











# How has Guinea learnt from the response to outbreaks? A learning health system analysis

Tamba Mina Millimouno <sup>1,2</sup>, Bruno Meessen <sup>3</sup>, Willem Van De Put <sup>4</sup>, Marlon Garcia <sup>4</sup>, Bienvenu Salim Camara <sup>1</sup>, Aliki Christou <sup>4</sup>, Therese Delvaux <sup>4</sup>, Sidikiba Sidibé <sup>1,2</sup>, Abdoul Habib Beavogui <sup>1</sup>, Alexandre Delamou <sup>1,2</sup>

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<sup>1</sup>Research Section, Centre National de Formation et de Recherche en Santé Rurale de Maferinyah, Forécariah, Guinea

<sup>2</sup>Centre d'Excellence d'Afrique pour la Prévention et le Contrôle des Maladies Transmissibles (CEA-PCMT), Conakry, Guinea

<sup>3</sup>Health Systems Governance and Financing Department, World Health Organization, Geneva, Switzerland

<sup>4</sup>Public Health Department, Institute of Tropical Medicine, Antwerpen, Belgium

## Correspondence to

Dr Tamba Mina Millimouno; [mina@maferinyah.org](mailto:mina@maferinyah.org)

## ABSTRACT

**Introduction** Learning is a key attribute of a resilient health system and, therefore, is central to health system strengthening. The main objective of this study was to analyse how Guinea's health system has learnt from the response to outbreaks between 2014 and 2021.

**Methods** We used a retrospective longitudinal single embedded case study design, applying the framework conceptualised by Sheikh and Abimbola for analysing learning health systems. Data were collected employing a mixed methods systematic review carried out in March 2022 and an online survey conducted in April 2022.

**Results** The 70 reports included in the evidence synthesis were about the 2014–2016 Ebola virus disease (EVD), Measles, Lassa Fever, COVID-19, 2021 EVD and Marburg virus disease. The main lessons were from 2014 to 2016 EVD and included: early community engagement in the response, social mobilisation, prioritising investment in health personnel, early involvement of anthropologists, developing health infrastructure and equipment and ensuring crisis communication. They were learnt through information (research and experts' opinions), action/practice and double-loop and were progressively incorporated in the response to future outbreaks through deliberation, single-loop, double-loop and triple-loop learning. However, advanced learning aspects (learning through action, double-loop and triple-loop) were limited within the health system. Nevertheless, the health system successfully controlled COVID-19, the 2021 EVD and Marburg virus disease. Survey respondents' commonly reported that enablers were the creation of the national agency for health security and support from development partners. Barriers included cultural and political issues and lack of funding. Common recommendations included establishing a knowledge management unit within the Ministry of Health with representatives at regional and district levels, investing in human capacities and improving the governance and management system.

**Conclusion** Our study highlights the importance of learning. The health system performed well and achieved encouraging and better outbreak response outcomes over time with learning that occurred.

## WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ A growing interest in learning health systems over the past decade has led the Alliance for Health Policy and Systems Research to conceptualise a framework for analysing learning health systems, which had not yet been implemented.
- ⇒ Guinea has experienced successive and parallel infectious disease outbreaks between 2014 and 2021 that have provided learning opportunities for the health system and is, therefore, an appropriate setting to apply the learning health systems analysis framework.

## WHAT THIS STUDY ADDS

- ⇒ Learning truly occurred in the response to outbreaks in Guinea's health system through—basic learning aspects (information, deliberation and single-loop learning) most often—action/practice and double-loop learning every so often—and triple-loop learning hardly ever; this learning led to improved performance of health system's response to outbreaks over time, resulting in better control of COVID-19 and a successful response to the 2021 Ebola virus disease and Marburg virus disease. Survey respondents reported enablers and barriers to learning and formulated recommendations for improvements.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Learning within Guinea's health system needs to be valued and promoted through addressing the recommendations made by study participants and researchers.
- ⇒ The framework needs to be improved to comprehensively capture learning aspects and further studies are needed to widely deploy this framework in different contexts to help scholars and practitioners better understand its practicalities and facilitate analysing learning health systems.

## INTRODUCTION

Learning is key to our lives, the success of our projects, performance of organisations and flourishing of our societies. Learning occurs naturally, but it can also be optimised. There are many definitions of learning.<sup>1–6</sup>

The one proposed by Fiol and Lyles, though limited by not including a behavioural change, better captures our perspective of learning—learning is the development of insights, knowledge and associations between past actions, the effectiveness of those actions, and future actions.<sup>5</sup> Referring to Garvin's definition of a learning organisation,<sup>7</sup> a learning health system (LHS) can be defined as a health system skilled at creating, acquiring, interpreting, transferring and retaining knowledge, and at purposefully modifying its behaviour to reflect new knowledge and insights. Over the past decade, there has been a growing interest in LHS.<sup>8–22</sup> An LHS builds on the recognition that health systems are complex, adaptive and social institutions that dynamically respond and adapt to changing needs and contexts, and it also potentially has a long-term orientation towards change and transformation that goes beyond resilience.<sup>20</sup> From this perspective, learning must be prioritised as a core component of health system strengthening agendas.<sup>11 17 18 21 22</sup>

Learning is essential to health system performance. An LHS can lead to more informed, critical and corrective practices and routines, resulting in improved performance of the health system's functions, increased adaptivity and innovation and greater self-reliance.<sup>10 20</sup> The following examples illustrated some benefits of LHS connected with outbreak response—Several Asian countries, for example, South Korea, Singapore, Taiwan, Hong Kong, Saudi Arabia, Cambodia and Vietnam have speedily controlled COVID-19 based on learning from previous outbreaks of Middle East respiratory syndrome and/or severe acute respiratory syndrome<sup>23–30</sup>—In Barbados, a learning collaboration between the Ministry of Health (MoH) and researchers was instrumental in developing a climate-sensitive and epidemiology-sensitive warning system for future dengue outbreaks<sup>31</sup>—In Georgia, an evidence synthesis from the experiences of the earlier-mentioned Asian countries in the successful response to COVID-19 helped health authorities to identify a set of measures for an effective response (achievement of intended goals) to this outbreak.<sup>32</sup> In Nigeria, the establishment of vital new learning processes for outbreak control drawn on the experience from the response to Lassa fever enabled the health system to strengthen its capacity to produce the knowledge needed to tackle future outbreaks.<sup>33–35</sup>

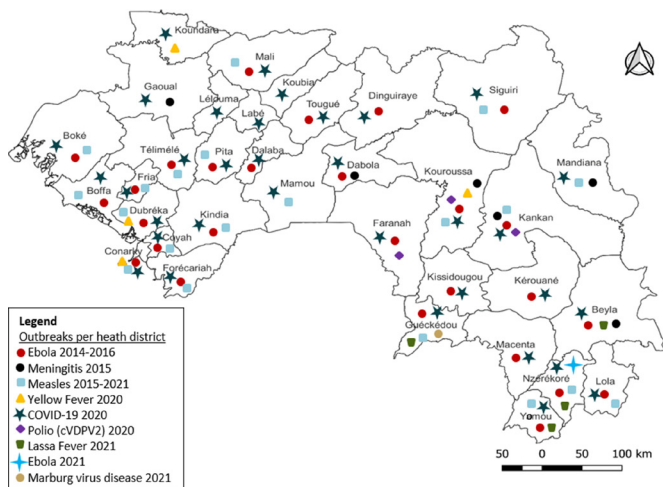
Despite the potential benefits of an LHS, many health systems in low-and middle-income countries are not always capable of effectively generating and using the knowledge they need for good performance. Reservoirs of tacit and experiential knowledge remain poorly deployed and harnessed,<sup>36 37</sup> and consequently, policies and practices are often insufficiently informed by experience, data and evidence.<sup>16</sup> Some LHS initiatives pointed out the lack of institutionalisation<sup>38 39</sup> and lack of resources<sup>40</sup> as barriers to success and sustainability. Other barriers include the lack of shared understanding of the concept of LHS.<sup>20</sup> A health system that does not learn from its own or others' experiences tends to repeat mistakes, and this has often

resulted in the failure of well-intentioned policies and programmes.<sup>11 41</sup>

In September 2021, the Alliance for Health Policy and Systems Research (AHPSR) published a report that outlines the different ways in which health systems can learn and the steps that different stakeholders (including researchers) can take to help build LHS.<sup>20</sup> In this report, the AHPSR combined three dimensions across which learning occurs in health systems grounded on the significant body of existing theories and frameworks of learning organisations and field case studies. These three dimensions are defined as learning levels (individual, team/group, organisation/cross-organisation), means of learning (information, deliberation and action/practice) and learning loops (single, double and triple).<sup>20</sup> These are intended to be a starting point for gaining a shared understanding of an LHS as an actionable agenda. As a result, the WHO called on all countries to invest in LHS since this is the surest track to strengthening health systems sustainably and to progress towards universal health coverage.<sup>3</sup> This study, therefore, subscribes to this call to action and is, to our knowledge, one of the first (if it is not the first) to examine how the conceptual framework proposed by the Alliance for analysing LHS can be implemented.

Guinea offers an ideal setting for such research for several reasons. First, the 2014–2016 Ebola virus disease (EVD) outbreak which severely undermined Guinea's health system (3814 infected cases and 2544 deaths<sup>42</sup>), provided outstanding opportunities to learn from its management for better preparedness to respond effectively to future outbreaks.<sup>43–45</sup> Moreover, after the EVD outbreak, Guinea experienced several other public health crises, such as Meningitis, Measles, Yellow Fever, Lassa fever, COVID-19, circulating vaccine-derived type 2 poliovirus (cVDPV2), 2021 EVD and Marburg virus disease. However, given the heavy workload and limited resources of Guinea's MoH, the documentation of its experience (both positive and negative) in responding to health system 'shocks' has not been undertaken. This raises a few questions—Has the succession of outbreaks been a source of learning for the health system?—Was this succession of outbreaks an asset in speedily containing, for example, the 2021 EVD and the Marburg virus disease? Nevertheless, no evidence exists on how Guinea's health system has responded to and how it learnt from these public health crises and adapted its strategies and actions as a result.

