functioning_computer
COM internet_access
COM functioning_phone
COM functioning_cell
ENERGY hours_a_day_open

Main sub-components

COLD CHAIN

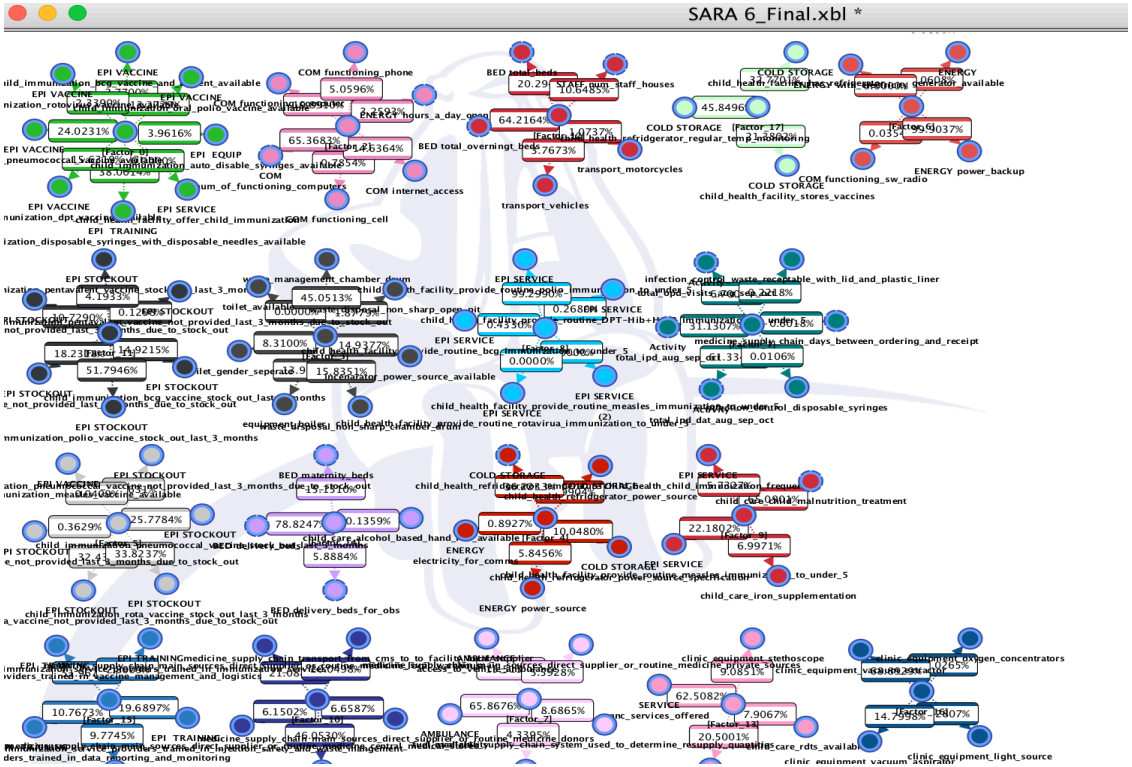
Vaccines are delicate products Most critical: national / regional cold store



TRAINING

Staff turnover rates and the introduction of new vaccines and technologies …

New latent Factor Induction via Multiple Clustering



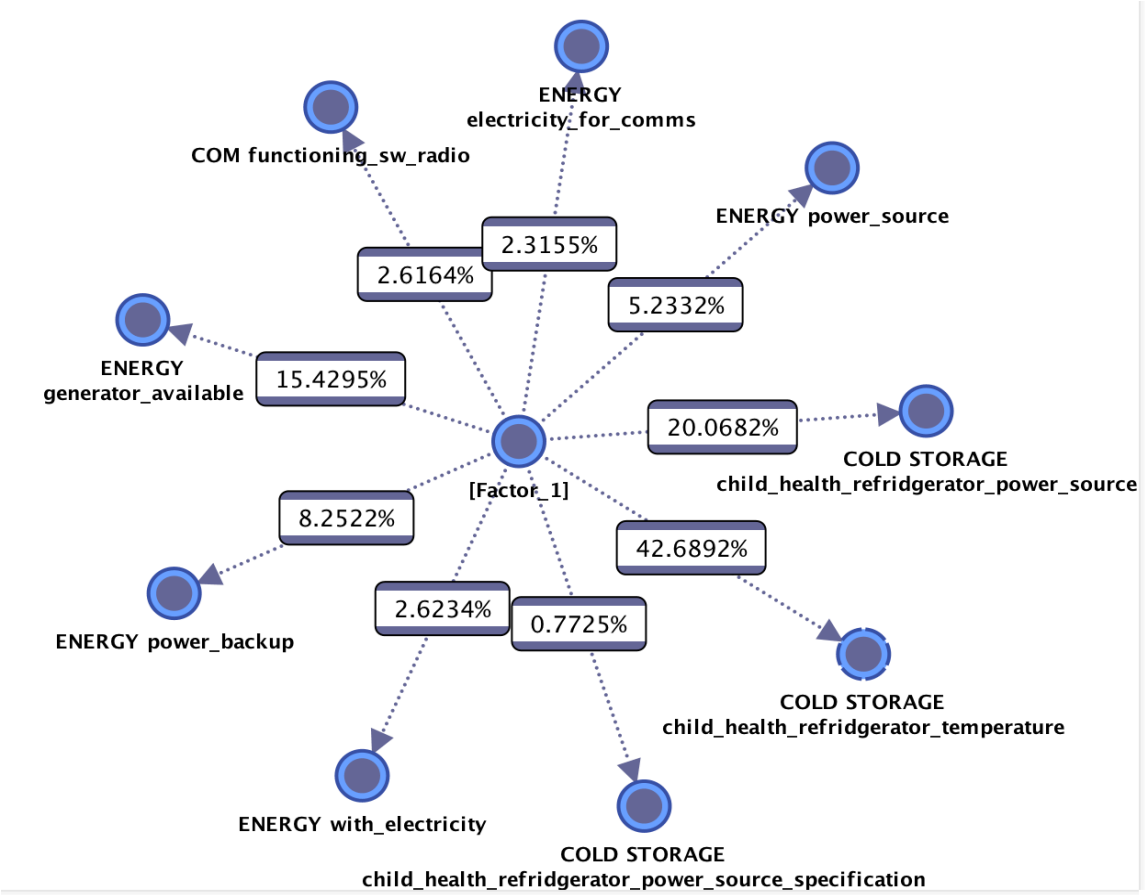
11 new dimensions in our network.

New mindset needed

System thinking skills

Usual approach	Systems thinking approach
Static thinking	**Dynamic thinking**
focus on events	focus on patterns of behaviour
Systems as effect	**Systems as cause**
behaviour as externally driven	responsibility for behaviour from internal actors and rules
Tree-by-tree thinking	**Forest-thinking**
knowledge from understanding details	knowledge from understanding contexts of relationships
Factors thinking	**Operational thinking**
concentrating on factors that influence or correlate	concentrating on causality and how behaviour is generated
Linear thinking	**Loop thinking**
view causality running in one direction	View causality as an on-going process with feedback influencing causes

