WHO Malaria Surveillance Reference Manual

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Global Malaria Programme

World Health Organization
FIG. 1.
*Global technical strategy for malaria 2016–2030: framework, pillars and supporting elements*

**Global technical strategy for malaria 2016–2030**

- **Pillar 1**
  - Ensure universal access to malaria prevention, diagnosis and treatment

- **Pillar 2**
  - Accelerate efforts towards elimination and attainment of malaria-free status

- **Pillar 3**
  - Transform malaria surveillance into a core intervention

**Supporting element 1. Harnessing innovation and expanding research**

**Supporting element 2. Strengthening the enabling environment**
Previous documents and the elimination framework
1. The two manuals have been combined into a single document and their content has been updated.

2. The revised manual is aligned with both the GTS and the *Framework for malaria elimination* (2017), which define the concept of a “malaria elimination continuum” & new ways of classifying foci in elimination settings.

3. New sections are included to cover surveillance in the private and community sectors and migrant and mobile populations and mapping of foci.

4. Four new sections have been added:
   1. surveillance of antimalarial drug efficacy and drug resistance;
   2. routine and focus-linked entomological surveillance;
   3. forecasting, early warning and detection of epidemics; and
   4. monitoring and evaluation of national malaria programmes (NMPs).

5. Basic resources for surveillance data analysis are presented, and the case and focus investigation forms have been updated.
FIG. 2.
**Malaria heterogeneity across the transmission continuum**
As transmission decreases, malaria becomes focal, and the intensity and frequency of reporting increase. Surveillance systems evolve from reporting aggregate case data by month over large geographical areas (e.g. district) to reporting near-real-time individual case data in small areas (foci).

<table>
<thead>
<tr>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
<th>Very low</th>
<th>Zero Maintain zero</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-receptive</td>
<td></td>
<td>Receptive with malaria transmission</td>
<td>Malaria without defined foci</td>
<td></td>
</tr>
<tr>
<td>Receptive, but no malaria</td>
<td></td>
<td></td>
<td>Malaria in active foci</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Monthly aggregate reporting</td>
<td>Monthly or weekly aggregate reporting</td>
<td>Weekly reporting</td>
<td>Immediate notification</td>
<td></td>
</tr>
</tbody>
</table>
Accurate parasitological diagnosis of a malaria case is the foundation of a malaria surveillance system.

All major components of a malaria surveillance system should be integrated into broader health management information systems (HMIS), including, where applicable, systems for reporting notifiable diseases.

National SOPs for surveillance should be based on a country’s needs and on WHO recommendations.

Regardless of the malaria burden, front-line staff involved in the detection, recording and reporting of cases should also be the first users of data.

Surveillance systems should address the heterogeneity of malaria within a country’s boundaries.

Necessary investments in surveillance and system transition, including in human resources, should be made to respond to the anticipated reduction in disease burden.

All surveillance data must be linked to a decision at some level of the health system, even if the decision results in no immediate change in interventions.
• In all transmission settings, a concerted effort must be made to include cases detected in other sectors (e.g. in private and other non-governmental health care facilities), as well as those detected in public health facilities.

• After interruption of transmission, surveillance for malaria may become the broad responsibility of general health services.

• Like most other health interventions, surveillance is likely to benefit from innovation and advances in technology. The choice of new technology should be based on proven additional benefits and the cost and sustainability, determined from empirical evidence by leading experts in the field, supported with the relevant WHO recommendations.

• Good understanding of the biology and behavioural ecology of vector species is essential for making programme decisions and monitoring and evaluating vector control interventions, including quality assurance.