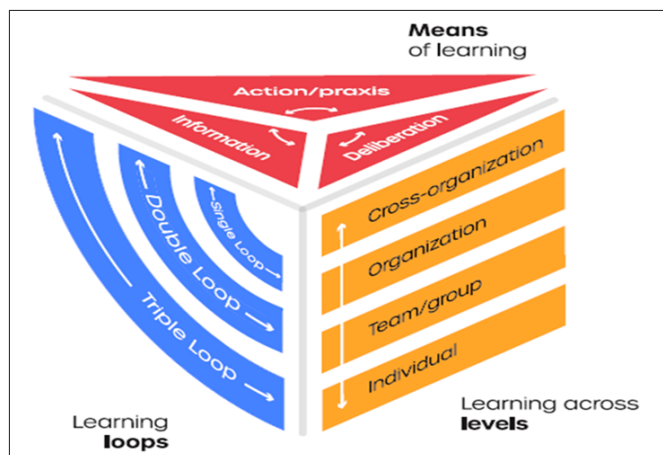
Second, during the 2014–2016 EVD outbreak, an LHS intervention called 'District.Team' was initiated by experts from the Health Service Delivery Community of Practice and implemented as an action-research by the Institute of Tropical Medicine (ITM) of Antwerp (Belgium) in collaboration with its partner institutions ('Centre National de Formation et de Recherche en Santé Rurale de Maferinyah' in Guinea and 'Centre de Recherche en Reproduction Humaine et en Démographie in Benin') and piloted in Guinea and Benin in 2016–2017 with funding from



**Figure 1** Outbreaks distribution in Guinea, 2014–2021.

UNICEF.<sup>38 46</sup> This initiative primarily targeted District Health Management Teams (DHMTs) and later involved staff from regional and central levels in online discussions. It aimed to capacitate DHMTs through participatory evidence production and peer-to-peer exchange to respond to outbreaks and other emerging health issues. Thus, it produced learning through information, deliberation, single-loop and triple-loop, and at the individual and team levels; this learning resulted in optimising the learning capacities of DHMTs.<sup>20 38 46</sup> However, there is no evidence about whether and how Guinea’s health system has taken advantage of this learning initiative in responding to outbreaks that followed the 2014–2016 EVD.

Therefore, this study aimed to analyse how Guinea’s health system has learnt from the response to outbreaks between 2014 and 2021. Specifically, we sought to (1) identify lessons learnt and whether and how the health system incorporated these lessons into its learning process and the response to future outbreaks, drawing on the literature, (2) describe learning that took place at different health system levels from the stakeholders’ perspective, (3) determine enablers and barriers to LHS



**Figure 2** The three learning dimensions in health systems.<sup>20</sup>

from the stakeholders’ perspective and (4) formulate recommendations for improvement of learning within the health system from the perspective of stakeholders.

**METHODS**

**Study design**

We used a retrospective longitudinal single embedded case study design.<sup>47</sup> The *case* is defined as the *Guinea health system*. The type of case study is *retrospective longitudinal* since we aimed to document and analyse change over time (the past 8 years) and *single embedded* because we included multiple units of analysis in the same case: health committees, health districts, health regions, the MoH and its partners (different contexts and levels). The study sites were the health districts and regions in Guinea where at least one outbreak occurred within the study period. Our *theoretical proposition* is that an LHS must incorporate all the aspects of the three learning dimensions (cf. Conceptual framework).

**Setting**

The study was conducted in Guinea, a West African country with a population of approximately 13million, 84% of whom live in rural areas.<sup>48</sup> The Guinean health system has three levels—local (38 health districts)—intermediate (eight health regions)—and central (MoH).<sup>49</sup> The structural organisation of the central level includes the National Agency for Health Security (ANSS), as an attached service. The ANSS, created on 4 July 2016 by presidential decree (N°:D/2016, 205/PRG/SGG)<sup>50</sup> after the EVD outbreak, is in charge of the prevention, surveillance and management of epidemic diseases in Guinea. It implements the strategic orientations of the MoH in terms of health security in the country.

Between 2014 and 2021, Guinea experienced several outbreaks such as EVD, Meningitis, Measles, Yellow Fever, COVID-19, cVDPV2, Lassa Fever and Marburg virus disease. Some of these outbreaks spread over all the health districts, and others affected only one or some health districts, as mapped in **figure 1** using the quantum geographic information system version 3.6. The two haemorrhagic fevers (EVD and Marburg virus disease) originated from the N’Zérékoré health region, where there exist two forests (Ziama and Diécké) considered among the world’s last remaining primary forests.<sup>51</sup>

**Conceptual framework**

The framework proposed by Sheikh and Abimbola<sup>20</sup> for analysing LHS is used and contributes to ensuring the external validity or transferability of this case study.<sup>47 52 53</sup> It presents three dimensions, namely levels, loops and means, whereby learning occurs in health systems. These dimensions are presented in **figure 2** and concisely described in **box 1**. Their full description can be found in the flagship report accessible from the following link : <https://ahpsr.who.int/publications/i/item/learning-health-systems-pathways-to-progress>



## Box 1 The three learning dimensions in health systems

### Learning across levels

Learning occurs at the individual, team/group, organisation and cross-organisation levels.

*Learning at an individual level* entails information-gathering from different sources, gaining tacit knowledge through experience and interpreting these knowledge inputs.

*Team or group-level learning* tends to involve the collective interpretation of knowledge through dialogue and exchange and the development of shared understanding about issues, problems and solutions.<sup>103</sup>

*Learning at the organisation and cross-organisation levels* happens when knowledge and understanding to facilitate more comprehensive coordinated action are integrated and become routine.<sup>103–105</sup>

### Learning loops

Theorists of learning organisations such as Argyris,<sup>79</sup> Argyris and Schön,<sup>92 106</sup> and Tosey *et al*<sup>86</sup> identified three learning loops, namely single, double and triple.

*Single-loop learning* contributes to adjustments and corrections in regular actions—adapting routines and practices within the system without checking assumptions or underlying root causes.<sup>79</sup>

*Double-loop learning* goes a step further to question and influence fundamental frameworks, mental models and assumptions around problems and their solutions, resulting in changes at the level of governing norms, policies or objectives/goals.

As for *triple-loop learning*, there is limited consensus among the scholars about its definition.<sup>96</sup> Nevertheless, often referring to as ‘learning how to learn’, triple-loop learning involves questioning the very basis (learning frameworks and assumptions) through which single-loop and double-loop learning occur and influencing them to change. It improves how the system learns through deliberate changes in or producing new learning structures, processes and strategies.<sup>79 92 106 107</sup>

### Means of learning

Crossan *et al*,<sup>103</sup> Stiglitz,<sup>108</sup> and Jenkin<sup>109</sup> identified three distinct and interconnected means whereby learning is produced in complex systems, namely learning through information, deliberation and action or practice.

*Learning through information* includes collecting, processing, deploying and disseminating information to meet the various learning aims of health systems, including measuring success and failure, anticipating trends and finding new approaches to address problems.<sup>110 111</sup>

*Learning through deliberation is about producing learning through acts of human deliberation.*<sup>108 112</sup> Processes of dialogue and reflection are essential to link past actions, the effectiveness of those actions, and future actions and consist of non-peer and peer engagements and may occur in-person or through technology-enabled platforms.<sup>113–115</sup>

*Learning through action* in complex social systems happens when people, whether individually or as part of a team, group or organisation, learn through the practice and iteration of tasks and projects.<sup>116–118</sup>

### Data collection methods

Data were collected by the primary author (TMM) over 2 months, that is, March–April 2022, through a mixed methods systematic review<sup>54</sup> (box 2) and an online survey (box 3). The review was carried out in March 2022 and informed the survey which was conducted in April 2022 after obtaining ethical approval from ethics bodies in Guinea and at ITM. The review identified lessons from the response to each outbreak and allowed for analysing whether and how Guinea’s health system (as a whole) incorporated these lessons into its learning process and the response to future outbreaks (specific objective 1). From these general knowledge about learning from each outbreak (at the HS level), the online survey explored how each HS level (specifically) learnt over the study period (specific objective 2), determined enablers and barriers to LHS for outbreak response (objective specific 3) and provided recommendations for improvement (specific objective 4) from the stakeholders’ perspective. Therefore, both review and survey complemented each other to answer the research question and to strengthen the construct validity of the case study.<sup>47 52 53</sup> The authors’ reflexivity statement has been added as an online supplemental appendix.

## RESULTS

### Findings from the mixed methods systematic review

Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 diagram

As depicted in figure 3, the initial literature search identified 1520 records, of which 1473 were from peer-reviewed literature and 47 from grey literature. After removing duplicates from the 1473 peer-reviewed records, we screened the titles and abstracts of the remaining 871 records, of which we excluded 707 irrelevant records, and sought 164 reports for retrieval. Then we assessed the retrieved full texts of 160 reports for eligibility, of which we excluded 70 irrelevant reports and 35 other reports that did not mention Guinea and included 55 reports in the synthesis. An irrelevant report was any report whose content (results and conclusion) did not present any lesson learnt related to outbreak response. As for the grey literature, from the 47 reports identified, 30 were sought for retrieval after screening the titles, of which five were discarded for not being relevant. A full-text assessment of the remaining 25 reports was done, and 15 were found relevant and included in the synthesis. Overall, 70 reports were included in the synthesis.

## Box 2 Mixed methods systematic review

We selected the mixed methods systematic review as the most appropriate review method to address the review question.<sup>119</sup> A mixed methods systematic review provides a more complete basis for complex decision-making than that offered by a single method review, thereby maximising its usefulness to clinical and policy decision-makers.<sup>119</sup> The review included peer-reviewed and grey literature on outbreaks in Guinea over the study period. Both quantitative and qualitative research designs and mixed methods primary research were included in the review.<sup>119</sup> In this review, we used the term 'report' instead of 'study', as it encompasses various documents (paper-based or electronic) that are relevant to the review question.<sup>120</sup>

### Review question

The review applied the setting-perspective/population-intervention/phenomenon of interest-comparison-evaluation (SPICE) question formulation framework<sup>121</sup> (online supplemental file 1). The review question was formulated as follows: *How has Guinea's health system learnt from the response to outbreaks over the past 8 years (2014–2021)?*

### Search strategy

A systematic electronic search was performed through PubMed, Web of Science and Google Scholar databases. The search filters included all study types (all fields), reports on Guinea outbreaks between January 2014 and December 2021, free full texts and French and English languages. Search terms or keywords were used for a pilot literature search, and when appropriate, Boolean operators helped combine them and develop a search strategy (online supplemental file 2). Medical subject headings were applied to synchronise synonymous terms in PubMed. In addition, Google customised search was carried out for online books, policy and professional websites, webpages, reports and outbreak response plans. The last search was performed on 5 March 2022.