Latent factor can already tell a story …

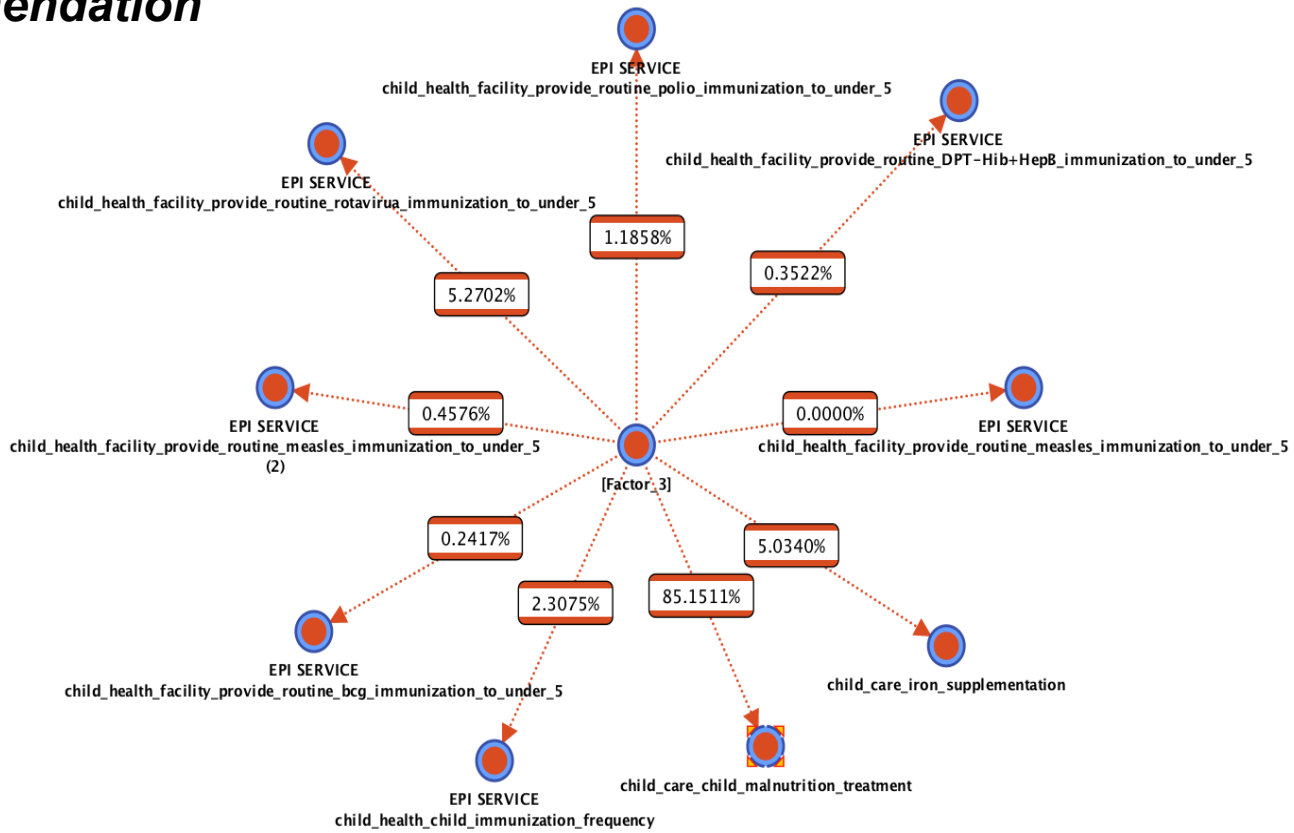


An example of story (Quality assurance) is temperature monitoring…

Factor States/Values

WHO recommends ….Every opportunity' or 'vial-opening' recommendation

multidose vial for a small session size

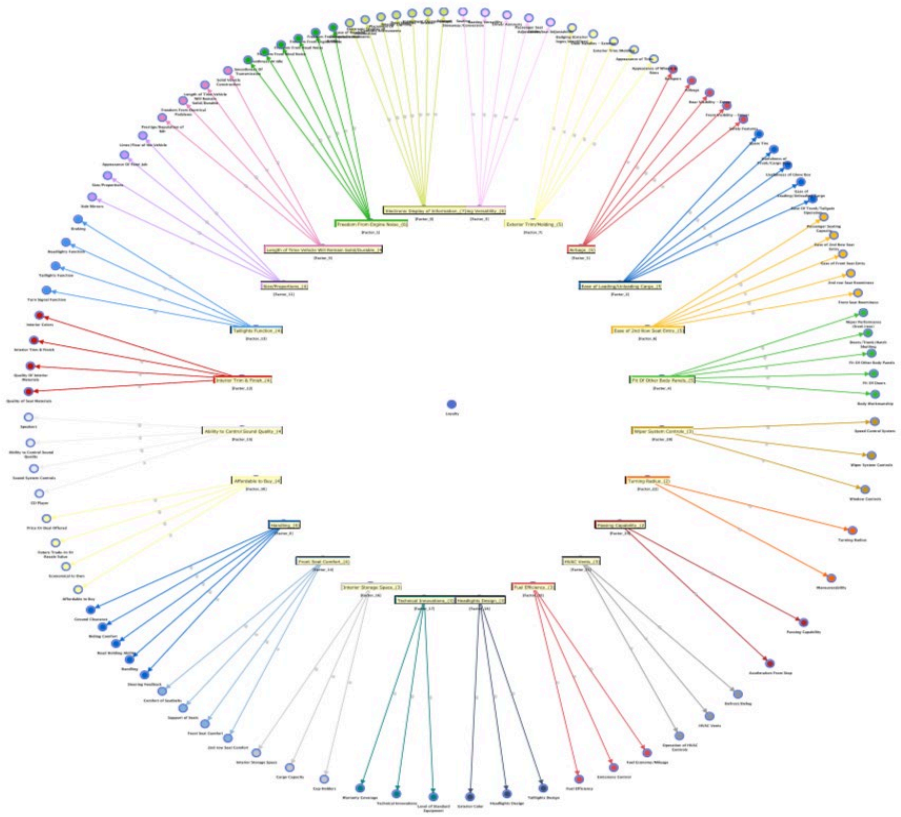


children are turned away

Commonly used 20-dose Bacillus Calmette Guérin (BCG) vaccine

Introducing the Target Node

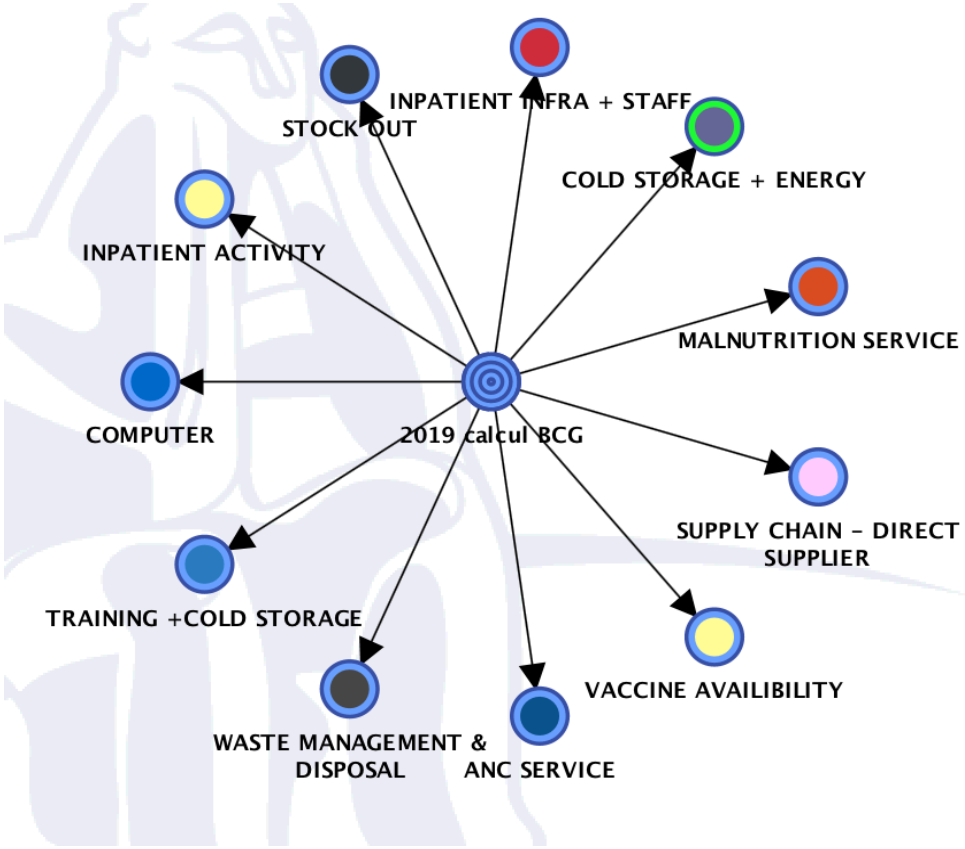
The outer ring contains the 91 manifest nodes



