Supplementary Information 1. Methodology

1.1 Definition of data quality outputs used in the review

"Relevance is assessed by comparing data collected against management information needs. Completeness is measured not only as filling in all data elements in the facility report form, but also as the proportion of facilities reporting in an administrative area (e.g. province or district). Timeliness is assessed as submission of the reports by an accepted deadline. Accuracy is measured by comparing data between facility records and reports, and between facility reports and administrative area databases, respectively." (Aqil et al 2009)

1.2 Search Strategy

Peer reviewed literature search strategy

1) Ovid MEDLINE(R) in Progress & Other non-indexed citations, Ovid MEDLINE (R) Daily and Ovid MEDLINE (R) 1946 to present, *searched on September 4th 2017* (233 results) re-searched on January 31, 2021 (251 results)

Ovid Medline R.pdf

2) EMBASE CLASSIC + EMBASE 1947 to 2017 September 5, *searched on September 5th 2017* (480 results)

Ovid Embase.pdf

3) Global Health 1910 to 2017 Week 36, *searched on September 5th 2017* (98 results)

Ovid Global Health.pdf

4) Web of Science core collection, *searched on September 6th 2017* (88 results) *Re-searched on December 10, 2020 (93 results)*
   1. TS=("data quality") OR TS=("data accuracy") OR TS=("data timeliness") OR TS=("data relevance") OR TS=("data completeness") OR TS=("data validity") OR TS=("data congruence") OR TS=("data reliability") OR TS=("data consistency") OR TS=("data precision") OR TS=("data correlation") OR TS=("data concordance") OR TS=("data correctness") OR TS=("data coverage") OR TS=("data exhaustiveness") OR TS=("data currency")
      DocType=All document types; Language=All languages;

2. TOPIC: ("routine health information system*") OR TOPIC: ("health information management system*") OR TOPIC: ("RHIS") OR TOPIC: ("disease surveillance system*") OR TOPIC: ("medical record system*") OR TOPIC: ("health info* system*") OR TOPIC: ("ambulatory care information system*") OR TOPIC: ("hospital information system*") OR TOPIC: ("health center information system*") OR TOPIC: ("electronic medical record*") OR TOPIC: ("community health data") OR TOPIC: ("community health information system*") *DocType=All document types; Language=All languages;*
3. #1 AND #2
   Refined by: COUNTRIES/TERRITORIES: (RUSSIA OR RWANDA OR BANGLADESH OR JORDAN OR BENIN OR KENYA OR BOTSWANA OR LAOS OR BRAZIL OR MADAGASCAR OR SOUTH AFRICA OR MALAWI OR MALAYSIA OR COTE IVOIRE OR MEXICO OR MOZAMBIQUE OR ETHIOPIA OR TANZANIA OR NIGERIA OR THAILAND OR TOGO OR GHANA OR PAKISTAN OR UGANDA OR HAITI OR PEOPLES R CHINA OR HONDURAS OR PERU OR VIETNAM OR INDIA OR ZAMBIA OR INDONESIA OR ZIMBABWE OR IRAN)
   DocType=All document types; Language=All languages;

5) Journal of Health Informatics in Developing Countries (http://www.jhidc.org/index.php/index/search), *searched on September 6th 2017* (56 results) Re-searched on December 10, 2020 (68 results)
   : Health information

Grey Literature search strategy

1) Routine Health Information Network (RHINO) Resource Library (239 results) (http://www.rhinonet.org/resource-library/), *searched on September 6-7th 2017, closed and not operating on Jan 2021*
   1. Health Information System
   2. EMR
   3. Electronic medical record system

2) Opengrey, *searched on September 9th 2017* (9 results) Re-searched on January 4, 2021 (412 results)
   : Health Information System

3) Popline, *searched on September 11th 2017* (356 results) no longer operating in January 2021
   1. health information system* OR routine health information system*
   2. data quality OR data timeliness OR data accuracy OR data completeness OR data relevance OR data validity OR data congrueny OR data reliability OR data consistency OR data precision OR data correlation OR data concordance OR data correctness OR data coverage OR data exhaustiveness OR data currency
   3. intervention*
   4. 1 AND 2 AND 3