### Selection and appraisal of reports and data extraction

All records identified from databases, websites and webpages were saved in Mendeley software then imported into Rayyan software<sup>122</sup> for screening (removing duplicates). The selection of reports for review followed the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 statement.<sup>120</sup> The appraisal of reports relied on the relevance of the information they contained related to lessons/recommendations about the response to outbreaks over the study period in Guinea, which determined the reports' inclusion in the synthesis. The included reports consisted of research articles (both observational and interventional studies, eg, field intervention), reviews, letters to editors, policy briefs, case reports, perspectives, debates, opinions, commentaries, books, websites, webpages, organisational reports and outbreak response plans. The reports for which the full text could not be retrieved were excluded. Reports' selection and appraisal were made independently by two researchers (TMM and BSC). Data were extracted using a 2016 Microsoft Excel spreadsheet. The following report characteristics were extracted: corresponding author, publication year, country, type of report, study design, outbreak, main lessons learnt or recommendations.

### Data synthesis and analysis

We used a convergent integrated approach for evidence synthesis and integration.<sup>119</sup> Narrative and tabular data synthesis were performed, followed by a chronological and thematic analysis.<sup>123</sup> Data were triangulated across sources in the narrative synthesis, while the tabular synthesis depicted the characteristics of reports and a short description of the lessons/recommendations. In the analysis, data were organised following the occurrence chronology of outbreaks they relate to, and themes (learning aspects) from the conceptual framework were applied when appropriate.

### Synthesis of lessons and related learning dimensions or aspects

The characteristics of reports included in the synthesis and lessons learnt or recommendations for rapid control of future outbreaks are displayed in online supplemental file 3. Here, we summarised these lessons following the chronology of outbreak occurrence, described whether lessons from the previous outbreaks (eg, 2014–2016 EVD) were incorporated in responding to future outbreaks and pointed out the dimensions or aspects across which learning occurred.

#### Ebola virus disease (2014–2016)

The 2014–2016 EVD outbreak spread over 30 out of 38 health districts and lasted about 2 years and half, with 3814 infected cases (3358 confirmed cases and 456 probable cases) and 2544 deaths (a total case fatality rate of 67%).<sup>42</sup> The main lessons learnt from the response to outbreaks over the study period came from EVD and they are grouped according to the health system building blocks (table 1).

This learning occurred through information (research and experts' opinions), action and practice (learning by doing) and deliberation/double-loop learning (decisions to withdraw the military from the response, involve anthropologists and create the ANSS—the change in the governing norms). Most lessons learnt were incorporated by the health system during and/or after the outbreak, through deliberation, single-loop, double-loop and triple-loop learning, as illustrated in table 2.

#### Measles

Since 2017, the Measles outbreak has been challenging the health system. The transmission persistence is due to insufficient herd immunity levels, which requires further reproduction number estimation to help decision-makers and field staff understand outbreak progress and the timing and type of vaccination efforts needed to stop transmission.<sup>55</sup> This learning was produced through information (research). However, we have not found

### Box 3 The online survey

An online survey was preferred to reach wider audience and because of time and resource constraints.<sup>124 125</sup> The survey was qualitative and conducted using an electronic (KoBoToolbox<sup>126</sup>) semi-structured questionnaire, whose design was informed by the conceptual framework. The questionnaire was pretested with non-participants to check the clarity of the questions and reformulate those that posed problems of understanding.

#### Participant sampling and recruitment

The survey targeted key informants at all levels of Guinea's health system and from partner organisations. They were purposively selected and consisted of community actors (members of the Committee for Health and Hygiene - COSAH), district medical officers (DMOs) and regional health inspectors (RHIs) in health districts and regions where at least one outbreak has been experienced within the study period, one representative from the ANSS, and one representative from each technical and financial partner such as WHO, CDC, UNICEF, IOM, UNFPA, USAID, Amref Health Africa, CRS, Red-Cross and Jhpiego. They were approached via email addresses. Since all the DMOs and RHIs and some staff from the central level participated in the 'District.Team' initiative, their electronic mailing list was still available.<sup>94</sup> The email addresses of key informants from partner institutions and newly appointed DMOs and RHIs were obtained from the Ministry of Health. The community actors received the questionnaire through the DMOs, who distributed it to the heads of the health centres (themselves members of the COSAH), who shared it with the whole COSAH.

#### Data analysis

Data from KoBoToolbox were exported to a 2016 Excel spreadsheet and downloaded. The overall case study database was developed to ensure the reliability of this case study.<sup>47 52 53</sup>

Thematic and content analysis was carried out manually by the primary author (TMM). Data were triangulated across respondents (eg, enablers, barriers and recommendations), contributing to ensuring the credibility or internal validity of the case study.<sup>47 52 53 127</sup> The information was then analysed using deductive coding (based on the conceptual framework and contextual factors). The codes were classified into main categories (levels, loops, means and contextual factors) and subcategories (individual, team, organisation, cross-organisation (for levels); single, double and triple (for loops); information, deliberation and action (for means); enablers and barriers (for contextual factors).

#### Monitoring and quality control

The first author (TMM) assured data monitoring and quality control daily. KoboToolbox offered the possibility to verify the completeness/accuracy of data submitted by respondents. The respondents who submitted incomplete questionnaires were requested via email to complete the missing information when needed.

evidence in the literature on whether the health system has incorporated this learning or not.

#### Lassa fever

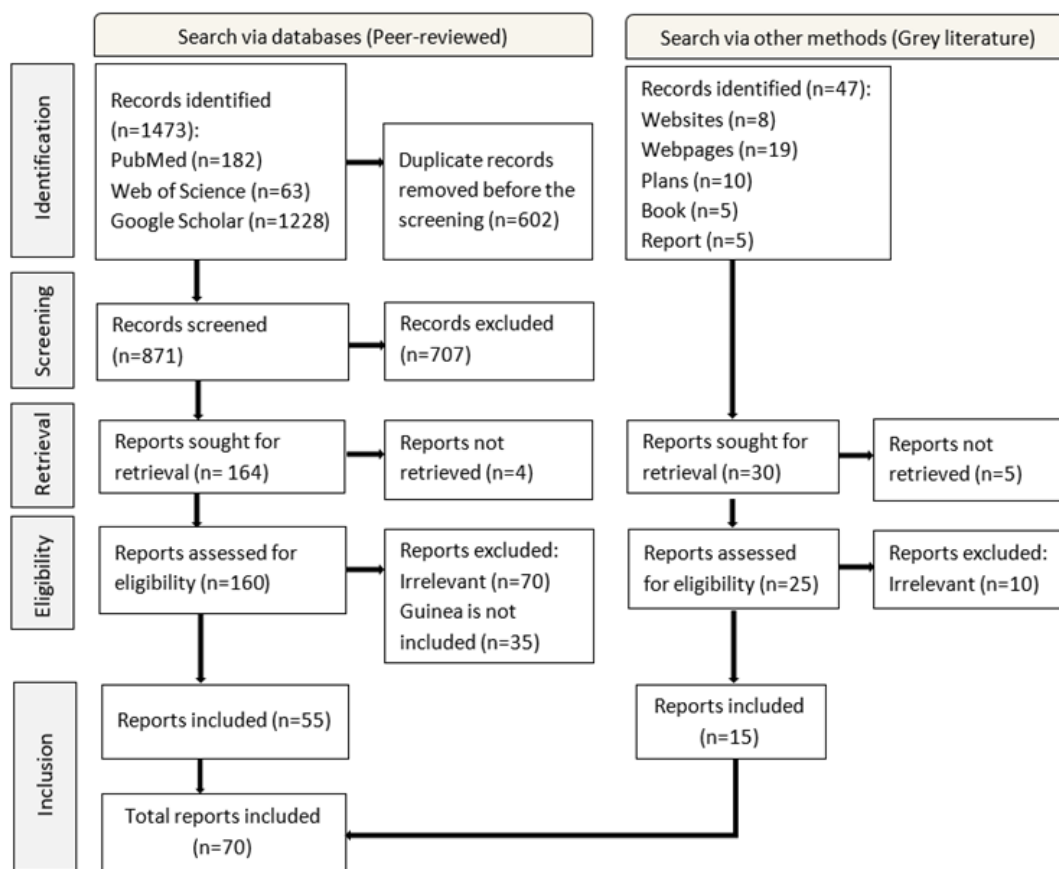
Lassa fever, which was first diagnosed in October 2011 in Guinea, is now endemic in the country. One reason could be the challenge in early identification of the disease in remote areas, that is, at health centre level.<sup>56</sup> Thus, there is a need for regular awareness training to facilitate the implementation of improved field surveillance and early detection.<sup>56</sup> The chemical treatment effectively controls local rodent populations. It can partly serve as a practical, holistic approach combining rodent trapping, use of local rodenticides, environmental hygiene, house repairs and rodent-proof storage.<sup>57</sup> Eradicating the Lassa virus requires controlling rodents in neighbouring villages, and the risk of Lassa virus spillover is heterogeneously distributed within Guinea's villages.<sup>58</sup> This learning happened through information (research) and was probably taken into account by the health system, as the ANSS strengthened multisectoral actors' capacity in the 'One Health' approach (through deliberation and double-loop learning), which has been implemented in the country since 2019 for better control of zoonotic diseases.<sup>59</sup> However, we have not found evidence about triple-loop learning.