the inner ring consists of the 11 factors

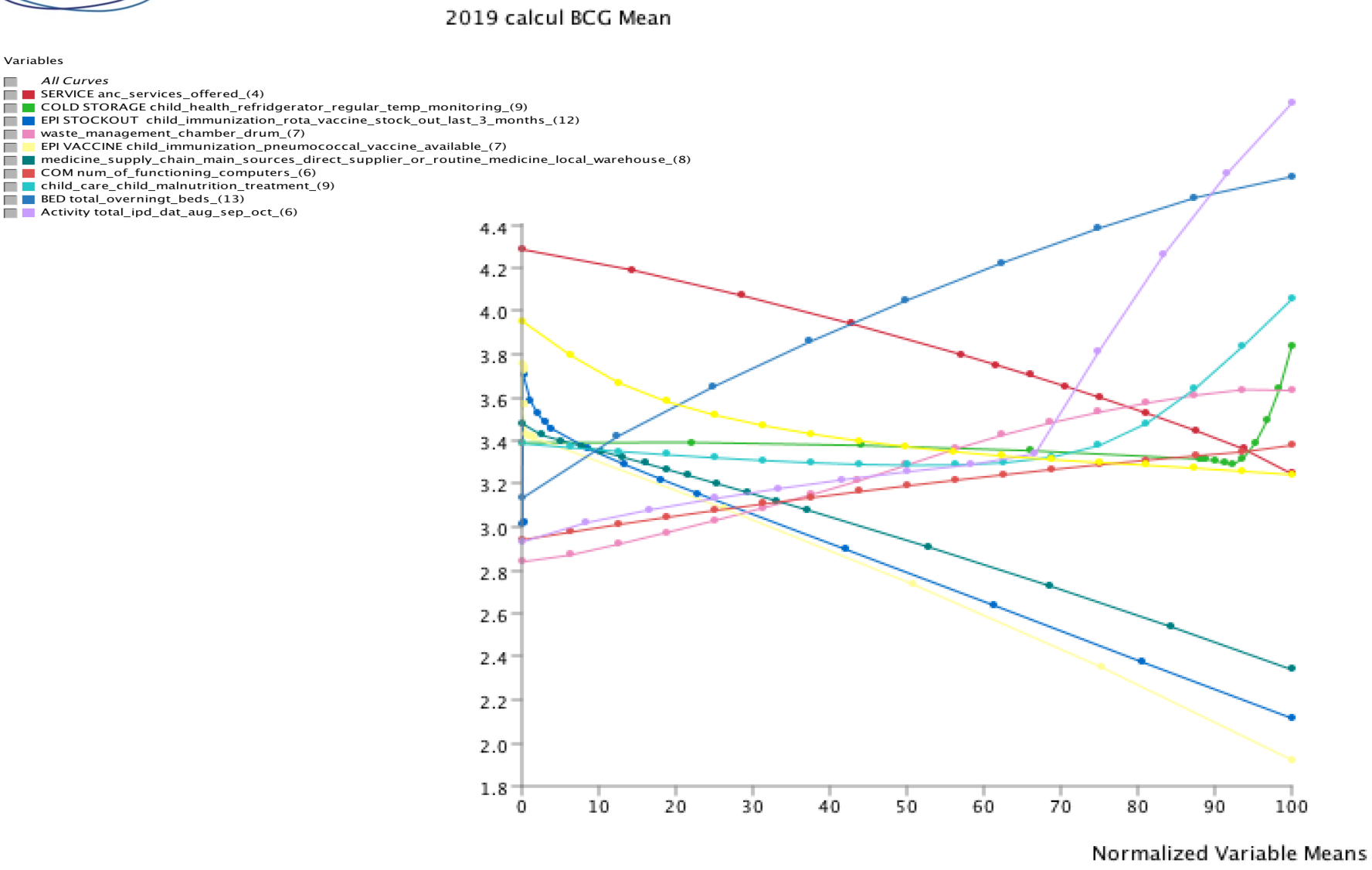
the yet-to-be-connected Target Node
exclusively with the factors

Supervised Learning

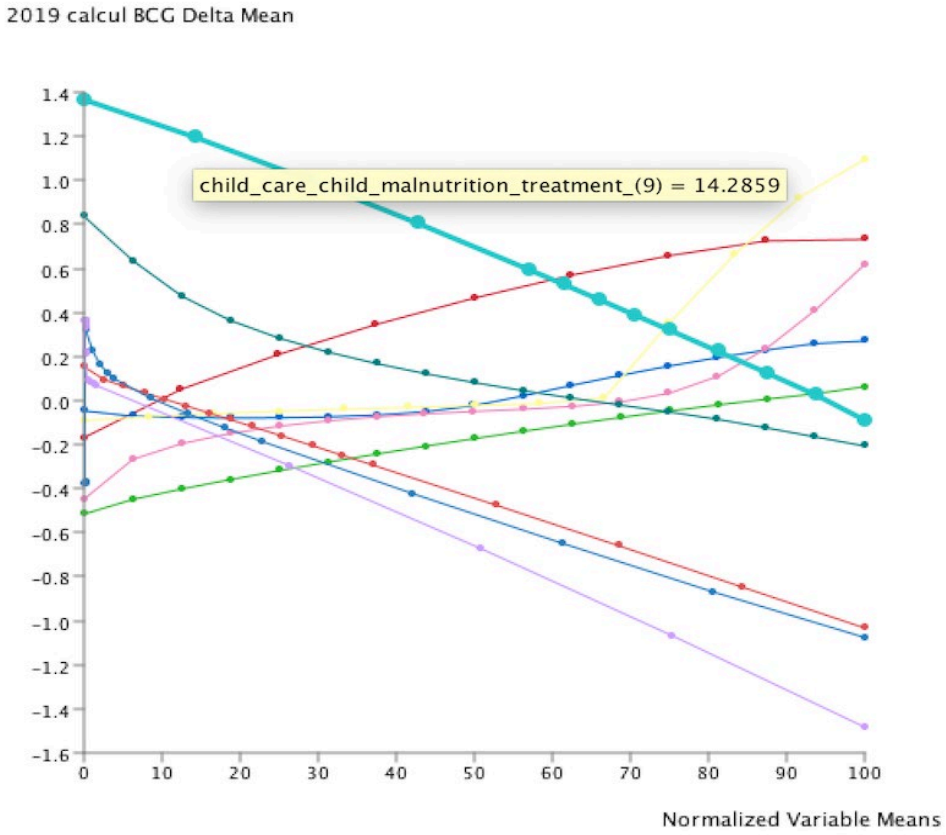


Bayesian network has a structure entirely dedicated to the characterization of a target variable

Target Mean Analysis

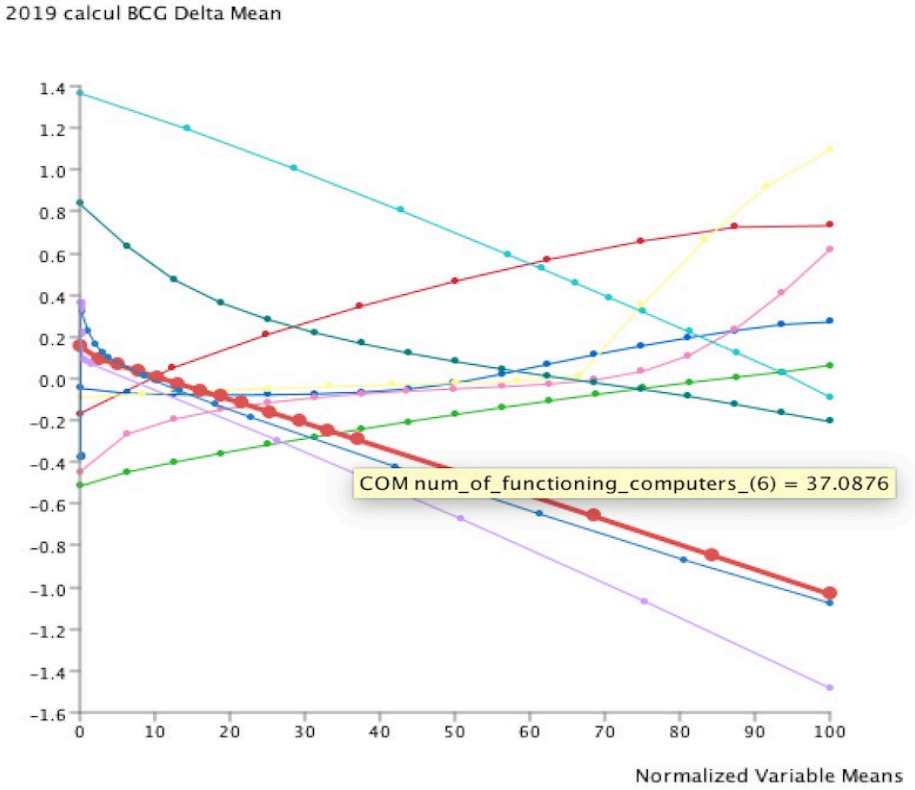


Positive effect when an increase of...
Child malnutrition treatment

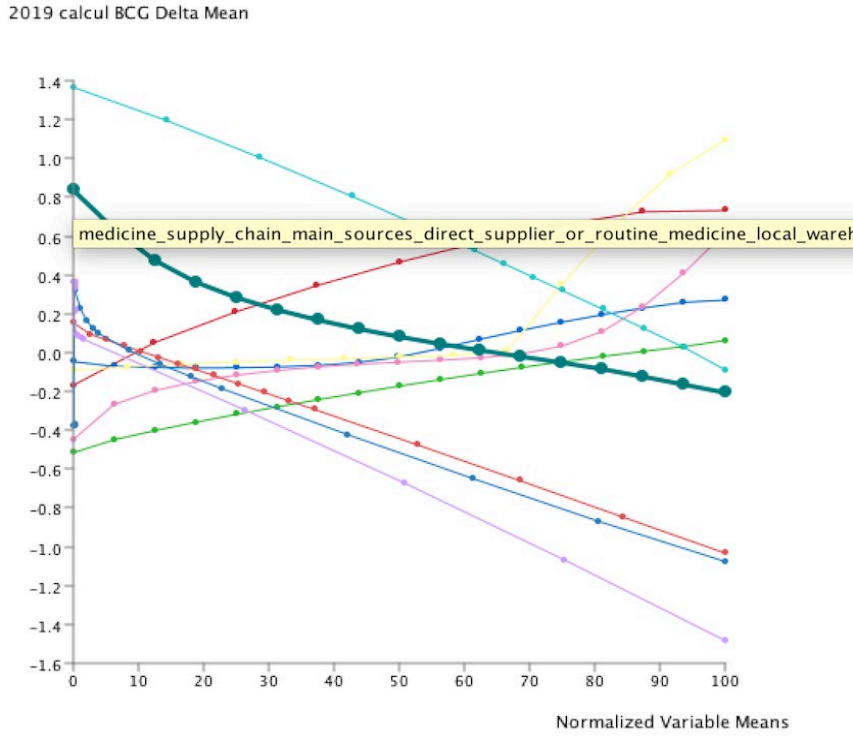


Optimizing immunization session frequency with session size and vial size

Positive effect when an increase of…
Direct medicine supplier - Number of computers