• Surveillance systems should be assessed routinely to ensure their accuracy, reliability, completeness, precision, timeliness and integrity. The assessment should also include the appropriateness of action taken as a consequence of the results of surveillance.
2. Establishing malaria surveillance systems

2.1 Requirements and processes
2.2 People-centred surveillance
2.3 Recording
2.4 Reporting
2.5 Data analysis and interpretation
2.6 Using data for making decisions in malaria control programmes
2.7 Structure of surveillance systems
2.8 Surveillance during prevention of re-establishment
2.9 Certification of elimination

FIG. 3.
The health information cycle, centred on a competent, adequately resourced health workforce

Dissemination and use

Interpretation and evaluation

People (the patients and communities whose details are registered, the health facility staff who gather and/or use the data and decision-makers both inside and outside the health service who use the data)

Recording

Analysis

Presentation

Reporting
Ch 2: Establishing malaria surveillance systems

FIG. 4.
Surveillance system processes and requirements along the continuum of malaria transmission settings

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
<th>Very low</th>
<th>Zero</th>
<th>Maintaining zero</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case detection</td>
<td>Passive case detection</td>
<td>Passive and active case detection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recording</td>
<td>Outpatient and inpatient registers</td>
<td>Individual patient forms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reporting frequency</td>
<td>Monthly</td>
<td>Weekly</td>
<td>Immediate case notification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution of reported data</td>
<td>Aggregate cases by sex and age category</td>
<td>Case report, age, sex, residence, travel history and case classification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data use: health facilities</td>
<td>Data analysed monthly</td>
<td>Weekly</td>
<td>Data analysed in real time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data use: intermediate levels</td>
<td>Data analysed monthly</td>
<td>Weekly</td>
<td>Data analysed weekly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data use: national</td>
<td>Data analysed monthly or quarterly</td>
<td>Weekly</td>
<td>Data analysed weekly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response time</td>
<td>Monthly or quarterly</td>
<td>Weekly</td>
<td>Case investigation within 24–48 h, focus investigation within 1 week</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedback frequency to upper and lower levels</td>
<td>Annually or quarterly</td>
<td>Monthly</td>
<td>Every 2 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surveillance system monitoring</td>
<td>Every two years</td>
<td>Annually</td>
<td>Annually or more frequently</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GTS, Global technical strategy for malaria 2016–2030; PR, parasite rate; API, annual parasite incidence
Active case detection includes both reactive case detection (RACD) triggered by an index case and proactive case detection (PACD) (see section 3.2).
FIG. 5.
Data flow and analysis, from national HMIS to NMP decision-making

National HMIS

Cases, deaths, tests, stocks etc.

NMP data repository

Malaria-specific data
- Human resources
- Logistics
- Funding
- Commodity procurements, stocks and distribution
- Population at risk
- Intervention coverage
- Efficacy studies
- Entomology
- Other

Bulletin
- Standard graphs, tables and maps

Report
- Monthly, quarterly or annually

Malaria management dashboard

Private
Public
Feedback

HMIS, health management information systems; NMP, national malaria programme
FIG. 6.
Processes and activities for establishing malaria surveillance for elimination

- Develop strategy, guidance and capacity
  - Develop surveillance SOP
  - Reach consensus on data elements and indicators
  - Establish case-based reporting system
  - Establish case and focus investigation system
  - Train health staff in SOP and system use
  - Establish infrastructure (tablets, PCs, transport etc.)
- Surveillance system ready for elimination
- Passive case detection, investigation, classification and notification
  - Notify within 24 h
  - Report line list of cases. Case investigation form completed for each patient
  - Define location of focus initially from routine case data. Maintain a focus register
- Further case investigation, detection and classification
  - Start when caseload is very low (e.g., ≤3 cases/week/investigation team)
  - Decide on investigation schedule, size of focus or detection radius
  - Decide on ACD (RACD, PACD or both)
  - Investigate and classify cases
- Entomological and environmental investigations
  - Use information on availability of sentinel site and on class of case and focus to trigger entomological and/or environmental investigation
- Focus response
  - Decide on response based on case and focus investigations of factors contributing to transmission and information on recent interventions in focus register
- Focus classification
  - Record response activities for case and focus