#### COVID-19

The primary outbreak that followed EVD was COVID-19, declared on 12 March 2020, the response of which

recorded improvements and success drawn on lessons learnt from the response to the EVD outbreak, such as—the early diagnosis of the disease (the first case detected within 48 hours) due to strengthened disease surveillance, outbreak investigation and laboratory capacities—the availability of epidemic treatment and isolation centres—and the knowledge about how to elaborate an outbreak response plan. In fact, the response plan was elaborated (in February 2020) even before the onset of the outbreak in the country.<sup>60</sup> This plan included most of the lessons from the response to EVD outbreak in terms of epidemiological surveillance, laboratory, infection prevention and control, information and communication, logistics, coordination, community engagement, risk communication, treatment centres, data collection and contact tracing (Go.Data) and also included a component specific to clinical manifestation of COVID-19, such as resuscitation. For instance, a community response strategic plan called 'stop COVID-19 within 60 days'<sup>61</sup> was implemented referring to the 'zero Ebola within 60 days' strategic plan successfully carried out during the EVD outbreak.<sup>62</sup>

However, despite the introduction of rapid readiness and response measures, some health system weaknesses persist (eg, lack of financial resources), and the unique nature of COVID-19 continues to challenge control efforts.<sup>63</sup> From these weaknesses, lessons that could be incorporated to improve future outbreak responses were connected to strengthening contact tracing, early community engagement,<sup>64</sup> optimal outbreak



**Figure 3** PRISMA 2020 updated flow diagram.<sup>120</sup> PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

preparedness (eg, sufficient case detection and response capabilities)<sup>65 66</sup> and reflecting on strategies to mitigate the effects of political unrest on outbreak control efforts or implementation of the response plan.<sup>64 67</sup> Moreover, for more success in responding to outbreaks, the health system needs to rethink the governance of the outbreak response by prioritising internal resource mobilisation and creating better synergy between national institutions to pool existing strengths and gain support from communities. To this end, national institutions tasked with each response pillar should be identified and provided with the required resources (eg, local budget lines) under the coordination of the MoH or the designated institution. When doing so, the path for long-term capacity building of local actors with support from technical and financial partners could be established.<sup>66 68</sup>

Besides, the COVID-19 pandemic jeopardised efforts to achieve Sustainable Development Goals for maternal and child health in urban settings in Guinea. Therefore, for the country's health system to be more resilient to crises such as COVID-19, interventions are needed to ensure the continuity of maternal and neonatal care.<sup>69</sup>

These lessons were learnt through information (research and experts' views), deliberation (meetings), action and practice ('stop COVID-19 within 60 days' strategy) and single loop (elaboration of the response plan). Looking at the above lessons to be considered to

improve future outbreak response, it appears that many lessons learnt from the response to the EVD outbreak were not adequately incorporated by the health system. Therefore, learning through action and practice was limited beyond the missing double-loop and triple-loop learning.

#### Ebola virus disease (2021)

Amid COVID-19, the MoH declared the EVD outbreak in the health district of N'zérékoré on 14 February 2021. Three confirmed and four probable cases and five deaths (one confirmed+the four probable) were notified two days later. The outbreak was successfully controlled within one health district and within four months, with 23 infected cases (16 confirmed+seven probable cases), of which 12 deaths (a total case fatality rate of 52%) and 11 cured/survivors. This success pertains to the integration into the response plan of experience and most lessons learnt from the 2014–2016 EVD outbreak.<sup>70</sup> These success factors include strengthened epidemiological surveillance, the deployment of skilled Guinean professionals trained during the previous EVD at all response pillars, good coordination and synergy of partners' actions, early community engagement and ring vaccination.<sup>71</sup> Moreover, a '90 days strengthened surveillance plan' was designed and implemented with the aims of—maintaining and



**Table 1** Lessons learnt from the 2014–2016 EVD response, Guinea

| Health system building blocks | Lessons learnt  |
|-------------------------------|---|
| Leadership and governance     | <ul style="list-style-type: none"> <li>▶ Engaging community early in the response<sup>43 57 77 85 128–136</sup></li> <li>▶ Performing social mobilisation<sup>43 77 85 128 133 135 137</sup></li> <li>▶ Strengthening community participation<sup>138 139</sup></li> <li>▶ Ensuring multisectoral collaboration<sup>139 140</sup></li> <li>▶ Establishing a sustainable structure (ANSS) for outbreak response with an autonomous management mandate<sup>85</sup></li> <li>▶ Elaborating the national post-Ebola health system strengthening investment plan<sup>141</sup></li> <li>▶ Enhancing governance<sup>85</sup></li> <li>▶ Evading the deployment of armies, especially western armies on the ground, to avoid fear in communities and prevent mistrust and violent fatal attacks on healthcare workers (HCWs) and volunteers<sup>133</sup></li> <li>▶ Avoiding partners or ‘friends’ command according to what they have known or used elsewhere, and taking into account local skills in the command<sup>85</sup></li> </ul>  |
| Human resources               | <ul style="list-style-type: none"> <li>▶ Prioritising investment in health personnel (training and capacity building, increasing the number through recruitment and retention strategies)<sup>85 132 137 142–145</sup></li> <li>▶ Involving social scientists/anthropologists early in the response<sup>45 146–149</sup></li> <li>▶ Putting local professionals to the fore of the response while external agents being in the background<sup>150</sup></li> </ul>  |
| Service delivery              | <ul style="list-style-type: none"> <li>▶ Enhancing preparedness to mitigate outbreak-collateral effects by designing parallel strategies and interventions to counter service disruptions (tuberculosis, maternal and child health including nutrition and prevention of mother-to-child transmission of HIV, malaria in under-five) particularly, developing toolkits for monitoring health service disruptions and adjusting programmes accordingly<sup>129 151–156</sup></li> <li>▶ Preserving communities’ values and addressing outbreak-related psychological effects<sup>157 158</sup></li> <li>▶ Implementing ring vaccination<sup>159</sup></li> <li>▶ Ensuring long-term follow-up of EVD survivors, as the virus can persist in their seminal fluid for a long period of time (531 days after onset of disease)<sup>160</sup></li> <li>▶ Strengthening infection prevention and control (IPC)<sup>161</sup></li> <li>▶ Addressing underlying social determinants of the country’s vulnerability and weak capacity for a successful response to outbreaks<sup>132</sup></li> <li>▶ Addressing survivors’ emotional reactions<sup>158</sup></li> </ul> |
| Information and knowledge     | <ul style="list-style-type: none"> <li>▶ Combining epidemiological surveillance with molecular surveillance (real-time sequencing)<sup>148 150 160 162</sup></li> <li>▶ Conducting crisis communication<sup>85 131 163</sup></li> <li>▶ Improving disease surveillance, including setting up the surveillance and alert system for early detection of EVD resurgence among survivors, and expanding disease-specific surveillance to areas surrounding the outbreak’s known geography<sup>145 164–166</sup></li> <li>▶ Building a multifaceted motivational approach which emphasises motivational messages that refer to patriotic values and moral responsibility when recruiting volunteers<sup>167</sup></li> </ul>   |
| Infrastructure and supplies   | <ul style="list-style-type: none"> <li>▶ Developing health infrastructure and equipment (epidemic treatment centres and laboratory capacity building)<sup>85 144 145</sup></li> <li>▶ Conducting a real needs assessment to avoid purchasing useless equipment<sup>85</sup></li> </ul>  |
| Finances                      | Managing the mobilised funds with transparency <sup>85</sup>  |

ANSS, National Agency for Health Security; EVD, Ebola Virus Disease.

strengthening community-based surveillance through the ‘One Health’ platforms—ensuring vaccination of health staff, corpse washers, traditional healers, red-cross staff, survivors’ relatives in the region of N’zérékoré—and strengthening the survivors’ monitoring programme, that is, clinical, biological and psychological monitoring, surveillance and vaccination around survivors and research.<sup>72</sup> However, as the Ebola virus can persist in survivors’ body fluids for five years, research efforts must focus on potent antiviral agents

that can eradicate the latent virus reservoir in patients with EVD and on efficient vaccines that provide long-term protection.<sup>73</sup>

Here, learning occurred through information (research, eg, survivors’ clinical, biological and psychological monitoring), deliberation (meetings), action and practice (ring vaccination, community engagement) and single loop (development of the response plan). However, no evidence exists about double-loop and triple-loop learning.





**Table 2** Incorporation of lessons learnt from the 2014–2016 EVD outbreak, Guinea

| Learning aspects     | Examples of incorporation ways of lessons  | After the outbreak |
|----------------------|--|--------------------|
| Deliberation         | Meetings and stakeholder consultations, for example, MoH, policy entrepreneurs and partners/donors   | NA                 |
| Single-loop learning | Reconstitution of regional and district epidemic alert and response teams. <sup>85</sup> — <i>It corresponds to adjustments and corrections in the system to achieve the outbreak response goals without questioning the underlying causes of problems.</i>  | NA                 |
| Double-loop learning | <p><i>Example 1:</i> Creation of the Ebola national coordination unit on 5 June 2014 which managed the EVD response up to its end in 2016 under the leadership of the president of the republic, in replacement of the national committee for health crisis (which existed before the EVD and was activated on 23 February 2014) because of its unsatisfactory management of the outbreak response over 4 months.</p> <p><i>Example 2:</i> Questioning the underlying causes of the dysfunction and poor performance of the health system, which led to the rapid spread of the EVD within and outside the country, through a popular forum ‘the general states of health’ organised by the MoH and its partners in May 2015 (during the outbreak).<sup>168</sup> The forum noted that the health system was characterised by—a still high morbidity and mortality rate, particularly among mothers and children—an insufficient coverage of essential health services, the quality of which was sometimes questionable—an inefficient and inequitable healthcare provision within an inappropriate environment and a lack of access to health services.<sup>168</sup></p> <p>Then, developing the 2015–2017 health system recovery and resilience plan (part of the 2015–2024 national health development plan) to address the issues highlighted at the forum and the lessons learnt from the EVD response.<sup>149</sup> Therefore, the expected and/or achieved changes included:</p> <ul style="list-style-type: none"> <li>▲ EVD and other diseases) eliminated through strengthened infection prevention and control, improved integrated disease surveillance and response and international health regulations<sup>168</sup></li> <li>▲ Improved performance of the local health system through improved service delivery and strengthened management system<sup>168</sup></li> <li>▲ Enhanced health system governance through support to management, coordination, accountability, community engagement and regulation<sup>168</sup></li> <li>▲ Reformed health sector by prioritising investment in health personnel (2950 health professionals recruited and deployed, some of whom received training/capacity building)<sup>44, 169–171</sup></li> <li>▲ Built health infrastructures (38 epidemic treatment centres and laboratory capacity were built).<sup>85, 172</sup></li> </ul> | NA                 |
|                      | <p><i>Example 3:</i> Moreover, after the EVD an epidemic preparedness plan was elaborated for a 5 year period.<sup>85</sup> As part of this plan, the Ebola national coordination unit was dissolved and replaced with the ANSS which is a sustainable structure with an autonomous management mandate, now responsible for organising epidemiological surveillance and response and preparing the country’s health security capacity-building.<sup>85</sup></p>   |                    |
|                      | <p>▲ <i>These examples relate to questioning the health system’s fundamental framework and assumptions around problems and their solutions resulting in changes at the level of governing norms, policies and objectives/goals</i></p>   |                    |

