

Attributes used in frameworks for surveillance evaluation

Attributes	N. of frameworks	Frameworks
Acceptability (and engagement)	10	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018) Evaluating a national surveillance system (WHO) (WHO, 2013) Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004) Guidelines for Evaluating Surveillance Systems (CDC) (Klaucke et al., 1988) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Availability and sustainability	1	The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Benefit	5	Framework in Babo Martins et al., 2016 Framework in Guo et al., 2014 SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Bias (or accuracy)	2	SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Collaborative added value	1	OH-EpiCap (Tegegne et al., 2023)
Communication	3	OASIS (Hendrikx et al., 2011) OH-EpiCap (Tegegne et al., 2023) SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015)

Attributes	N. of frameworks	Frameworks
Compatibility	1	The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Completeness	2	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012)
Coordination and supervision of the network	1	OASIS (Hendrikx et al., 2011)
Cost	6	Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004) Framework in Babo Martins et al., 2016 Framework in Guo et al., 2014 Framework in Rivers et al., 2023 SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Coverage (and transdisciplinary)	3	OH-EpiCap (Tegegne et al., 2023) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Data analysis (and interpretation)	4	OASIS (Hendrikx et al., 2011) OH-EpiCap (Tegegne et al., 2023) SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018)
Data (and information) collection	3	OASIS (Hendrikx et al., 2011) OH-EpiCap (Tegegne et al., 2023) SurF (Muellner et al., 2018)
Data completeness (and correctness)	2	SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018)

Attributes	N. of frameworks	Frameworks
Data management (and storage)	3	OASIS (Hendrikx et al., 2011) SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018)
Data quality	5	Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018) Evaluating a national surveillance system (WHO) (WHO, 2013) Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Data sharing	1	OH-EpiCap (Tegegne et al., 2023)
Decision support	1	SurF (Muellner et al., 2018)
Efficiency	1	SurF (Muellner et al., 2018)
Evaluation and resilience	1	OH-EpiCap (Tegegne et al., 2023)
External communication and dissemination/ information distribution	2	OASIS (Hendrikx et al., 2011) SurF (Muellner et al., 2018)
False alarm rate (inverse of specificity)	1	The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Field and laboratory services	1	SurF (Muellner et al., 2018)
Field institutional organization	1	OASIS (Hendrikx et al., 2011)

Attributes	N. of frameworks	Frameworks
Flexibility (or adaptability)	12	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018) Evaluating a national surveillance system (WHO) (WHO, 2013) Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004) Framework in Rivers et al., 2023 Guidelines for Evaluating Surveillance Systems (CDC) (Klaucke et al., 1988) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011) SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Formalization	1	OH-EpiCap (Tegegne et al., 2023)
Historical data	2	SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018)
Immediate and intermediate outcomes	1	OH-EpiCap (Tegegne et al., 2023)
Impact	1	SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015)
Internal communication	1	SurF (Muellner et al., 2018)
Interoperability	1	SurF (Muellner et al., 2018)
Laboratory (management)	2	OASIS (Hendrikx et al., 2011) SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015)

Attributes	N. of frameworks	Frameworks
Minimum sample size	1	Framework in Rivers et al., 2023
Multiple hazard	1	The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Multiple utility	2	SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018)
Negative predictive value	2	The RISKSUR EVA tool (Survtool) (Peyre et al., 2019) SurF (Muellner et al., 2018)
OH learning	1	NEOH – Network for the Evaluation for One Health (Rüegg et al., 2018)
OH planning	1	NEOH – Network for the Evaluation for One Health (Rüegg et al., 2018)
OH sharing (sharing infrastructure and processes)	1	NEOH – Network for the Evaluation for One Health (Rüegg et al., 2018)
OH thinking	1	NEOH – Network for the Evaluation for One Health (Rüegg et al., 2018)
OH working	1	NEOH – Network for the Evaluation for One Health (Rüegg et al., 2018)
Organization and management	1	SurF (Muellner et al., 2018)
Participation	1	SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015)
Performance indicators and evaluation	2	OASIS (Hendrikx et al., 2011) SurF (Muellner et al., 2018)
Portability	1	Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004)
Positive predictive value	6	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018)