4) MEASURE Evaluation publications search (https://www.measureevaluation.org/resources/publications), *searched on September 11th 2017* (267 results)*, re-searched on January 2-3, 2021 (1015 results)*
   1. Routine health information system
   2. Health information system
   3. Health management information system
   4. Electronic medical record
   5. Disease surveillance
   6.
5) Google search, *searched on September 12th 2017 / Re-searched on January 1-2, 2021*
   1. Routine health information system AND interventions AND district level
   2. DHIS2 interventions
   3. Health information system AND intervention AND district
   4. District health information intervention
   5. Community health information system intervention

   * For each search, screened search results up to first 100, total of 500 results

6) Global Resource Center HRH (https://www.hrhresourcecenter.org/taxonomy/term/87) *searched on September 12th 2017* (113 results) Re-searched on January 4, 2021 (240 results) : Health information systems

7) John Snow International (http://www.jsi.com/JSIInternet/index.cfm) *searched on September 12th 2017* (114 results) re- searched resources section (https://www.jsi.com/resources/) on January 4 (75 results for digital health)
   1. routine health information system
   2. health information system

8) University of Oslo, Department of Informatics, Health Information System Program Thesis list (http://www.mn.uio.no/ifi/english/research/networks/hisp/research-library/phd-thesis-list.html), *accessed on September 12th 2017.* (38 results) *Re-searched on January 4, 2021 (49 results)*

Supplementary Information 2: Results

2.1. Summary of selected studies

2.1. Summary of Selected Studies.pd

2.2. Details on intervention components implemented in selected studies

RHIS Determinants Addressed	Definitions/ Descriptions	References
Technical	**Improving data collection forms (paper-based)** -Standardizing indicators -Creating forms to aggregate reports -Translating the forms into local language - Making forms user-friendly (creating sections and headings, simplification) - Disseminating a simple summary of key indicators	Admon, A. J. Ahanhanzo, Y (2014) Asangansi, I Barnett, D Gilbert, S.S. Ishijima Khatri, U Kintu, P Ledikwe J.H Mwakyusa, F Shieshia, M Tuti, T USAID Wagenaar B.H Wong, R.E.X
	Utilizing mHealth -A mobile phone module/ application -SMS based data transmission system -A PDA module/ application	Ali, S.M Asangansi, I Auld, A.F Barnett, D Blaya, H.S. Gilbert, S.S Gold, J Kagiri, M Medhanyie, A A Rosewell, A Thriemer, K Tobgay, T Torre, C.D. Shieshia, M Were, MC Yugi, J

	Establishing Electronic Health Information Systems (EHMIS) - A real-time inventory visibility software - DHIS2 - OpenMRS	Amoroso, C Blaya, H.S. Blaya, J.A Gilbert, S.S Gimbel, S Githinji,S Haskew, J Huang, F Ishijima Kariuki, J.M. MEASURE evaluation 2018 MEASURE evaluation 2019 Moomba,K Ndira S.R. Pascoe, L Shieshia, M Sowe, A Tobgay, T Tuti, T USAID Wong, R.E.X
	Equipment purchase and maintenance - Sim-cards -Mobile phones	Asangansi, I Barnett, D Blaya, H.S Hazel, E Kintu, P MEASURE evaluation 2019 Thriemer, K Wagenaar B.H
	Conducting Data Quality Assessment (DQA) - Implementation and routine use of the Joint Routine Data Quality Assessment (RDQA) tool	Gimbel, S Hazel, E MEASURE evaluation 2018 Mphatswe, W Muthee, V Njuguna, C Wagenaar B.H USAID
	Improving data storage - A procedure put in place to store records in a dedicated area of the clinic	Ledikwe J.H Kyeyagalire, E
	Data Quality Checks - Supervisor checking monthly report, providing feedback and supervision - Automated alerts for discrepancies - Retrospective record reviews - Data audits at individual facilities	Amoroso, C Asangansi, I Blaya, J.A Chisha, Z Haskew, J Huang, F Kintu, P Mulissa, Z Sowe, A Thriemer, K