Continued

| Table 2 Continued  |  |
|--|--|
| Examples of incorporation ways of lessons  |  |
| Learning aspects   | After the outbreak   |
| Triple-loop learning   | <p>The health system, capitalising on learning from the EVD outbreak response, engaged in learning how to improve the disease surveillance process. It set up a new disease surveillance system using DHIS2 over 4 years, from the pilot in two health regions between Mai and November 2017 to scale up at the national level between January 2018 and March 2020.<sup>87</sup> This new process which resulted from substantial evolution (from a system focused on aggregate reporting only, transmitted from health facilities to the national level by phone and case forms on paper, to a fully integrated and electronic disease surveillance system that allows both for aggregate and individual case reports proved instrumental in COVID-19 response for which a module for case data was swiftly established in the DHIS2 by the ANSS in March 2020.<sup>87</sup> Using DHIS2 for the COVID-19 response, stakeholders, including laboratories, now better understand and support the process of individual case reporting and timely data entry, as they can see the line lists with case characteristics, yield summary statistics, and have a real-time dashboard useful to evidence-based decision-making.<sup>87</sup></p> <p>▶ <i>This corresponds to improvements in how the health system learns through deliberate changes in learning structures, processes and strategies.</i></p> |
| ANSS, National Agency for Health Security; DHIS2, District Health Information System version 2; EVD, Ebola Virus Disease; MoH, Ministry of Health; NA, not applicable. |  |

### Marburg virus disease

On 3 August 2021, two months after, the end of the EVD outbreak, while COVID-19 was in progress, the health district of Guéckédou was alerted by the health centre of Koundou, located 54 kilometres from Guéckédou city, of a community death of a 46-year-old male resident of Tèmèsadou M'boket (a small village situated nine kilometres from the Sierra Leone border). An investigation team was immediately deployed to the village and conducted a preliminary investigation by collecting a postmortem oral swab sent to the viral haemorrhagic fever laboratory in Guéckédou the same day. The result of the reverse transcription-PCR test on 3 August 2021 was positive for Marburg virus disease. Immediately, a multidisciplinary team was put in place to implement response activities supported by a response plan.<sup>74</sup> The outbreak was controlled within 42 days, with only one confirmed case/death. The rapid implementation of response activities, coupled with the experience of the affected health district in fighting against viral haemorrhagic diseases, played a central role in controlling the epidemic's spread to other health districts and the neighbouring countries.<sup>75</sup> In particular, the training and vigilance of HCWs in the surveillance of epidemic-prone diseases were essential to the early detection of the case.

"We immediately informed the district health authorities so that they could take a sample," as asserted the lead of the health centre of Koundou.<sup>76</sup>

In addition, effective contact tracing, community engagement, social mobilisation, improvement in border disease surveillance and WHO experts' support for outbreak investigation, rapid emergency response and improvement in disease surveillance and testing were instrumental in the rapid outbreak control.<sup>77</sup> The WHO Regional Director for Africa, impressed with the growing expertise in outbreak response in Guinea, stated:

Without immediate and decisive action, highly infectious diseases like Marburg can easily get out of hand. Today we can point to the growing expertise in outbreak response in Guinea and the region that has saved lives, contained and averted a spillover of the Marburg virus.<sup>78</sup>

However, the source of the epidemic is still unknown, and the wife of the unique case could not be found, which constitutes a significant risk for the resurgence of cases. Consequently, investigations and research (seroprevalence of Marburg in the population of Guéckédou) were in progress during the review period.<sup>75</sup>

Here, learning happened through information (notification of death, oral swab collection and testing), deliberation (meeting and expert consultations), action and practice (implementation of outbreak response activities, eg, surveillance, contact tracing and community engagement), single loop (elaboration of the response plan and on-site testing thanks to laboratory capacity building). Besides, ongoing research on Marburg seroprevalence is also a source of learning through

**Table 3** Enablers and barriers to learning health system in terms of response to outbreaks in Guinea, 2022

| Factors  | Enablers   | Barriers  |
|--|--|---|
| Organisational structure                                       | <ul style="list-style-type: none"> <li>▶ Creation of the national agency for health security (ANSS)*</li> <li>▶ Decentralisation of coordination teams (ERARE, EPARE/ECARE)*</li> <li>▶ Activation of COU-SP</li> <li>▶ Existence of research and training facilities</li> <li>▶ Existence of a scientific advisory committee</li> </ul> | <ul style="list-style-type: none"> <li>▶ Lack of ownership of the concept of LHS†</li> <li>▶ Over-dependence on technical and financial partners</li> </ul>   |
| Learning-friendly leadership and hierarchical culture          | <ul style="list-style-type: none"> <li>▶ Availability of political and administrative authority</li> </ul>   | <ul style="list-style-type: none"> <li>▶ Cultural, hierarchical and political considerations†</li> <li>▶ Suboptimal enabling conditions</li> <li>▶ Ignorance of the bottom-up planning/voice in decision-making†</li> <li>▶ Lack of staff accountability</li> </ul>                             |
| Human resources  | <ul style="list-style-type: none"> <li>▶ Availability of human resources (including the presence of experts)</li> <li>▶ Presence and commitment of staff, in particular, those who participated in the EVD outbreak response*</li> <li>▶ Trained staff in FETP</li> </ul>  | <ul style="list-style-type: none"> <li>▶ Lack of time in DHMTs</li> <li>▶ Interference of activities (multiplicity of vertical programmes) in health districts</li> <li>▶ Lack of commitment of DHMTs (reluctance in some cases)</li> <li>▶ Lack of ownership of the concept of LHS†</li> </ul> |
| Financial, logistic and technical resources                    | <ul style="list-style-type: none"> <li>▶ Support from development partners</li> </ul>  | <ul style="list-style-type: none"> <li>▶ Lack of funding (non-implementation of the decisions made at the bottom level)†</li> <li>▶ Lack of logistic resources</li> <li>▶ Technical barriers (internet, computer equipment)</li> </ul>  |
| Active learning agenda and vision                              | NA   | <ul style="list-style-type: none"> <li>▶ Insufficient establishment of objective or performance contracts to stimulate learning</li> </ul>  |
| Capacity building  | <ul style="list-style-type: none"> <li>▶ Continuous training/capacity-building workshops</li> <li>▶ Experience/solution sharing (lessons learnt and good practice)*</li> </ul>   | NA  |
| Enabling environment for teamwork                              | <ul style="list-style-type: none"> <li>▶ Motivation of staff by the hierarchy</li> <li>▶ Involvement of all stakeholders, including partners, communities and socio-anthropologists</li> </ul>   | <ul style="list-style-type: none"> <li>▶ Insufficient communication between the community and the health staff (lack of information and awareness)†</li> </ul>  |
| Non-alignment of incentive structures to learning requirements | NA   | <ul style="list-style-type: none"> <li>▶ Lack of reward/sanction system</li> <li>▶ Delay in paying workers</li> <li>▶ Incentives related to the distance for workers in remote areas not taken into consideration</li> </ul>  |
| Monitoring and evaluation                                      | <ul style="list-style-type: none"> <li>▶ After-action review</li> </ul>  | NA  |
| Outbreak   | <ul style="list-style-type: none"> <li>▶ Presence of the outbreak itself</li> </ul>  | <ul style="list-style-type: none"> <li>▶ Politicisation of outbreaks</li> <li>▶ Rumours</li> </ul>  |

\*Commonly-reported enablers.  
 †Commonly-reported barriers.  
 COU-SP, Public Health Emergency Operation Centre; DHMTs, District Health Management Teams; ECARE, Communal Epidemic Alert and Response Team; EPARE, Prefectural Epidemic Alert and Response Team; ERARE, Regional Epidemic Alert and Response Team; EVD, Ebola Virus Disease; FETP, Field Epidemiology Training Programme; LHS, Learning Health System.

information. However, we have not found in the reports we reviewed evidence of what we could categorise as double-loop and triple-loop learning.

### Findings from the survey

In this section, we showed participants' characteristics, described learning that occurred at the different health system levels employing the learning dimensions, determined enablers and barriers to LHS from

the respondents' perspective and formulated recommendations for improvement of learning within the health system from the perspective of respondents.