ACD, active case detection; M&E, monitoring and evaluation; PACD, proactive case detection; PC, personal computer; SOP, standard operating procedure
3. Concepts and practice of malaria surveillance

3.1 Case definitions
3.2 Case detection
3.3 Case classification
3.4 Focus classification
3.5 Routine activities in malaria elimination surveillance and response
3.6 Reactive surveillance activities in the focus
3.7 Focus response

FIG. 8. Classification of malaria cases

- Parasitologically confirmed malaria infection
- Due to mosquito-borne transmission
- Not due to mosquito-borne transmission
- Acquired abroad or outside area
- Acquired locally

- Imported
  - First-generation local transmission; epidemiologically linked to proven imported case
- Introduced
  - All cases without evidence of a direct link to an imported case
- Indigenous
  - Relapsing: History of P. vivax or P. ovale infection within past 3 years; no epidemiologically linked cases in vicinity
  - Recrudescent: Recurrence of asexual parasitaemia of the same genotype(s) that caused the original illness, due to incomplete clearance of asexual parasites after antimalarial treatment

- Induced e.g. due to blood transfusion, congenital malaria
FIG. 11.
**Case notification and case and focus investigation systems according to the “1–3–7 days” approach**

**Within 1 day: at local health facility**
- All cases of suspected malaria
  - Diagnosis by microscopy or RDT; treatment with recommended antimalarial agent
  - Case investigation form filled, preliminary case classification may be done, case notification by health worker to field team within one day

**Within 3 days: case investigation team**
- Locally acquired (indigenous, introduced)
  - Index case classification confirmed
  - Further investigation of index case and detection of other cases in the household

**Within 7 days: focus investigation team**
- Focus investigation (including expanded case detection, entomological, ecological and intervention assessments)
  - Active focus
  - Residual non-active
  - Cleared

**Response**
# Ch 3: Concepts and practice of malaria surveillance

**FIG. 10. Routine activities in focus-based surveillance and response**

<table>
<thead>
<tr>
<th><strong>Prevention</strong></th>
<th><strong>Passive case detection</strong></th>
<th><strong>Active case detection</strong></th>
<th><strong>Community mobilization</strong></th>
<th><strong>Drug efficacy surveillance</strong></th>
<th><strong>Entomological surveillance</strong></th>
<th><strong>Monitoring and evaluation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal coverage of IRS and/or LLIN</td>
<td>High coverage of routine case management services.</td>
<td>Monthly PACD during high transmission season (especially for vivax and ovale where relapse is a problem).</td>
<td>Case investigation and RACD when there are few cases (e.g., fewer than three per week per investigation team).</td>
<td>Routine community engagement and knowledge transfer on malaria prevention, treatment and environmental management.</td>
<td>Efficacy surveillance linked to case follow up of index cases and others detected in the community during RACD.</td>
<td>Register all foci.</td>
</tr>
<tr>
<td>Larviciding and other environmental management activities</td>
<td>High-quality diagnosis and treatment.</td>
<td>Case investigation and RACD when there are few cases (e.g., fewer than three per week per investigation team).</td>
<td>Investigate all cases during RACD.</td>
<td>Use ACD for supplementary community engagement.</td>
<td>(See section 4 for more information.)</td>
<td>Ensure all households are mapped.</td>
</tr>
<tr>
<td>Mass drug administration</td>
<td>Community health workers or volunteers in settings where access is low.</td>
<td>Monthly PACD during high transmission season (especially for vivax and ovale where relapse is a problem).</td>
<td>Investigate all cases during RACD.</td>
<td>Work with institutions that train the health workforce to ensure maintenance of good clinical and laboratory practice as malaria becomes rare.</td>
<td>(See section 5 for more information.)</td>
<td>Update population data by age category.</td>
</tr>
<tr>
<td></td>
<td>Individual case reporting and notification in place.</td>
<td>Case investigation and RACD when there are few cases (e.g., fewer than three per week per investigation team).</td>
<td>Investigate all cases during RACD.</td>
<td>Conduct spot checks in focus as necessary.</td>
<td>(See section 5 for more information.)</td>
<td>Update interventions implemented in foci.</td>
</tr>
<tr>
<td></td>
<td>Case investigation form completed at health facility, preliminary case classification implemented.</td>
<td>Case investigation and RACD when there are few cases (e.g., fewer than three per week per investigation team).</td>
<td>Investigate all cases during RACD.</td>
<td>Conduct spot checks in focus as necessary.</td>
<td>(See section 7 for more information.)</td>
<td>Reclassify foci annually, if necessary.</td>
</tr>
</tbody>
</table>