		Tuti, T Wagenaar B.H
	Database Harmonisation **-** Integration of multiple HMIS into one	MEASURE evaluation 2019
Technical/ Organisational/ Behavioural	**Training** **-**Using EHMIS -Using M-health -Using a revised tool -Data quality in general -Follow-up trainings / Pre-post training tests	Admon, A. J. Ahanhanzo, Y Amoroso, C Auld, A.F Barnett, D Blaya, J.A Chisha, Z Ejeta, L.T Gilbert, S.S Gimbel, S Gold, J Haskew, J Hazel, E Huang, F Kagiri, M Kariuki, J.M. Kyeyagalire, E MEASURE evaluation 2018 MEASURE evaluation 2019 Medhanyie, A A Mphatswe, W Mpofu, M Mwakyusa, F Njeru, I Nwankwo, B Osa-Eloka, C Pascoe, L Rosewell, A Shieshia, M Thriemer, K USAID Uzochukwu, B Wagenaar B.H Were, MC Wong, R.E.X Yugi, J
Organizational/ Behavioural	**Enhanced training** - Topics similar to that of 'Training' yet duration and regularity differs (training: less than 5 days, enhanced training: weeks/ months)	Ishijima Kintu, P Ledikwe J.H Mulissa, Z Ndira S.R. Tobgay, T

	Engagement of core partners in the intervention **-** Data quality assessment - Designing data collection tools - Data journey mapping - Data collection process assessment and design	Ahanhanzo, Y (2014) Asangansi, I Blaya, H.S Hazel, E Ishijima, H Kagiri, M Kintu, P Kyeyagalire, E MEASURE evaluation 2018 MEAUSRE evaluation 2019 Mulissa, Z Muthee, V Shieshia, M Were, MC Yugi, J
	Task-shifting & creation of new roles -designation of data collection roles to existing health workers -strengthening accountability of district level staffs -creating a new cadre of M&E officers at health centers	Admon, A. J. Gilbert, S.S. Kyeyagalire, E Ledikwe J.H Mpofu, M
	Supervision **-** data quality check & feedback - routine monitoring visits	Chisha, Z Kintu, P Mphatswe, W Mpofu, M USAID Shieshia, M Wagenaar B.H Wong, R.E.X
	Enhanced supervision - Topics similar to that of 'Supervision' yet duration and regularity differs (supervision: monthly and/or irregular, enhanced training: weekly/ daily and regular)	Blaya, J.A Gimbel, S Haskew, J Ishijima, H Ledikwe J.H Marshall, A Mulissa, Z Thriemer, K Tuti, T
	Dissemination meetings - Monthly reviews and monthly DQA - Workshop to discuss data quality	Ahanhanzo, Y Chisha, Z Gimbel, S Huang, F Kyeyagalire, E MEASURE evaluation 2019 Mphatswe, W Wagenaar B.H
	Incentives **-** Motivational SMS on data collection - Financial incentives	Joos, L.C Yugi, J

	Standardised Protocols - Improved procedures for data collection process (QI journals) - Standardised procedures for handling and filing	Ejeta, L.T Hazel, E Kyeyagalire, E MEASURE evaluation 2019 Wong, R.E.X