Attributes	N. of frameworks	Frameworks
		Guidelines for Evaluating Surveillance Systems (CDC) (Klaucke et al., 1988) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Precision	3	SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
RAAR (reliability, availability, repeatability and robustness)	1	SurF (Muellner et al., 2018)
Reliability	2	National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011)
Repeatability	1	SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015)
Representativeness (and bias)	10	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018) Evaluating a national surveillance system (WHO) (WHO, 2013) Guidelines for Evaluating Surveillance Systems (CDC) (Klaucke et al., 1988) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011) SERVAL – SuRveillance EVALuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)

Attributes	N. of frameworks	Frameworks
Resources or resources availability	1	OH-EpiCap (Tegegne et al., 2023)
Risk-based criteria definition	1	The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Robustness	1	The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Sensitivity	12	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018) Evaluating a national surveillance system (WHO) (WHO, 2013) Framework in Colón-González et al., 2018 Framework in Guo et al., 2014 Guidelines for Evaluating Surveillance Systems (CDC) (Klaucke et al., 1988) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011) SERVAL – SuRveillance EVAuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Simplicity	8	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018) Evaluating a national surveillance system (WHO) (WHO, 2013) Guidelines for Evaluating Surveillance Systems (CDC) (Klaucke et al., 1988) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)

Attributes	N. of frameworks	Frameworks
		Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Specificity	5	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011) SERVAL – SuRveillance EVAuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018)
Stability (and sustainability)	6	Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018) Evaluating a national surveillance system (WHO) (WHO, 2013) Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004) OASIS (Hendrikx et al., 2011) SERVAL – SuRveillance EVAuation framework (Drewe et al., 2015) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Stakeholder analysis	1	Framework in Rivers et al., 2023
Suitability of the system objectives/ Objectives and scope of surveillance	2	Framework in Rivers et al., 2023 OASIS (Hendrikx et al., 2011)
Surveillance system organization/ systemic organization/ central institutional organization	3	NEOH – Network for the Evaluation for One Health (Rüegg et al., 2018) OASIS (Hendrikx et al., 2011) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019)
Surveillance procedures	1	OASIS (Hendrikx et al., 2011)
Surveillance tools	1	OASIS (Hendrikx et al., 2011)

Attributes	N. of frameworks	Frameworks
Technical outputs	1	OH-EpiCap (Tegegne et al., 2023)
Timeliness	12	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) Early Warning Alert And Response Network in emergencies: evaluation protocol (WHO) (WHO Regional Office for the Eastern Mediterranean, 2018) Evaluating a national surveillance system (WHO) (WHO, 2013) Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004) Framework in Colón-González et al., 2018 Guidelines for Evaluating Surveillance Systems (CDC) (Klaucke et al., 1988) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011) SERVAL – SuRveillance EVAuation framework (Drewe et al., 2015) SurF (Muellner et al., 2018) The RISKSUR EVA tool (Survtool) (Peyre et al., 2019) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Training (technical competence and training)	2	OASIS (Hendrikx et al., 2011) SurF (Muellner et al., 2018)
True prevalence	1	Framework in Rivers et al., 2023
Type I error	1	Framework in Grosbois et al., 2015
Type II error	1	Framework in Grosbois et al., 2015
Ultimate outcomes	1	OH-EpiCap (Tegegne et al., 2023)
Usefulness	6	Communicable disease surveillance and response system – Guide to monitoring and evaluating (WHO) (WHO, 2006) Evaluating a national surveillance system (WHO) (WHO, 2013)

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		Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004) Guidelines for Evaluating Surveillance Systems (CDC) (Klaucke et al., 1988) National Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) (Uganda Ministry of Health, 2012) OASIS (Hendrikx et al., 2011) Updated Guidelines for Evaluating Public Health Surveillance Systems (CDC) (German et al., 2001)
Utility	1	SurF (Muellner et al., 2018)
Validity	1	Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks (CDC) (Buehler et al., 2004)