**ACD, active case detection; PACD, proactive case detection; RACD, reactive case detection; IRS, indoor residual spraying; LLIN, long-lasting insecticidal net; MDA, mass drug administration; LSS, larval source management; SOP, standard operating procedures.**

* Larval source management should be used where vector breeding sites are few, fixed and findable. Routine sentinel entomological surveillance should be maintained in all transmission settings. For entomological surveillance during focus investigation, see section 5.

* See WHO recommendations and mass drug administration field manual (23) for further guidance.
Ch 3: Concepts and practice of malaria surveillance

Follow up all cases to ensure compliance with treatment and complete cure.
<table>
<thead>
<tr>
<th>Transmission level</th>
<th>Standard inclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Patients, aged 6–59 months, with fever and 2 000–200 000 asexual parasites/µL.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Patients with fever or a history of fever, children ≤ 12 years and 1 000–100 000 asexual parasites/µL.</td>
</tr>
<tr>
<td>Low</td>
<td>Patients with fever or a history of fever, all age groups and ≥ 250 or 500 asexual parasites/µL</td>
</tr>
<tr>
<td>Very low</td>
<td>Patients with fever or a history of fever, all age groups and any parasitaemia</td>
</tr>
</tbody>
</table>
### Early treatment failure
- danger signs or severe malaria on day 1, 2 or 3 in the presence of parasitaemia;
- higher parasitaemia on day 2 than on day 0, irrespective of axillary temperature;
- parasitaemia on day 3 with axillary temperature ≥ 37.5 °C; and
- parasitaemia on day 3 ≥ 25% of count on day 0.

### Late clinical failure
- danger signs or severe malaria in the presence of parasitaemia on any day between 4 - 28 (or day 42) in patients who did not previously meet any of the criteria of early treatment failure; and
- presence of parasitaemia on any day between 4 - 28 (or day 42) with axillary temperature ≥ 37.5 °C in patients who did not previously meet any of the criteria of early treatment failure.

### Late parasitological failure
- presence of parasitaemia on any day between 7 - 28 (or day 42) with axillary temperature < 37.5 °C in patients who did not previously meet any of the criteria of early treatment failure or late clinical failure.