### Participants' characteristics

Overall, 33 key informants participated in the survey, including one representative of the ANSS (central level), five regional health directors (regional level), 13 district medical officers (DMO) (district level), five community

**Table 4** Recommendations for learning improvement linked to outbreak response in Guinea from respondents' perspective, 2022

| Recommendation  | Related factor (result)   | Recommendation target  | Implementation term   |
|---|---|--|---|
| <ul style="list-style-type: none"> <li>▶ To improve the leadership of the MoH and coordination</li> <li>▶ To improve the governance and management system at all levels, including transparency and accountability to the population, government and donors*</li> <li>▶ To create a sharing environment and making available the necessary resources</li> </ul>   | <ul style="list-style-type: none"> <li>▶ Learning-friendly leadership and culture</li> </ul>    | <ul style="list-style-type: none"> <li>▶ MoH General Secretariat</li> <li>▶ MoH Policy advisor</li> </ul>  | <ul style="list-style-type: none"> <li>▶ Short (&lt;1 year)</li> </ul>          |
| <ul style="list-style-type: none"> <li>▶ To establish a knowledge management unit within the MoH with representatives at regional and district levels*</li> <li>▶ To strengthen operational research at the health district level</li> <li>▶ To improve the use of the digital strategy for facilitating learning*</li> <li>▶ To involve all stakeholders on all health issues</li> <li>▶ To institutionalise key learning functions within the Guinean health system*</li> </ul> | <ul style="list-style-type: none"> <li>▶ Organisational structure</li> </ul>                    | <ul style="list-style-type: none"> <li>▶ MoH General Secretariat</li> <li>▶ Office for strategy and development</li> </ul>                               | <ul style="list-style-type: none"> <li>▶ Short to medium (1–3 years)</li> </ul> |
| <ul style="list-style-type: none"> <li>▶ To create and deploy human capacities required to perform learning functions*</li> <li>▶ To promote local recruitment based on priorities</li> </ul>   | <ul style="list-style-type: none"> <li>▶ Human resources</li> </ul>                             | <ul style="list-style-type: none"> <li>▶ MoH Training Service</li> <li>▶ Programme coordinators</li> <li>▶ ANSS director</li> <li>▶ RHIs/DMOs</li> </ul> | <ul style="list-style-type: none"> <li>▶ Short/medium</li> </ul>                |
| <ul style="list-style-type: none"> <li>▶ To create performance or target contracts with managers at the ANSS, regional and district levels</li> </ul>   | <ul style="list-style-type: none"> <li>▶ Active learning agenda and vision</li> </ul>           | <ul style="list-style-type: none"> <li>▶ Managers' hierarchical supervisors</li> <li>▶ Partners</li> </ul>   | <ul style="list-style-type: none"> <li>▶ Medium</li> </ul>                      |
| <ul style="list-style-type: none"> <li>▶ To provide the necessary resources for the implementation of activities*</li> <li>▶ To improve the financial contribution of the government to be less dependent on TFPs</li> <li>▶ To continue supporting health structures with logistics, communication and funding</li> <li>▶ To ensure technical and financial support to COSAH, reinforcing community health and real-time information sharing</li> </ul>                          | <ul style="list-style-type: none"> <li>▶ Financial, logistic and technical resources</li> </ul> | <ul style="list-style-type: none"> <li>▶ MoH General Secretariat</li> <li>▶ MoH Policy advisor</li> <li>▶ Partners</li> </ul>                            | <ul style="list-style-type: none"> <li>▶ Short to medium</li> </ul>             |

\*Commonly-reported recommendations.

ANSS, National Agency for Health Security; COSAH, Committee for Health and Hygiene; DMOs, District Medical Officers; MoH, Ministry of Health; RHIs, Regional Health Inspectors; TFP, Technical and Financial Partner.

actors and nine representatives of different partners (online supplemental file 4).

#### Learning at the central, regional and district levels

The ANSS informants responded to all outbreaks in Guinea from 2014 to 2021. Each health district experienced at least one outbreak that the regional health inspectors and DMO were involved in controlling. In summary, the ANSS staff, the RHIs and DMOs have mostly learnt through fundamental aspects (information, deliberation and single loop) and partly across action and double loop, while triple-loop learning was missing.

Online supplemental file 5 details learning that occurred at the central, regional and district levels.

#### Learning at the community level

Over the study period, the first outbreaks that community respondents were involved in fighting against were the EVD outbreak (2014–2016) and Polio (cVDPV2 – October 2021). Most community respondents were involved in EVD outbreak response, and one was involved in Polio control. Respondents are all men and from four health districts, namely, Guéckédou, Kissidougou, Dabola and Faranah.



#### Box 4 Our observations about the learning health system (LHS) analysis framework

This framework enlightens the concept of learning health system by encompassing good features of learning organisation from the literature. Certain frameworks used in health systems, such as Cynefin's, allow for learning but are limited in their current conceptualisation and application. The Cynefin framework,<sup>173 174</sup> a leaders' decision-making tool, brings about action-focused learning, from which the other learning aspects (except triple-loop learning) can derive according to the different levels of uncertainty (simple, complicated, complex and chaotic). As an illustration, Holly *et al*<sup>175</sup> applied the Cynefin framework to report on a learning approach to community response during the COVID-19 pandemic in the USA, which missed the triple-loop learning.

Despite the value of the current LHS analysis framework, we operationally and conceptually noticed that some areas need to be improved. First, double-loop and triple-loop learning boundaries are blurred in practice and can be inversely and confusingly employed. Confusion may arise from the diverse conceptualisations of triple-loop learning in the literature, some of which overlap with double-loop learning. Nevertheless, to operationally distinguish between learning loops, we think that it may be helpful to pay attention to key attributes (expected changes) such as—altered actions (for single-loop learning)—altered governing norms, policies or objectives/goals (for double-loop learning)—altered learning processes, structures or strategies (for triple-loop learning). Second, the emotional aspect of learning (learning by feeling/going through) is not captured by the current LHS analysis framework. This could be taken into account by reframing learning through action/practice (learning by doing/seeing) as 'learning through experience' because the latter incorporates the former and learning by feeling things.<sup>176</sup> We believe that as individuals, teams and even organisations, we also learn by 'going through'. For instance, experiencing barriers, facing humiliation, hate, discrimination, fighting bureaucracy, political oppositions or private interests call to deeper human processes than adapting routines or solving problems. Also, learning coming from handling an epidemic can entail strong emotions (pain, death, fear, stigmatisation) that are source of learning (willingness to change) for a team, society or nation, though these emotions can be sometimes tough. Thus, the description of 'learning through experience' could be extended to knowledge translation to explain how knowledge generated by doing, seeing or feeling can be applied.<sup>83</sup> Third, the current framework focuses only on analysing the learning process. It does not say anything about learning outcomes. However, analysing an LHS must consider both the learning process and outcomes for a comprehensive performance evaluation. Therefore, there is a need to review the current framework design by relating the learning dimensions to outcomes (key changes/potential benefits) with a description about how to evaluate outcomes. For instance, when the framework is applied to a specific domain (eg, outbreak response or maternal deaths surveillance and response system), the evaluation of learning outcomes (health system performance) may draw on the domain-specific indicators. Last, further studies are needed to widely deploy the LHS framework in different contexts to help scholars and practitioners better understand its practicalities and facilitate analysing LHS.

In short, to operationally and conceptually improve the current framework, we suggest—making a clear distinction between learning loops—reframing learning through action/practice as 'learning through experience'—relating the learning dimensions to outcomes with a description about how to evaluate outcomes—and deploying the framework in different contexts.

They were tasked with awareness-raising on outbreak preventive measures, kit distribution, social mobilisation and management of community reluctance.

After training on the disease [Ebola], we were hired to raise awareness in the community and on the radio (community relay, man).

I was part of one of the committees set up to deal with reluctance and community mobilisation to adhere to the outbreak control measures (community leader, man).

My role was to distribute hand-washing kits and inform people to report foreigners who come for visits or to the market, and I was involved in transporting corpses from point A to point B (community relay, man).

More than half of them fought against the outbreak (COVID-19) that followed the one they were involved in responding to for the first time. The non-involvement of certain informants in future outbreak response was due to either the non-availability (hired on another activity) of the person concerned or because his/her health area/locality did not experience any future outbreak.

Respondents reported having learnt lessons from the health system outbreak control strategies such as the involvement of all actors (including communities) in the response, setting up committees in the villages to task with alerts, recommendations to comply with hygiene rules, wearing of face masks, physical distancing, hand

#### Box 5 Study implications

We hope that the findings of this study will inform policymakers and decision-makers about strategies or mechanisms required to build an learning health system (LHS) or advance learning within Guinea's health system, particularly by relying on recommendations made. Furthermore, this study could stimulate the emergence of a learning ecosystem in Guinea, as the current study and our past work on learning<sup>38 46 169–171</sup> show that there is a promising momentum. This hope is supported by the increase in the number of Guinean first authors on scientific papers (eg, 21/55 peer-reviewed papers included in the evidence synthesis have a Guinean as first author). Moreover, as Guinea's health system tackles multiple public health challenges in succession/parallel, the evidence of lessons learned and incorporated would help it raise its profile in the African region and could support the mobilisation of technical and financial resources needed to institutionalise key learning functions. Finally, demonstrating that Guinea's health system actively incorporates what it learns into its approaches and actions might encourage other African countries' MoH to set their own goals of establishing their countries' health systems as LHS and to strengthen domestic research capacity, especially for health policy and systems research.

**Table 5** Recommendations from researchers related to learning improvement within Guinea's health system

| Recommendations  | Recommendation target  | Support                 | Implementation term                          |
|--|--|-------------------------|--|
| ▶ To take into account the recommendations made by respondents (cf. table 4) because they contribute to building an LHS. We suggest starting with a cluster or consultation meeting to discuss these recommendations and prioritise and advocate them. | ▶ MoH General Secretariat<br>▶ ANSS Director<br>▶ Programme coordinators<br>▶ RHIs<br>▶ DMOs | ▶ Partners<br>▶ Experts | ▶ Short<br>▶ (<1 year) to medium (1–3 years) |
| ▶ To establish regular post-action reviews   | ▶ ANSS Director<br>▶ RHIs<br>▶ DMOs  | ▶ Partners              | ▶ Short                                      |
| ▶ To balance investments in the health system hardware and learning capacities   | ▶ MoH General Secretariat<br>▶ MoH Policy Advisor<br>▶ Partners                              | ▶ Partners              | ▶ Short/medium                               |
| ▶ To train/build the capacity of staff at the ANSS, regional, district and community levels in knowledge management and the concept of LHS   | ▶ MoH Secretariat General<br>▶ MoH Training Service  | ▶ Partners<br>▶ Experts | ▶ Short/medium                               |
| ▶ To strengthen supportive supervision   | ▶ Programme coordinators<br>▶ Managers   | ▶ Partners              | ▶ Short                                      |
| ▶ To establish and align incentive mechanisms to learning requirements   | ▶ MoH General Secretariat<br>▶ ANSS Director<br>▶ Programme coordinators<br>▶ RHIs<br>▶ DMOs | ▶ Partners              | ▶ Short/medium                               |
| ▶ To integrate learning into existing health programmes  | ▶ MoH General Secretariat<br>▶ Programme coordinators  | ▶ Partners<br>▶ Experts | ▶ Short/medium                               |
| ▶ To develop an active learning agenda and vision  | ▶ MoH General Secretariat  | ▶ Experts               | ▶ Short/medium                               |
| ▶ To improve/rethink governance in terms of response to outbreaks  | ▶ MoH General Secretariat<br>▶ ANSS Director   | ▶ Partners              | ▶ Short                                      |
| ▶ To set up a collaboration frame between researchers and policy/decision-makers to motivate knowledge use and learning  | ▶ MoH General Secretariat  | ▶ Partners              | ▶ Short                                      |
| ▶ To invest in domestic capacity for health system research and policy analysis  | ▶ MoH General Secretariat  | ▶ Partners              | ▶ Medium                                     |
| ▶ To recognise and make use of innovations emerging from day-to-day experience   | ▶ MoH General Secretariat<br>▶ MoH Policy Advisor<br>▶ Programme coordinators                | ▶ Partners              | ▶ Short                                      |
| ▶ To listen to and learn from communities served by the health system  | ▶ MoH Directorate of Community Health<br>▶ RHIs<br>▶ DMOs                                    | ▶ Partners              | ▶ Short                                      |
| ▶ To incorporate learning into basic training curricula  | ▶ Faculty of Health Sciences and Techniques (UGANC)  | ▶ Partners<br>▶ Experts | ▶ Short/medium                               |