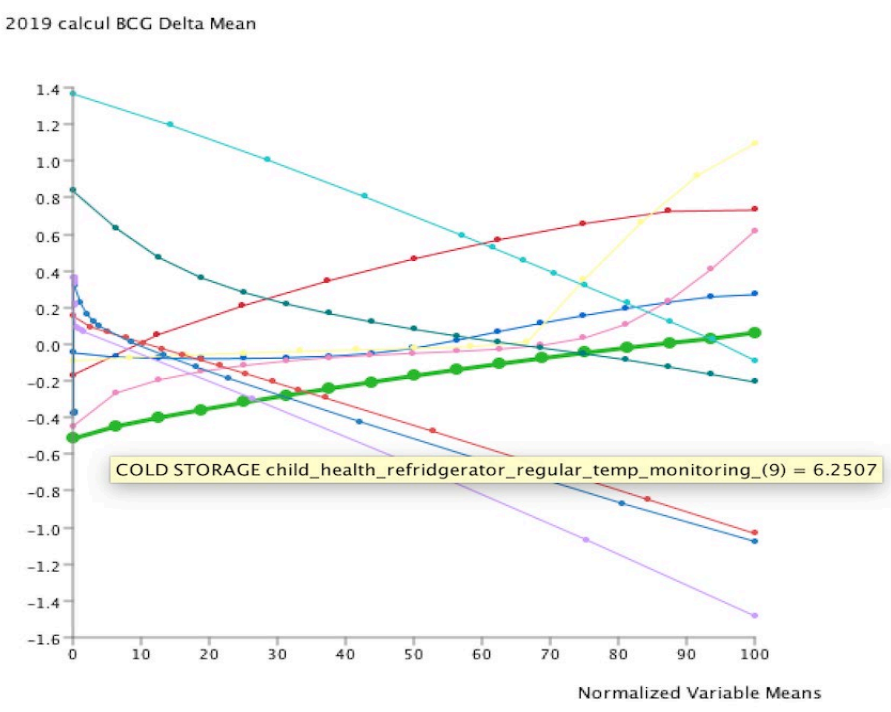


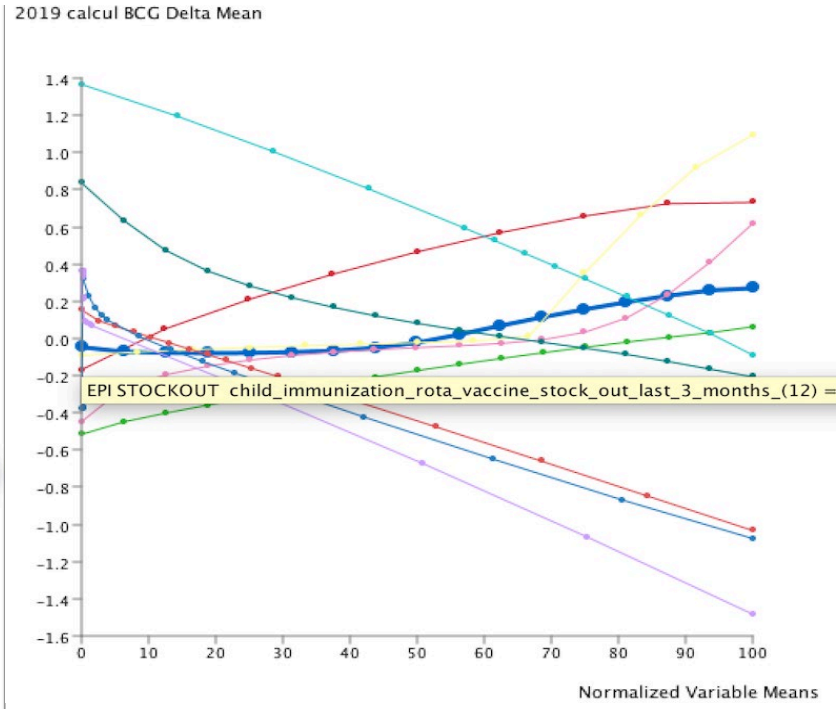
Right quantity at the right place at the right time …drone in Ghana !



Computers are efficiently used for stock management and forecasting calculation

Negative effect when an increase of…
Rota vaccine stock-outs - Refrigerator temperature