### Adequate clinical & parasitological response
- absence of parasitaemia on day 28 (or day 42), irrespective of axillary temperature, in patients who did not previously meet any of the criteria of early treatment failure, late clinical failure or late parasitological failure.
Activities and information required for integrated surveillance of drug efficacy:
• patient classification and diagnosis,
• molecular analysis,
• treatment,
• patient follow-up,
• information on efficacy of first- and second-line treatments,
• classification of responses to treatment, and
• data interpretation and policy considerations.
<table>
<thead>
<tr>
<th>NO.</th>
<th>INDICATOR</th>
<th>OUTCOME(S)</th>
<th>CALCULATION OR EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Adult vector composition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Occurrence</td>
<td>Adult female vectors present or absent.</td>
<td>Presence of Anopheles species known to support the development of Plasmodium sporozoites. Requires correct identification of species.</td>
</tr>
<tr>
<td>1.2</td>
<td>Density</td>
<td>Number of adult female vectors collected, usually per sampling method and unit time.</td>
<td>Collection numbers are reported by individual sampling method or summed for all sampling methods. Vector seasonality refers to changes in species abundance by season. Vector composition is the relative abundance of each species as a proportion of the total number of vectors collected.</td>
</tr>
<tr>
<td></td>
<td><strong>Adult vector behaviour</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Human biting rate</td>
<td>Number of adult female vectors that attempt to feed or are freshly blood-fed, per person per unit time.</td>
<td>Number of female Anopheles vectors collected that were freshly blood-fed or attempted to feed per total number of units of collection. The units of collection depend on the sampling method; yields from human landing catches are reported per human per collection hour, and yields from CDC light traps, pyrethrum spray catches and window exit traps are reported per trap per night per number of human occupants in houses used for collection.</td>
</tr>
<tr>
<td>2.2</td>
<td>Human blood index (host preference)</td>
<td>Proportion of blood-fed adult female vectors that feed on humans.</td>
<td>Number of female Anopheles vectors that feed on human blood / total number of Anopheles vectors the blood meal of which was identified.</td>
</tr>
<tr>
<td>2.3</td>
<td>Biting time</td>
<td>Number of adult female vectors that attempt to feed or are freshly blood-fed, per person per unit time, usually expressed per 2-h increment.</td>
<td>As for “human biting rate” but reported for individual time increments. Numbers are compared by period to identify peak biting times.</td>
</tr>
</tbody>
</table>
FIG. 17.
Model system for forecasting, early warning and early detection of epidemics

**LONG-RANGE WEATHER FORECASTING:**
- long lead times but little specificity
- warnings at national or regional scale

Possible indicators: ENSO parameters, medium-range weather forecasts
Responses: Ensure that early warning and detection systems are operational; mobilize national resources.

**EARLY WARNING FROM METEOROLOGICAL INDICATORS**
- shorter lead times and better specificity
- warnings at district scale

Probable indicators: Meteorological parameters
Responses: Ensure that surveillance systems are functioning and local response reserves prepared.

**EARLY DETECTION**
- short lead times and very high specificity
- detection at sub-district scale

Indicators: Facility data
Responses: Epidemic control measures

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No. of malaria cases, magnitude of risk factors
FIG. 16. Factors that contribute to epidemics

**Human-made**
- Development activities
  - Economic or development activities in forests that increase risks of infections.
  - Agricultural irrigation, micro-dams, mining, logging, road construction.
  - Poor or inappropriate water storage.
  - Fast and unplanned urbanization.
  - Human population movement.
  - Overpopulation leading to increased pressure on land.
- Breakdown of health services
  - Loss or breakdown of epidemiological surveillance; inadequate response.
  - Deterioration of health services (including malaria control activities).
  - Increased parasite resistance to effective antimalarial medicines.
  - Increased vector resistance to insecticides.

**Natural disasters**
- Natural disasters
- Climatic variations
  - El Niño oscillations leading to unusual increases in rainfall, temperature and humidity may lead to rapid development of infective stages of Plasmodium in both aquatic and adult mosquitoes.
FIG. 20.
Epidemic thresholds for 2011–2015 as compared with the suspected epidemic year 2016 from data in Table 12.
FIG. 22.
Monitoring and evaluation framework: from input to impact

**Inputs**
- Financial, human, information and other resources mobilized to support activities.
- Budgets, staffing, health facilities, medicines and other resources.

**Process**
- Action or work to convert inputs into outputs.
- Delivery of supplies, staff training, supervision, logistics management systems.

**Outputs**
- Services resulting from converting inputs into outputs, e.g. RDTs, ACTs, LLINs, surveillance, staff.
- Goods and services produced and delivered by main implementing agency and partners.

**Outcomes**
- Use of outputs by targeted population, e.g. people with suspected malaria receive a diagnostic test or sleep under LLINs.
- Programme, surveillance, surveys and census data to measure outcomes.