This supplementary material warrants some considerations. The framework provided in Crawley et al. (2024) is not included, since the authors referred to indicators and not attributes. However, it is important to note that these indicators can point to attributes used in other frameworks, including *sensitivity*, *timeliness*, *usefulness* and *cost-effectiveness*. For instance, in the outcome section are listed indicators such as timely event detection, timely event verification, timely event notification, timely event risk assessment, and timely initial response, which refer to the attribute *timeliness*. The frameworks *NEOH* (Rüegg et al., 2018), *Oh-EpiCap* (Tegegne et al., 2023), along with those presented by Colón-González et al. (2018), Guo et al. (2014), and Babo Martins et al. (2016) did not explicitly define their components as attributes. However, their elements were treated as attributes in this study because they were used to assess the quality of a surveillance system. Within the OASIS framework (Henrikx et al., 2011), both the predefined attributes and elements from the ten sections and eight critical control points were treated as attributes. *Usefulness* is not explicitly listed as an attribute in the CDC's *Updated Guidelines for Evaluating Public health Surveillance Systems* (German et al., 2001), the CDC's *Framework for Evaluating Public Health Surveillance System for Early Detection of Outbreaks* (Buehler et al., 2004), and the CDC's *Guidelines for Evaluating Surveillance Systems* (Klaucke et al., 1988). However, these guidelines do require that the level of usefulness of a surveillance system be indicated. Because *usefulness* is recognized as an attribute in other frameworks and in publications applying CDC guidelines, it is included in the table along with references to the relevant CDC frameworks.

The most prevalent attributes across all the frameworks are *sensitivity*, *timeliness*, and *flexibility or adaptability*, which are present in 67% (12/18) of frameworks, followed by *acceptability (and engagement)*, *representativeness and bias* (10/18, 56%), and *simplicity* (8/18, 44%), which are relevant to both frameworks aimed at the evaluation of public health surveillance systems (Buehler et al., 2004; German et al., 2001; Klaucke et al., 1988; Uganda Ministry of Health, 2012; WHO, 2006; WHO Regional Office for the Eastern Mediterranean, 2018), and those evaluating animal health surveillance (Hendrikx et al., 2011; Muellner et al., 2018; Peyre et al., 2019). Attributes less commonly used include *cost*, *positive predictive value*, *stability (and sustainability)*, *usefulness* (6/18, 33%), *benefit*, *data quality*, *specificity* (5/18, 28%), *data analysis* (4/18, 22%), *communication*, *coverage (and transdisciplinarity)*, *data analysis (and interpretation)*, *data (and*

information) collection, data management (and storage), precision, surveillance system organization (systemic organization or central institutional organization) (3/18, 17%), bias (or accuracy), completeness, data completeness (and correctness), external communication and dissemination (or information distribution), historical data, laboratory (management), multiple utility, negative predictive value, performance indicators and evaluation, reliability and suitability of the system objectives (or objectives and scope of surveillance) (2/18, 11%).

Economic attributes such as *cost* and *benefit* are included only in frameworks aimed at evaluating animal health surveillance (Drewe et al., 2015; Guo et al., 2014; Muellner et al., 2018; Peyre et al., 2019; Rivers et al., 2023) or the one health aspect of zoonoses surveillance (Babo Martins et al., 2017), with the only exception being the adoption of the attribute *cost* by the CDC *Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks* (Buehler et al., 2004). In practice, other public health frameworks state that the evaluation should also consider surveillance costs, without including it within the attributes (German et al., 2001; Klaucke et al., 1988).

Some attributes appear only in a single framework; examples include: attributes aimed at evaluating one health initiatives such as *collaborative added value*, which addresses the strengthening of the one health team and network, international collaboration, and common strategy design (Tegegne et al., 2023), *portability*, which addresses how well the system could be duplicated in another setting (Buehler et al., 2004), and *risk-based criteria definition*, assessing the validity and relevance of the risk criteria selected and the approach/method used for their identification (Peyre et al., 2019).

Certain attributes have a corresponding definition across different frameworks, but are referred to with a different name. For instance, *interoperability* (Muellner et al., 2018) and *compatibility* (Peyre et al., 2019) are both defined as the compatibility with and ability to integrate data from other sources and components.

References

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