2.3. Processes addressed in selected studies

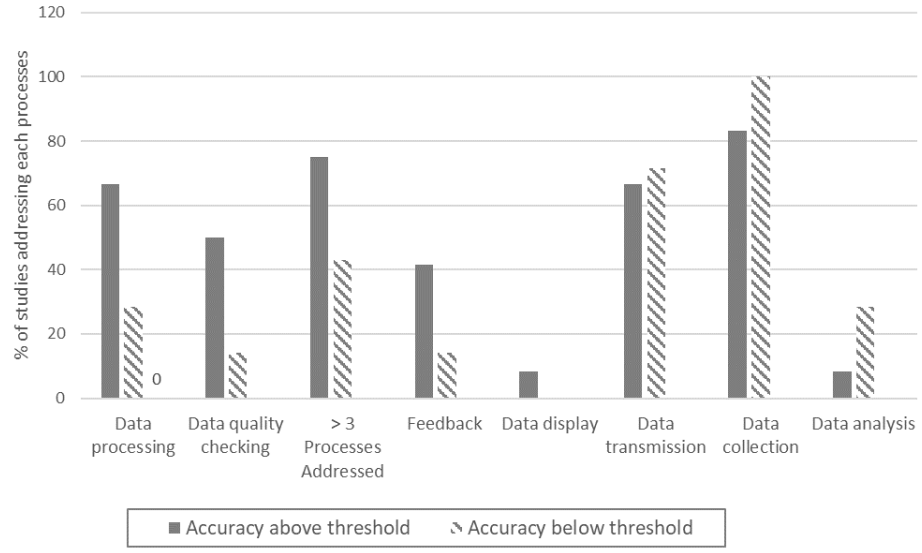
#	First author	Data collection	Data transmission	Data processing	Data analysis	Data display	Data quality checking	Feedback	# Processes Addressed
1	**Admon, A. J.**	**X**		**X**					2
2	**Ahanhanzo, Y (2014)**	**X**							1
3	**Ahanhanzo, Y (2015)**	**X**							1
4	**Ali, S.M.**	**X**	**X**						2
5	**Amoroso, C**						**X**		1
6	**Asangansi, I**	**X**	**X**				**X**		3
7	**Auld, A.F.**	**X**	**X**						2
8	**Barnett, D**	**X**	**X**	**X**					3
9	**Blaya, H.S.**	**X**	**X**	**X**		**X**	**X**		5
10	**Blaya, J.A.**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	7
11	**Chisha, Z**	**X**					**X**	**X**	3
12	**Ejeta, L.T.**	**X**							1
13	**Gilbert, S.S.**	**X**	**X**	**X**					3
14	**Gimbel, S.**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	7
15	**Githinji, S.**	**X**	**X**	**X**	**X**				4
16	**Gold, J**	**X**	**X**	**X**			**X**		4
17	**Haskew, J**	**X**	**X**	**X**	**X**		**X**		5
18	**Hazel, E.**	**X**			**X**	**X**	**X**	**X**	5
19	**Huang, F**	**X**	**X**	**X**			**X**		4
20	**Ishijima**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	7
21	**Joos, L.C**	**X**							1
22	**Kagiri, M**	**X**	**X**						2
23	**Kariuki, J.M.**		**X**	**X**					2
24	**Khatri, U**	**X**		**X**	**X**				3
25	**Kintu, P**	**X**	**X**	**X**	**X**		**X**	**X**	6
26	**Kyeyagalire, E**	**X**						**X**	2
27	**Ledikwe J.H**	**X**	**X**	**X**	**X**		**X**	**X**	6
28	**Marshall, A**						**X**	**X**	2
29	**Measure Evaluation**	**X**			**X**	**X**			3

	(2018)								
30	**Measure Evaluation (2019)**	**X**		**X**	**X**		**X**		4
31	**Medhanyie, A A**	**X**	**X**						2
32	**Moomba, K.**	**X**							1
33	**Mphatswe, W**	**X**					**X**	**X**	3
34	**Mpofu, M**	**X**					**X**	**X**	3
35	**Mulissa,Z.**	**X**	**X**				**X**	**X**	4
36	**Muthee, V.**	**X**		**X**					2
37	**Mwakyusa, F**	**X**							1
38	**Ndira S.R.**	**X**	**X**	**X**	**X**				4
39	**Njesu, I.**	**X**					**X**		2
40	**Njuguna,C.**						**X**		1
41	**Nwankwo, B.**	**X**					**X**		2
42	**Osa-Eloka, C**	**X**	**X**					**X**	3
43	**Pascoe, L**	**X**	**X**	**X**				**X**	4
44	**Rosewell, A**	**X**	**X**	**X**	**X**			**X**	5
45	**Shieshia, M.**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	7
46	**Sowe, A.**	**X**	**X**	**X**	**X**		**X**		5
47	**Thriemer, K**	**X**	**X**	**X**			**X**	**X**	5
48	**Tobgay, T**	**X**	**X**	**X**	**X**				4
49	**Torre, C.D.**	**X**	**X**						2
50	**Tuti, T**	**X**	**X**	**X**		**X**	**X**	**X**	6
51	**USAID**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	7
52	**Uzochukwu, B.**	**X**			**X**				2
53	**Wagenaar B.H**	**X**					**X**	**X**	3
54	**Were, M.C.**	**X**	**X**						2
55	**Wong, R.E.X**	**X**						**X**	2
56	**Yugi, J**	**X**	**X**	**X**					3
	Total	**52**	**32**	**27**	**18**	**9**	**27**	**21**	

2.4. Examples of definition of Data Quality Output Measures in studies with quantitative outcome

2.4. Definition of output measures.p

2.5. RHIS Processes addressed in studies with improved data accuracy above threshold (>=80%) versus those with no improvement or did not reach the threshold, ranked by the greatest difference in the % of studies that addressed each of the processes



2.6. RHIS Processes addressed in studies with improved data accuracy above threshold (>=80%) versus those with no improvement or did not reach the threshold, ranked by the greatest difference in the % of studies that addressed each of the processes