**Impact**
- Reduction in, e.g. cases of severe malaria, deaths from malaria.
- Analysis of surveillance, surveys, census and other contextual data to measure outcomes.

**Implementation (supply)**
**Results (supply and demand)**

ACT, artemisinin-based combination therapy; RDT, rapid diagnostic test; LLIN, long-lasting insecticidal net
FIG. 24.
Framework for stratifying malaria risk

Determinants
- Ecological (receptivity)
  - Vector species, habitats, density, behaviour
  - Altitude, temperature, rainfall, humidity and vegetation
  - Type of housing, urbanization, other land use
  - Environmental changes that increase vector transmission
- Population (vulnerability)
  - Unusual human population movements
  - Level of importation of malaria
  - Expected immunity of incoming and resident populations
  - Level of security and general accessibility of populations
- Epidemiological
  - Parasite species
  - Trends in number of malaria cases and incidence
  - History of malaria epidemics
  - Cause of previous epidemics and response
- Intervention
  - Access to health services
  - Coverage of preventive interventions (vector control, chemoprevention)
  - Vector susceptibility to insecticides
  - Parasite susceptibility to antimalarial drugs
  - Level of acceptance of malaria interventions

Data elements

Outputs
Malaria risk mapping and stratification

Global Malaria Programme
FIG. 25.
District-level stratification by annual parasite incidence in 2017 in Lao People's Democratic Republic

To further demonstrate heterogeneity of annual parasite incidence within a province, the example of districts within Champasak province is presented (inset).
FIG. 26.
Charts for analysis of malaria trends

1. Malaria incidence rates
   - Confirmed cases per 10,000
   - Inpatients per 10,000
   - Deaths per 100,000

2. Proportional malaria incidence
   - Slide positivity rate
   - Proportion of inpatients due to malaria
   - Proportion of deaths due to malaria

3. General patient attendance
   - Outpatients per 1000
   - Inpatients per 10,000
   - Deaths per 100,000

4. Diagnostic effort
   - Annual blood examination rate

5. Quality of diagnosis and reporting
   - Proportion of health facilities reporting
   - Proportion of suspected cases tested

6. Proportion of cases due to *P. falciparum*
FIG. 29. 
Components of a surveillance and response system to be assessed by monitoring and evaluation

<table>
<thead>
<tr>
<th>Structure of surveillance system</th>
<th>Core functions of surveillance system</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Legislation for surveillance</td>
<td>• Case detection</td>
</tr>
<tr>
<td>• Surveillance strategy</td>
<td>• Case registration</td>
</tr>
<tr>
<td>• Implementers and stakeholders</td>
<td>• Case confirmation</td>
</tr>
<tr>
<td>• Networking and partnership</td>
<td>• Reporting</td>
</tr>
<tr>
<td></td>
<td>• Data analysis and interpretation</td>
</tr>
<tr>
<td></td>
<td>• Epidemic preparedness</td>
</tr>
<tr>
<td></td>
<td>• Response and control</td>
</tr>
<tr>
<td></td>
<td>• Feedback</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality of surveillance Completeness</th>
<th>Support functions of surveillance system</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Timeliness of reporting</td>
<td>• Standards and guidelines</td>
</tr>
<tr>
<td>• Usefulness of data and surveillance system</td>
<td>• Training</td>
</tr>
<tr>
<td>• Simplicity of system</td>
<td>• Supervision</td>
</tr>
<tr>
<td>• Acceptability of system</td>
<td>• Communication facilities</td>
</tr>
<tr>
<td>• Flexibility of system</td>
<td>• Resources</td>
</tr>
<tr>
<td>• Sensitivity in surveillance</td>
<td>• Monitoring and evaluation</td>
</tr>
<tr>
<td>• Specificity in surveillance</td>
<td>• Coordination</td>
</tr>
<tr>
<td>• Positive predictive value</td>
<td></td>
</tr>
<tr>
<td>• Representativeness of system</td>
<td></td>
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</table>