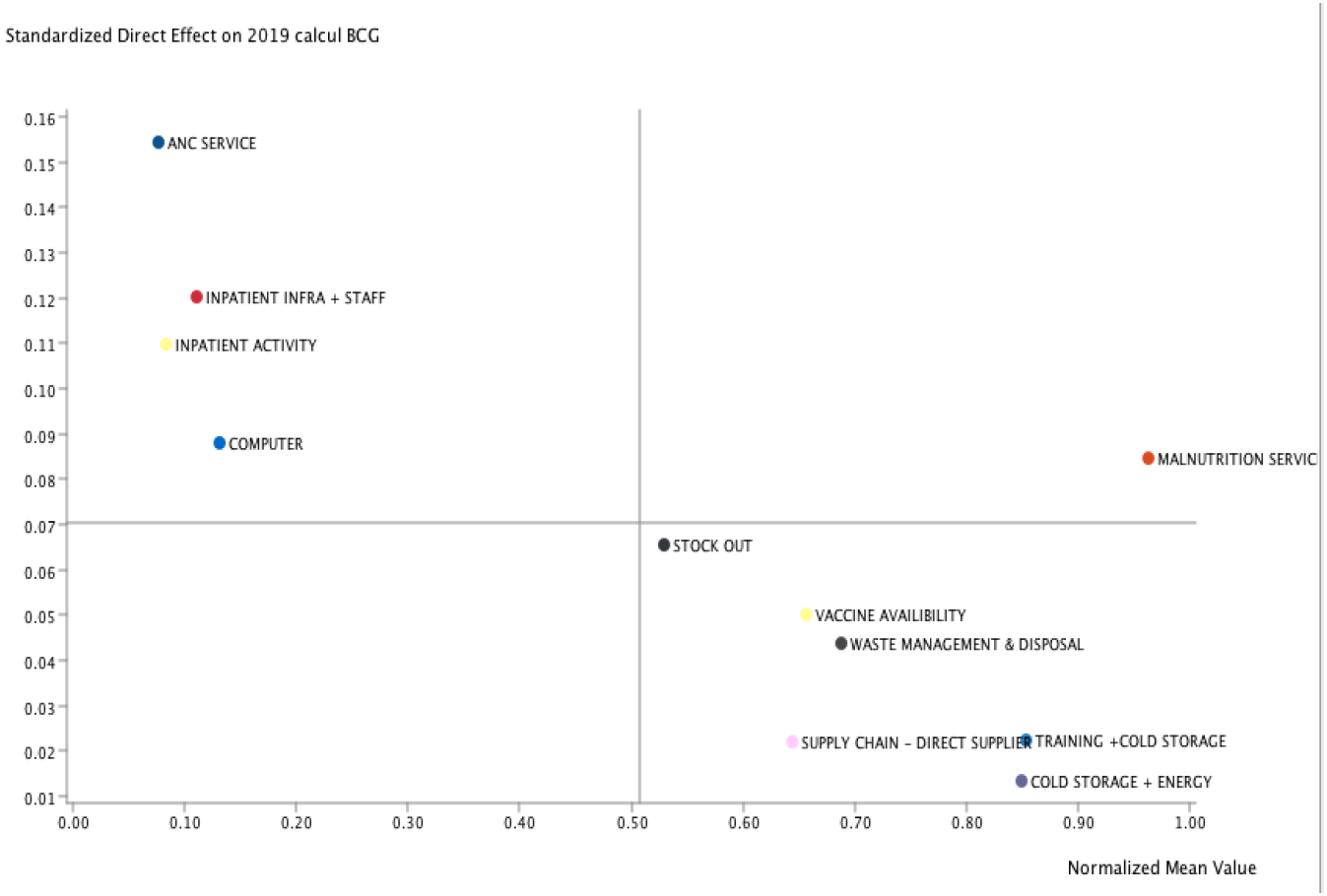




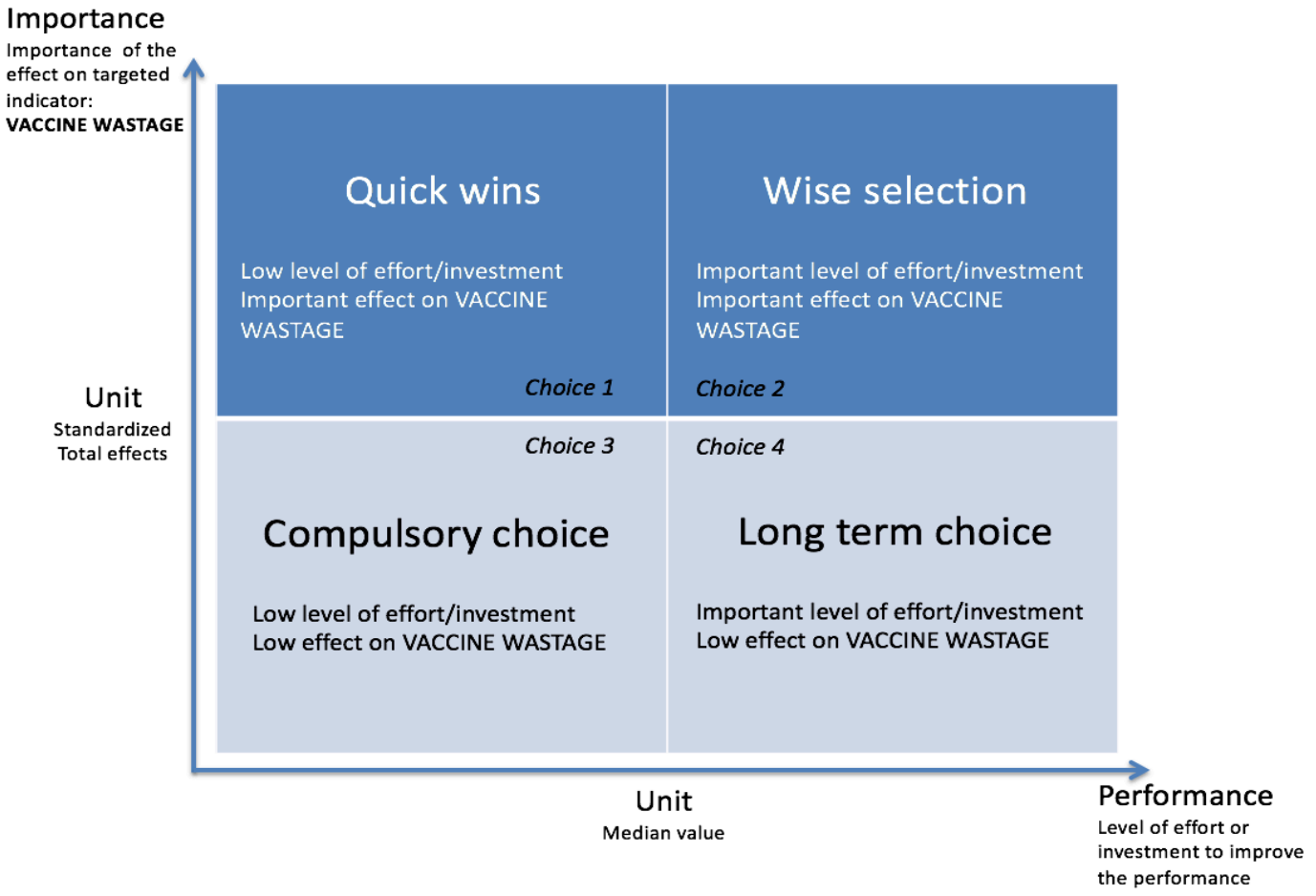
Earliest-expiry-first-out (EEFO) principle

Heat-damaged vials, frozen vials or vials with cumulated T° tracking beyond the discard point