ANSS, National Agency for Health Security; DMOs, District Medical Officers; LHS, Learning Health System; MoH, Ministry of Health; RHI, Regional Health Inspector.

washing for public and health staff, the declaration to the hierarchy of any suspected case. They learnt those lessons through deliberation (meetings) and action/practice (written recommendations or shared guidelines). They applied what they learnt across daily use, disease surveillance, awareness-raising, meetings with health professionals, community relays and village committees.

In our area, we set up a multisectoral committee for local decision making and awareness-raising (head of health centre, man).

We work with communities to whom we constantly remind the compliance with outbreak control measures (head of health centre, man).

#### Learning at the technical and financial partners' level

MoH's technical and financial partners who participated in this study were WHO, UNICEF, USAID, UNFPA, CRS, Jhpiego and Amref Health Africa. WHO and UNICEF were involved in responding to all outbreaks that occurred over the study period. Others responded to at least two outbreaks, the most common of which were EVD and COVID-19.

Respondents reported having learnt many lessons from the strategies used by the MoH in outbreak response. These lessons relate to:

The creation of a national agency in charge of outbreak prevention and response (ANSS) and decentralised coordination teams (ERARE, EPARE/ECARE, COU-SP).

There was better diligence in the response between the two outbreaks [Ebola 2014 and 2021], such as establishing an agency and coordination bodies and partners' engagement though we faced coordination deficit at times (UNFPA, man).

The focus put on training health staff, equipping health facilities and community engagement.

We learnt from Guinea's MoH that the outbreak response strategy should focus on strengthening the health system by emphasising staff training and equipping health facilities, strengthening community health by focusing training and involvement of affected communities, good coordination of actors and documentation of lessons learnt (Amref Health Africa, man).

The use of past experiences by the MoH in responding to future outbreaks.

Lessons learnt from the 2014–16 EVD outbreak response allowed for rapid control of the 2021 EVD and a better response to COVID-19 (UNICEF, man).

The need for better coordination of mobilised funds for outbreak response, better management of partners' assistance by a strengthened leadership, and ensuring accountability of all actors at all levels.

There was a fairly prompt reaction from the MoH. Efforts were made to mobilise funds. Nevertheless, it should be noted that coordination efforts must be improved to capitalise on the funds received for the response to outbreaks

and strengthen the MoH's leadership for better management of partners' assistance and to avoid everyone doing what they want. Efforts should also be made to improve the responsibility and accountability of MoH officials at all levels (Jhpiego, woman).

They learnt these lessons through deliberation (meetings), action/practice (shared guidelines, written recommendations) and single-loop (participation in elaborating outbreak response plans). Besides, they transmitted to or shared with Guinea's MoH some experiences (organisation/cross-organisation learning) in terms of outbreak response that were mainly about:

#### *Epidemiological surveillance*

We shared technical experience in epidemiological surveillance through training on Integrated Disease Surveillance and Response (IDSR) offered to MoH officials, and supervision missions in the field (WHO, man).

#### *Risk communication and community engagement*

Based on the response pillars, UNICEF provided expertise in risk communication and community engagement, water sanitation and hygiene (WASH) and infection control and prevention, psycho-social support, child care, community-based surveillance, prevention of sexual abuse and exploitation (UNICEF, man).

Concerning Ebola, we documented the lessons we learnt in the community response approach and shared them with other stakeholders, including the MoH (Amref Health Africa, man).

#### *Infection prevention and control*

We have provided infection prevention and control in all aspects, especially in health facilities, to protect providers and clients by ensuring continuity of services. Case management is important but ensuring continuity of services is also essential; thus, the MoH must consider this aspect (Jhpiego, woman).

#### *Minimum initial response package*

We shared our experience with the MoH in outbreak preparedness and response through the Minimum Initial Response Package, including capacity building in humanitarian emergency preparedness and response in sexual and reproductive health (UNFPA, man).

#### Enablers and barriers to LHS in terms of outbreak response in Guinea

**Table 3** summarises the respondents' reported enablers and barriers to learning within Guinea's health system from all levels, connected with outbreak response. The commonly mentioned enablers included creating the ANSS and the establishment of its decentralised coordination teams/local governing bodies (ERARE and EPARE/ECARE) and gaining support from development partners. Common barriers included cultural and political considerations and lack of funding resulting in the non-implementation of the decisions made at the bottom level (**table 3**).

Recommendations for learning improvement within the health system (respondents' perspective)

Table 4 depicts the respondents' recommendations to state authorities related to learning improvement within the HS (including in terms of outbreak response). The commonly-reported recommendations included establishing a knowledge management unit within the MoH with representatives at regional and district levels, creating and deploying human capacities needed to perform learning functions and improving the governance and management system at all levels (table 4).

## DISCUSSION

This study is the first of its kind to be conducted in Guinea. It analysed how Guinea's health system has learnt from the response to outbreaks. In doing so, it demonstrated how the new LHS analysis framework can be applied. Both systematic review and online survey complemented to answering the research question and improving the construct validity of the case study. The review provided an overview of how the health system has learnt while responding to each outbreak, without specifying learning by HS level. In contrast, the online survey revealed how each health system level has learnt over the study period without focusing on each outbreak.

Our findings reveal that, in the response to outbreaks between 2014 and 2021, the health system learnt to some extent through all aspects of the learning dimensions. The common learning aspects at all the health system levels were learning at the individual, team and organisational levels, through information, deliberation, action/practice, single and double loop. We noted one occurrence of triple-loop learning after the 2014–2016 EVD leading the health system to establish new disease surveillance system. However, triple-loop learning was missing within the ANSS since it started operating and health regions and districts. Besides, learning produced through double loop and action was limited.

Nonetheless, these findings imply that the health system's recent achievements in controlling outbreaks such as COVID-19, the 2021 EVD and the Marburg virus disease could be attributable to fundamental learning aspects (at individual, team and organisation levels, and through information, deliberation and single loop) that happened regularly at all the health system levels and advanced learning aspects (double-loop and triple-loop learning and learning across action) that occurred sometimes and/or partially in the health system. We posit that if the advanced learning aspects (eg, action/praxis, double loops and triple loops) were often and fully implemented at all the health system levels, the health system's functions, adaptivity, innovation and self-reliance would have better improved, leading to more effective and efficient outbreak response. Our results corroborate the existing literature pointing out the challenges in achieving double-loop and triple-loop learning<sup>79 80</sup> and learning through action.<sup>81–83</sup>

Below, we separately discussed the outbreak response outcomes and the learning weaknesses of the health system in relation to advanced learning aspects, outlined our observations about the LHS framework (box 4), posited study implications (box 5), acknowledged the study limitations and drew a conclusion.

## LHS-wide effects and outbreak response outcomes

Learning truly occurred in the response to outbreaks. This led to improved health system's functions,<sup>84</sup> increased adaptivity and innovation and greater self-reliance, resulting in better response outcomes, including for haemorrhagic disease outbreaks that followed the 2014–2016 EVD, in terms of outbreak spread, response duration, infected cases and deaths. For instance, the 2014–2016 EVD outbreak spread over 30 out of 38 health districts and lasted about two years and half, with 3811 infected cases and 2543 deaths,<sup>42</sup> while the subsequent 2021 EVD outbreak was contained within one health district and within four months, with 16 confirmed cases recorded overall, of which five deaths, and the Marburg virus disease was controlled within 42 days, with only one confirmed case/death. These outcomes revealed that the health system's outbreak response performance has improved over time thanks to learning. They exemplified or verified the LHS-wide effects (potential benefits) hypothesised by Sheikh and Abimbola—when means of learning and learning loops happen together either at the individual, team or organisation level, they result in improved performance of the health system's functions, increased adaptivity and innovation and greater self-reliance.<sup>20</sup> In terms of performance of the health system's functions, we note—some improvements in the outbreak response governance and leadership (better coordination of outbreak surveillance and response with an autonomous management authority)<sup>85</sup>—the training of health personnel<sup>85 86</sup>—improvements in service delivery (response and case management)<sup>85 86</sup>—the building and equipment of health infrastructures (epidemic centres, laboratories and health centres)<sup>85 86</sup>—the strengthening of health information system using DHIS2 for disease surveillance and reporting<sup>87 88</sup>—and improvements in finances (increase in the national budget allocated to the MoH, from 3% to 8% in 2018, though this budget remains inferior to the requirement (15%) of the West African Health Organisation), approval of orders for supplies by the laboratory committee and other national committees to reduce waste of resources and improvements in funding mobilisation mechanisms<sup>85</sup>. Regarding the increased adaptivity and innovation, we point out namely—the strengthened capacity of health personnel including the leads of health centres in integrated disease surveillance and response, and computer science—and the developed local genomic surveillance capacity. Concerning the greater self-reliance, we highlight—the primary use of local experts in the response to recent outbreaks (COVID-19, 2021 EVD and Marburg virus disease)—and the established local diagnostic capacity.