Select Quadrants ...Scatterplot matrix



Conceptual diagram

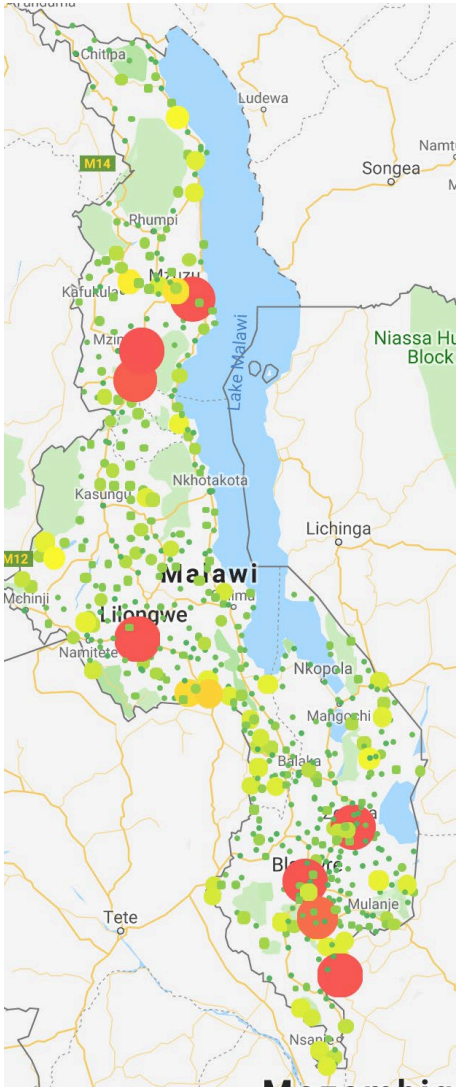


Map: Categorized wastage rate / health facilities

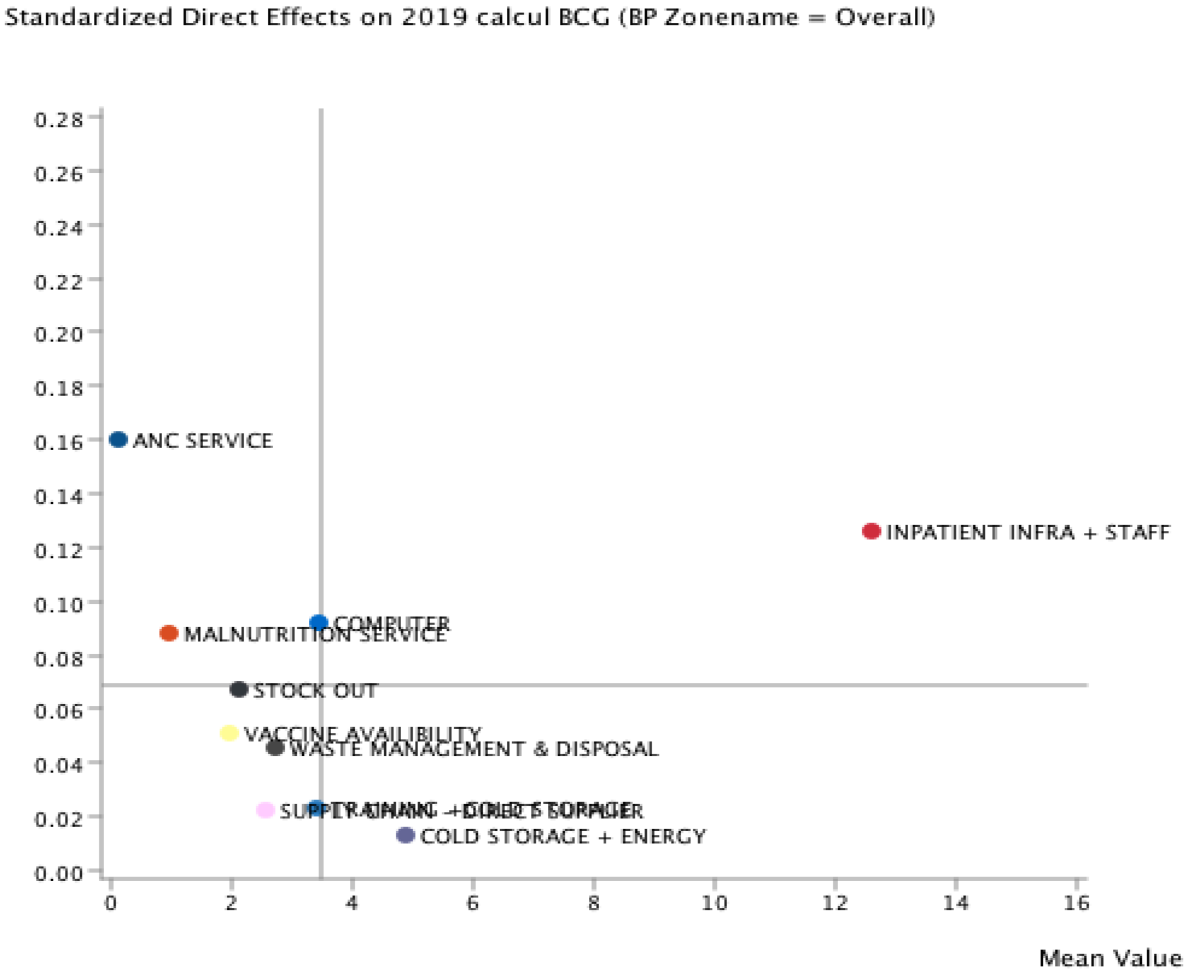
little practical use

effect heterogeneity

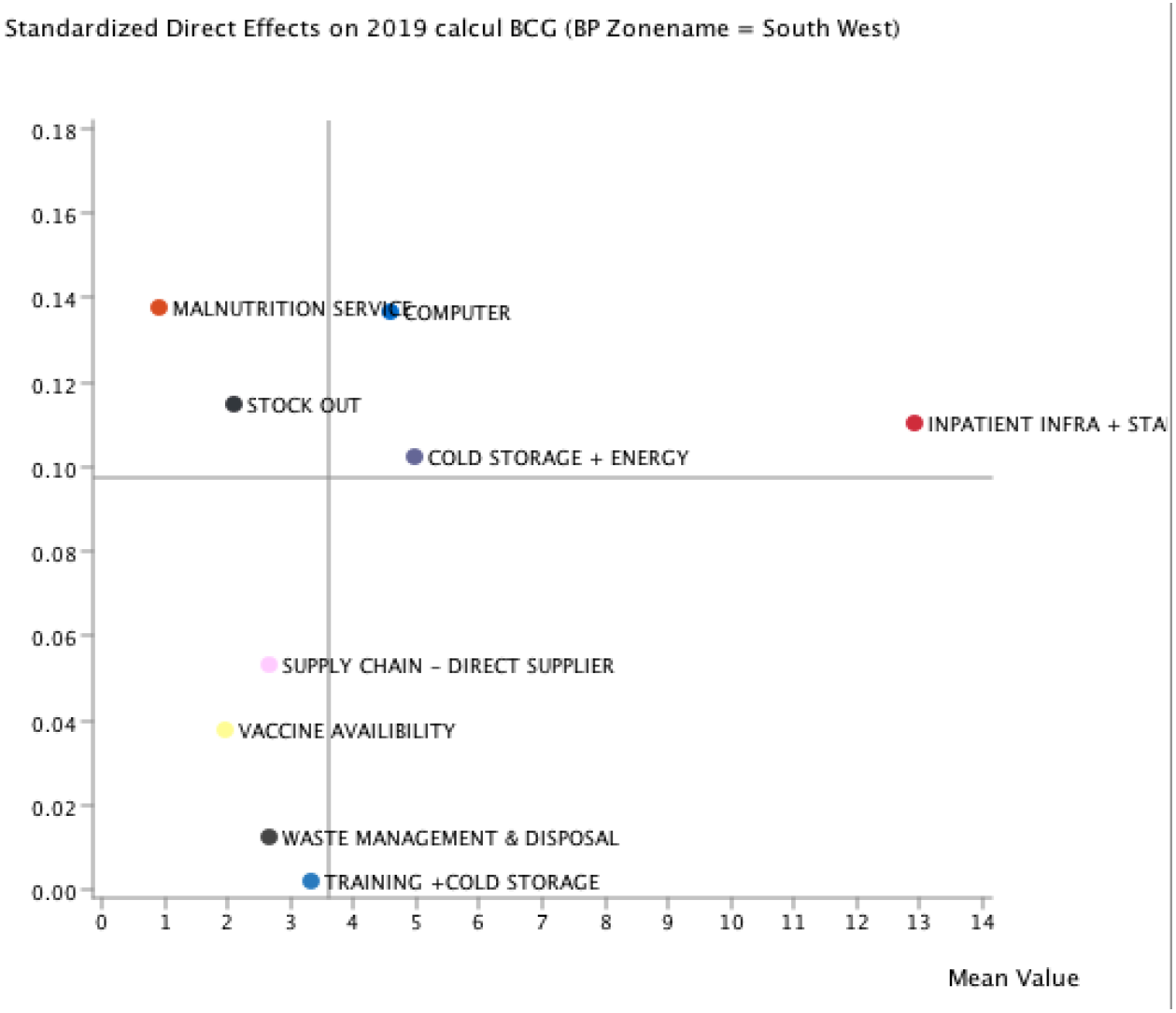
Breaking out variable



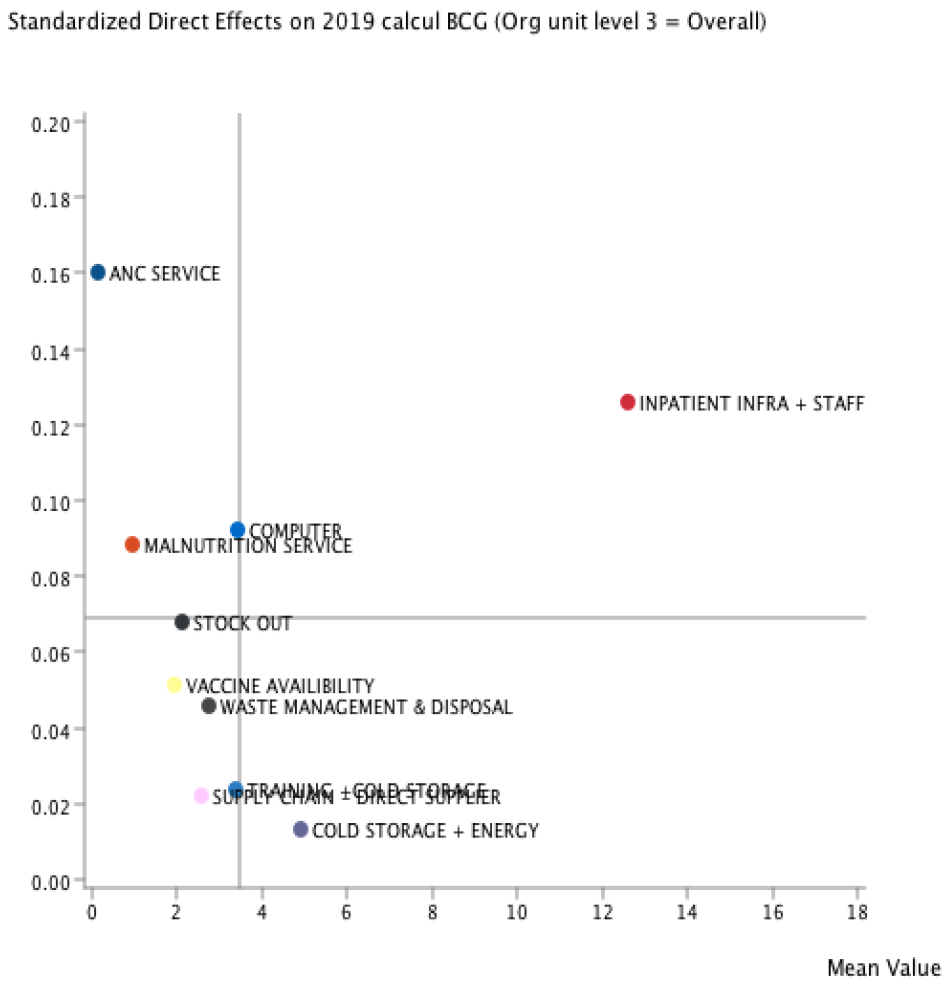
Multi-Quadrant Analysis: Region



South West region



Multi-Quadrant Analysis: District



Multi-Quadrant Analysis: Actors

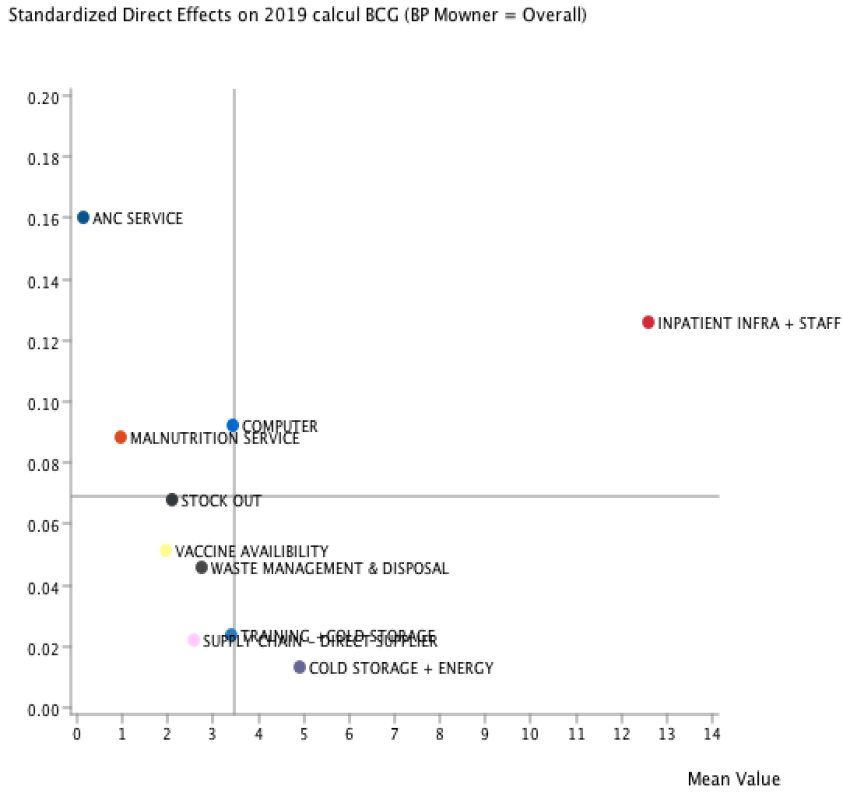
Organizational component
Ownership of the Health Facility

Government

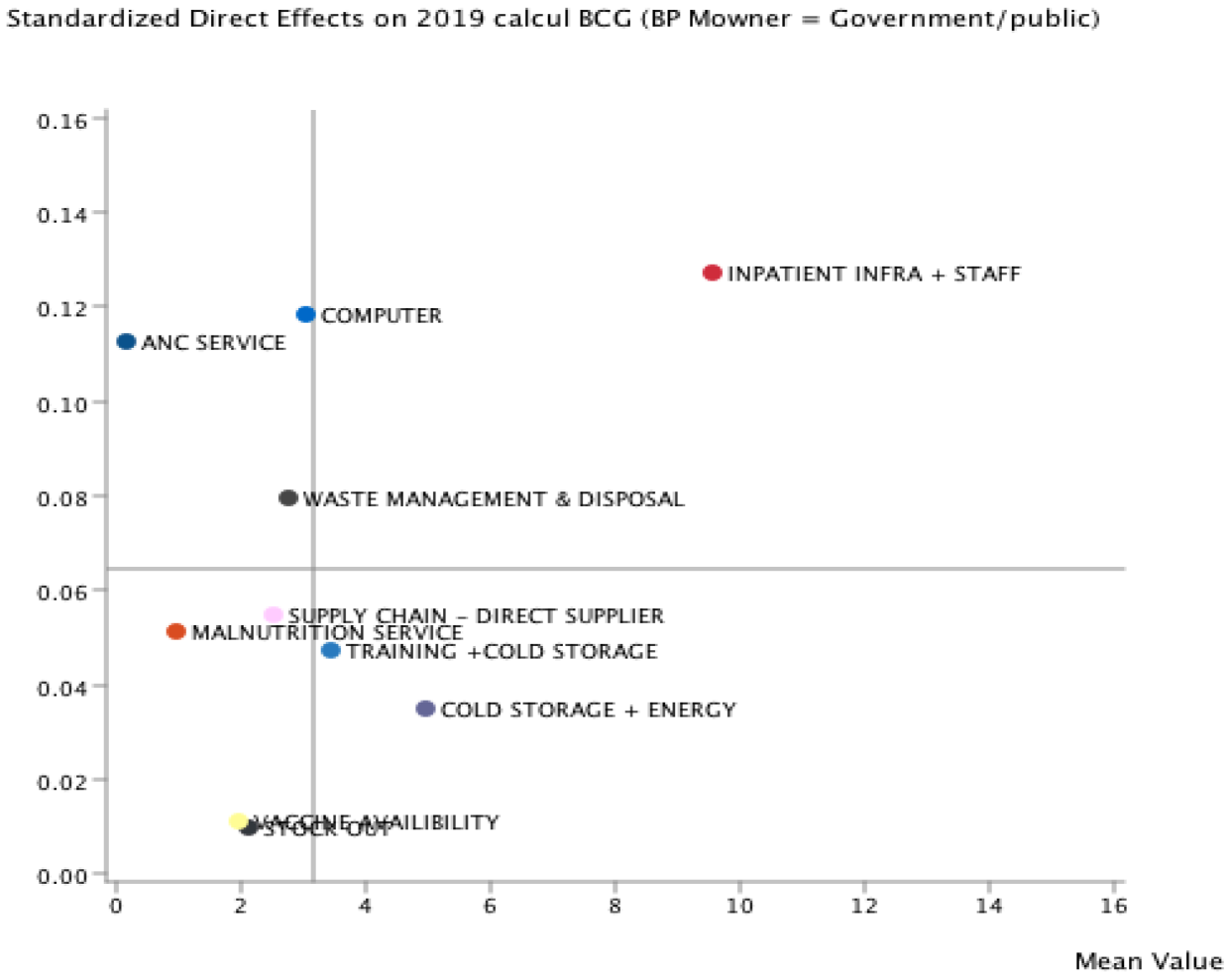
Christian Health Associations of Malawi

Private

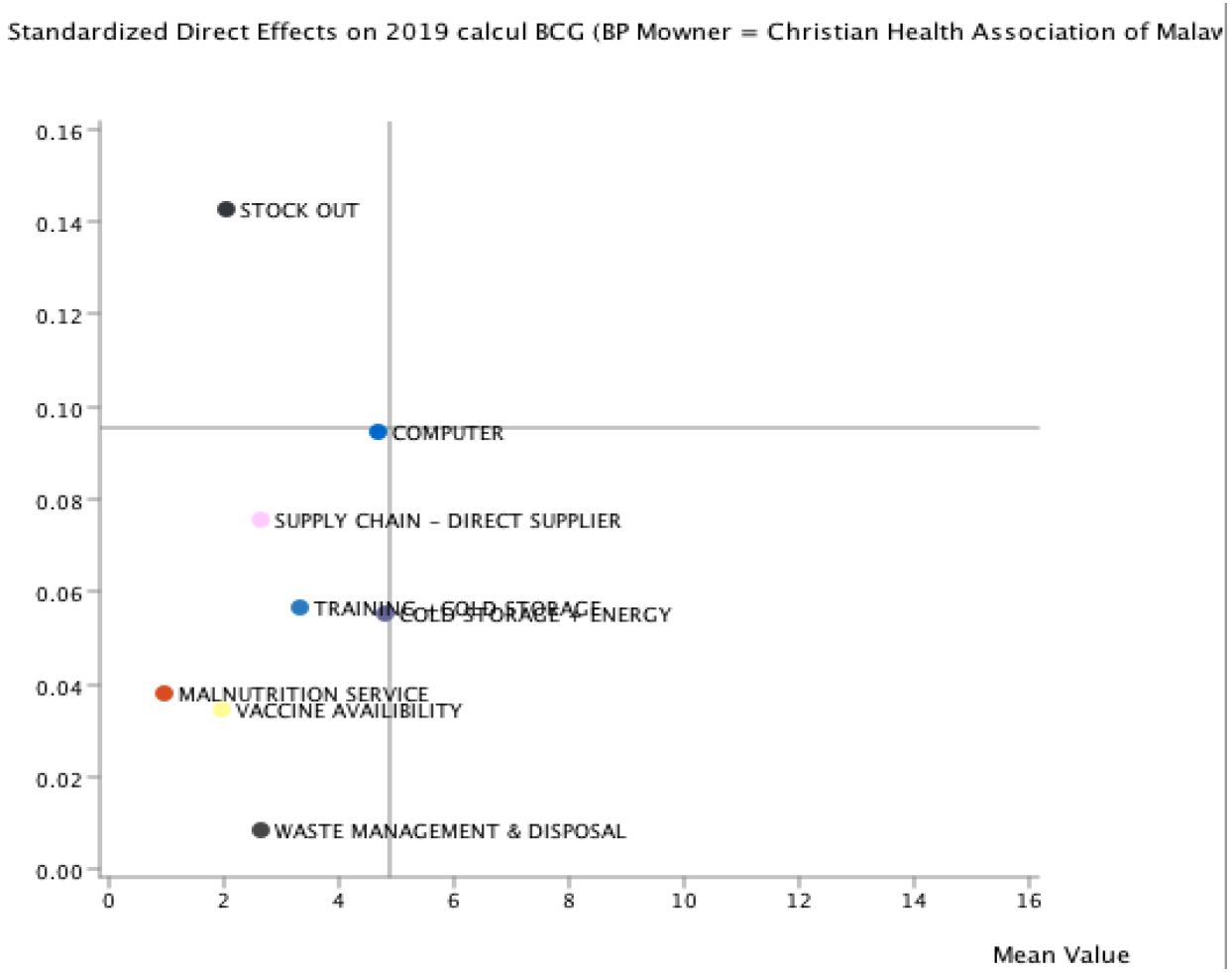
NGO



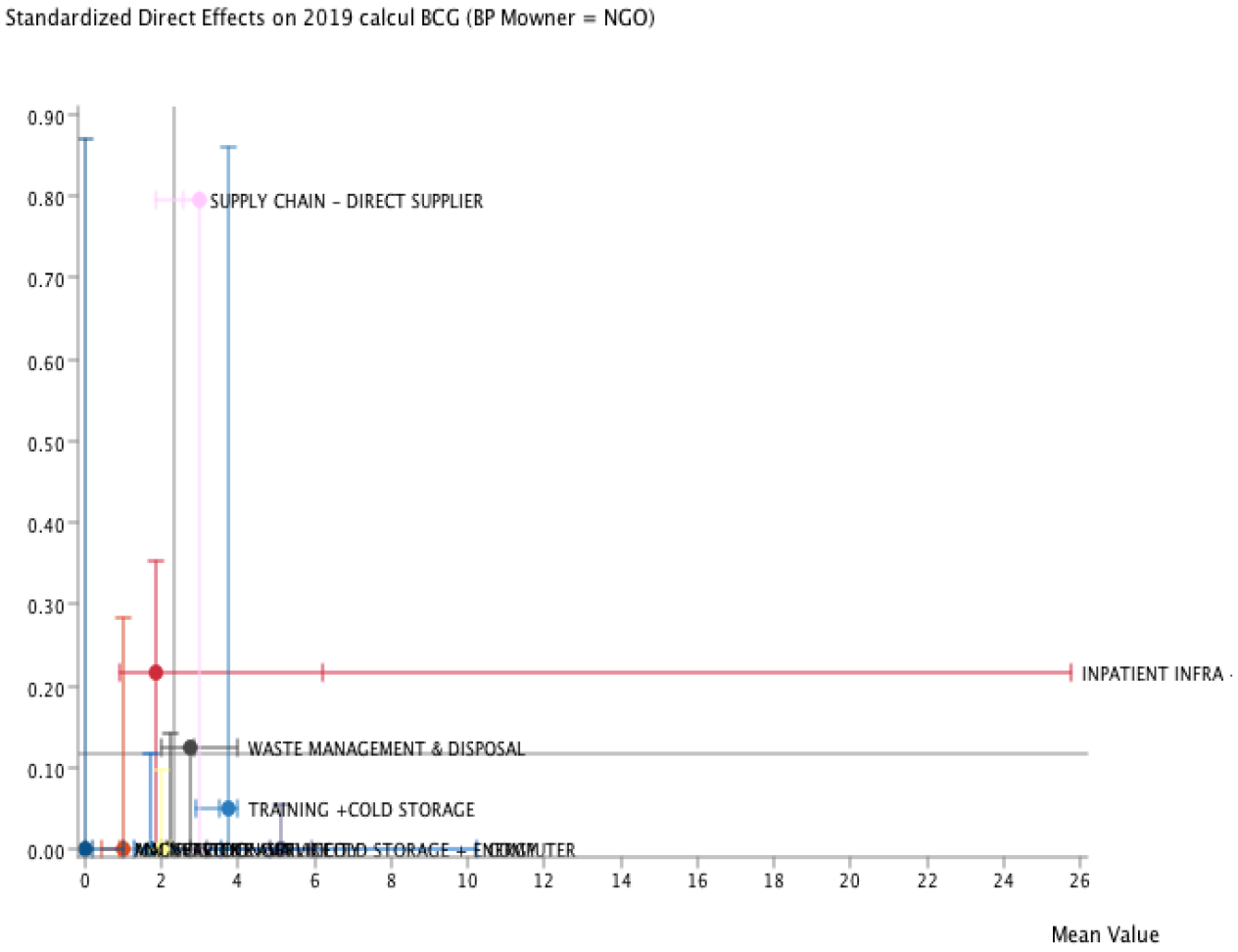
Government


Standardized Direct Effects on 2019 calcul BCG (BP Mowner = Government/public)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
2
4
6
8
10
12
14
16
INPATIENT INFRA + STAFF
COMPUTER
ANC SERVICE
WASTE MANAGEMENT & DISPOSAL
SUPPLY CHAIN – DIRECT SUPPLIER
MALNUTRITION SERVICE
TRAINING +COLD STORAGE
COLD STORAGE + ENERGY
VACCINE AVAILIBILITY
STOCK OUT
Mean Value

Christian Health Associations of Malawi



Horizontal/Vertical Scales

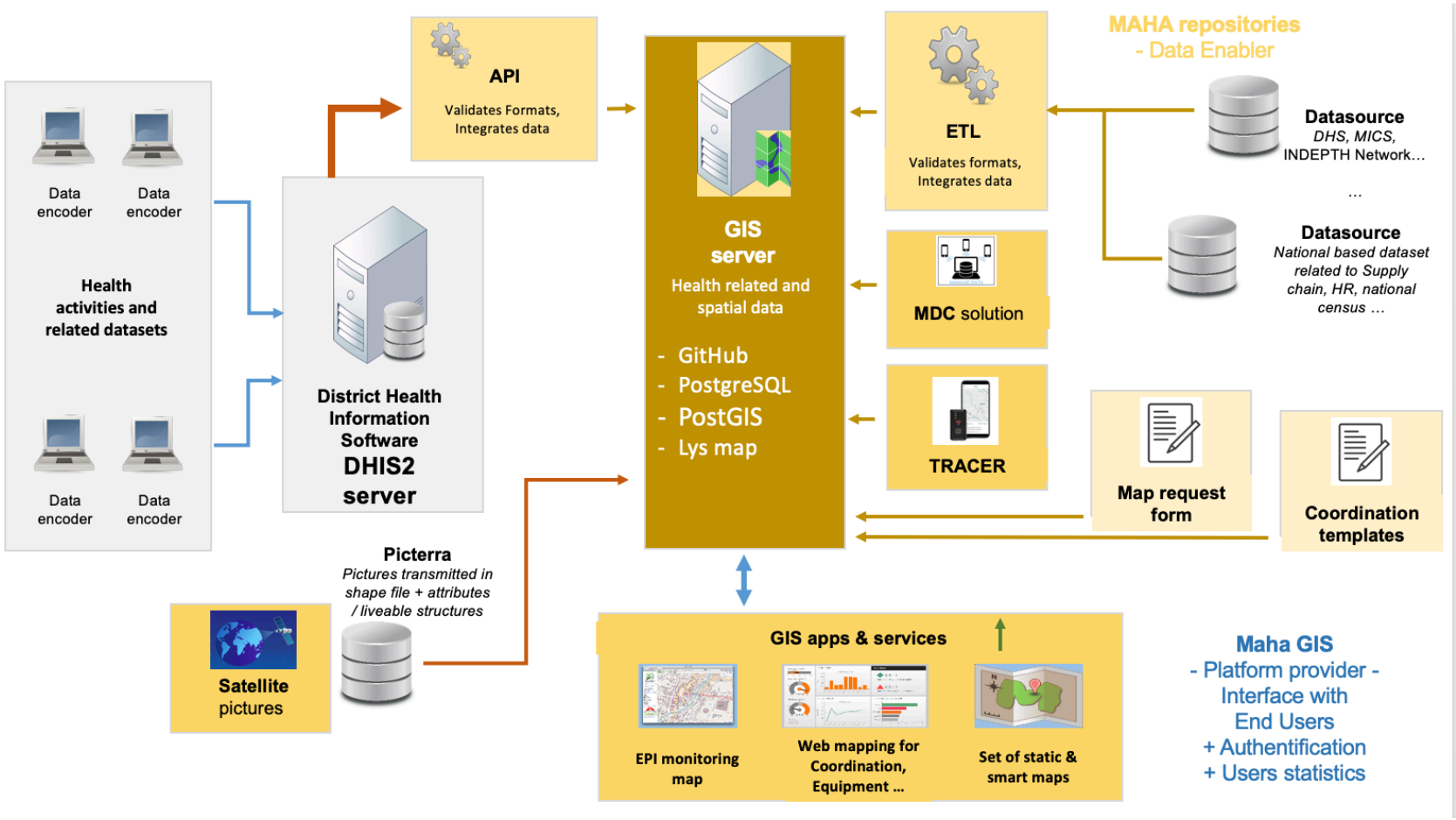


TAKE AWAY POINTS

Bayesian Network can be applied to Immunization programs

- As a practically feasible form of knowledge representation Bayesian networks is attractive for exploring and explaining complex problems.
- Ability of capturing both qualitative knowledge through their network structure: Theory of change for Immunization program, and quantitative knowledge through health information system.
- With this approach, public policy researchers can quickly and transparently, generate clear recommendations for decision makers.

MAHA GIS platform Development Strategy



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FOCUS
LA BOMBE URBAINE
THE URBAN BOMB
Quel impact pour les humanitaires ?
Which impact for humanitarian workers?

Thank you

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