Moreover, learning that happened in our context shows the strength of democratic governance and the necessity, though compromised some times, to foster the emergence of institutions that ensure the establishment of rules to enable the discovery of the factual truth.

### Double-loop learning

Guinea's health system achieved double-loop learning several times, resulting for instance in the—withdrawal of the military from the EVD response—strong involvement of anthropologists—creation of the ANSS—rise of the one-health paradigm. However, it is noteworthy that double-loop learning is challenging. Argyris said, *It is not easy to create organisations capable of double-loop learning, but it can be done. Even with minimal awareness, the results are encouraging.*<sup>79</sup> Several reasons explain this challenge—problem solving efforts are more likely to focus on single-loop learning, in which people always try to do the same things right.<sup>89</sup> However, routines are intended to reduce the necessity for double-loop change, predisposing workers to become desensitised to inner contradictions that routines often develop<sup>90</sup>—The research emphasis on single-loop learning leads to scholarship that is in the service of the status quo. Such limits unnecessarily constrain the progress of inquiry in producing new knowledge<sup>91</sup>—Combined, the reasons mentioned above lead researchers and practitioners to create and reward mindsets that inhibit exploring non-trivial changes within organisations, including those originating from their own research and practice.<sup>92</sup> Institutionalising participatory health governance (democratic governance), which leads to change in policies, practice, behaviour and power relations, is essential to producing double-loop learning.<sup>93</sup> As emphasised by the respondents, there is a need to create a real-time information-sharing environment involving all stakeholders on health issues. This will result in improving governance and management systems at all levels, including transparency and accountability to the population, the government and donors. A digital strategy such as the 'District.Team' platform is a showcase that the health system could harness and scale-up to set up such a sharing environment.<sup>38 46 94</sup> Additionally, among LHS enabling factors that respondents reported, we suggest giving a particular space to regular after-action reviews to yield double-loop learning. An after-action review is a structured review or debriefing process for analysing what happened, why it happened, and how it can be done better by the participants and those responsible for the project or event.<sup>95</sup> In Nigeria, the establishment of after-action reviews in addition to outbreak surveillance software enhanced the ability of the health system to learn while combatting outbreaks, allowing to shape preparedness for future outbreaks.<sup>20</sup>

### Triple-loop learning

Double-loop learning and triple-loop learning are both 'overhanging' and challenging learning aspects, but of a different order. The former is about the articulation

of explanations of a phenomenon and the latter about the learning process itself. Bateson's conceptualisation of triple-loop learning (learning III) raised a paradox—'learning III (ie, learning about learning II) may lead either to an increase in learning II or to a limitation and perhaps a reduction of that phenomenon'.<sup>80</sup> Indeed, this led Tosey *et al* to speculate that in many situations, organisations may not be in need of learning or learn through single loop more than transformation (double-loop and triple-loop learning).<sup>96</sup> In other words, significant improvements in performance can often be achieved through enabling existing competences to be used to greater effect—probably by resisting a felt need for transformation.<sup>96</sup> Therefore, and as transformation at the triple-loop level in particular, relates to profound changes,<sup>80 97</sup> Bateson said that triple-loop learning is a rare event.<sup>80</sup> This Bateson's statement is supported by an empirical study conducted in Tunisia in 2017, which reported that 95% of participating companies (n=60) have not resorted to triple-loop learning in a postcrisis situation related to textile activities, as this learning aspect implies questioning the identity of an organisation, which can lead to the radical transformation of cognitive structures, the way of thinking, methods of working and the way to act, to solve problems and manage all critical situations.<sup>98</sup> These companies relied solely on single-loop and double-loop learning which was essential to their survival and continuity. Despite the Bateson's paradoxical conceptualisation of triple-loop learning, he stated that certainly triple-loop learning must lead to a greater flexibility in the premises acquired by the process of double-loop learning—a freedom from their bondage.<sup>80</sup> From this perspective, we assume that triple-loop learning is a beneficial investment to the other learning loops (single and double), which requires deeper strategic thinking. The present work would belong to this category of reflective positioning and raises further questions—Is not systemic learning a central condition for the outbreak response? Can we study this systemic learning in academic institutions? This work will fully reflect triple-loop systemic learning if Guinea's health system translates its findings into policy and practice (eg, creating a knowledge management unit within the MoH with representatives at regional and district levels), leading to the creation of new and well-organised learning structures/processes/strategies. Fahrenbach *et al* suggested that deepening understanding of Bateson's learning III theory is useful to operationalise triple-loop learning.<sup>99</sup> Furthermore, achieving triple-loop systemic learning requires a very important leadership commitment and momentum for change in depth<sup>98</sup>—leaders can provide a powerful role model of active learning that will help sustain an organisation's efforts, through direct involvement that reflects coordination, vision and integration.<sup>100</sup> In addition, we believe that the institutionalisation of democratic governance mentioned above for double-loop learning is also essential for operationalising triple-loop systemic learning.

## Learning through action and practice

Learning through action/practice (learning that emerged from action) was limited at the ANSS and most health regions, while better in health districts. About half of the health regions and districts took advantage of the experiential and tacit knowledge from 'District.Team' to respond to outbreaks. Our findings point out the issue of translating knowledge into action. Ensuring that knowledge produced through repetitive tasks or projects is codified into information and turned into action is complex and challenging.<sup>83</sup> Knowledge translation into action is an iterative, dynamic and complex process involving knowledge creation and application (action cycle).<sup>83 101</sup> The lack of skills in knowledge management is often reported as a common challenge that all decision-makers, that is, clinicians, patients, managers and policy-makers, face.<sup>101</sup> Furthermore, several other factors, often local (national or subnational), impact how knowledge is created and used—organisational culture (way things are done)—resources—tools, systems, processes—leadership and governance (influenced by power, politics and policy).<sup>102</sup> Therefore, achieving knowledge translation into action requires an exchange of knowledge among key stakeholders, starting with cultivating appropriate relationships and establishing a shared understanding of what knowledge to action means and why it is crucial.<sup>83</sup>

## Our recommendations for learning improvement within Guinea's health system

In light of the findings and the resulting discussion, our recommendations are formulated in table 5. We particularly emphasise creating a sustainable collaboration frame between researchers and policy/decision-makers to motivate knowledge use and learning.

## Study limitations

This study has some limitations. First, the current political context (transitional government originated from a *coup-d'Etat*) in the country might have influenced the participation of some key informants in the online survey, particularly the DMOs. Indeed, some new DMOs have been appointed; their participation might have been affected by the many new duties there are tasked with and the fear of sharing views on such a sensitive topic. Also, they might not have sufficient experience to share as they are new at the job position. Second, since the survey was about past events, this might suffer from recall biases among respondents. Third, we acknowledge that the online survey is not the best data collection method for such research; as a result,—some questions were not well understood and correctly answered by respondents; nevertheless, this limitation was overcome by recontacting those respondents for clarifications;—some answers entailed the need to ask further questions for deeper understanding, but impossible; nonetheless, we resorted to ANSS' experts for clarifications (cf. acknowledgements);—the community voice in the learning discourse was quite limited, as a very few

community actors participated in the survey. All these definitely give an avenue for future research, which need to be conducted in face-to-face and can be people centred (eg, service users) to widely explore their perspective of learning. Overall, combining the survey with the review and the data triangulation across respondents and sources helped to address some limitations (eg, recall biases).

## CONCLUSION

Our study highlights the strength of learning, as with the fundamental and partial advanced learning aspects that occurred in the response to outbreaks in Guinea, the health system achieved encouraging outcomes. Therefore, there is a need to advance learning within Guinea's health system, particularly in the response to outbreaks, by turning into action the recommendations issued by both respondents and researchers. Besides, this study provided insights into the LHS analysis framework for informed future application.

**Twitter** Tamba Mina Millimouno @MinaTamba, Bruno Meessen @bmeessen, Willem Van De Put @willemvandeput, Bienvenu Salim Camara @salimbienvo, Aiki Christou @alichristou and Alexandre Delamou @Alexdelamou

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#### ORCID iDs

Tamba Mina Millimouno <http://orcid.org/0000-0002-4628-1296>

Bruno Meessen <http://orcid.org/0000-0002-0359-8621>

Willem Van De Put <http://orcid.org/0000-0002-3306-5287>

Marlon Garcia <http://orcid.org/0000-0002-9528-2295>

Bienvu Salim Camara <http://orcid.org/0000-0002-2859-7684>

Aliki Christou <http://orcid.org/0000-0001-9525-8255>

Therese Delvaux <http://orcid.org/0000-0001-6299-2648>

Sidikiba Sidibé <http://orcid.org/0000-0002-7905-9042>

Abdoul Habib Beavogui <http://orcid.org/0000-0003-4950-6224>

Alexandre Delamou <http://orcid.org/0000-0002-9397-7106>

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## Supplementary Appendix – Reflexivity Statement

### 1. How does this study address local research and policy priorities?

This study was conducted as part of the first author (TMM)'s Master's thesis in public health (orientation: health systems and disease control) at the Institute of Tropical Medicine (ITM) of Antwerp in Belgium. It comes in continuation of other activities developed by the *Centre National de Formation et de Recherche en Santé Rurale de Maferinyah* in Guinea on learning health systems (LHS) for response to infectious disease outbreaks<sup>1,2</sup>. The lack of knowledge use (a learning aspect) for policy- and decision-making is a key challenge of the domestic health system<sup>3,4,5</sup>. The current study provided actionable recommendations on how learning can be promoted within the health system.

### 2. How were local researchers involved in study design?

The core idea was proposed by BM and then elaborated through a discussion between BM, TMM and AD. TMM took forward the idea for his thesis, and brought the methodology strategy, with inputs from a lecturer in the ITM Master's degree (MG) and the thesis supervisor (WVP).

### 3. How has funding been used to support the local research team?

This question is not applicable, as the study was not funded.

### 4. How are research staff who conducted data collection acknowledged?

TMM conducted the data collection. However, the staff who facilitated the online survey by reminding participants through phone calls to fill in the questionnaire or by clarifying certain information was acknowledged (cf. acknowledgements). The online survey facilitators who contributed to the writing of the thesis or the manuscript were included as co-authors (SS and AHB).

### 5. Do all members of the research partnership have access to study data?

All data generated or analysed during this study are included within the manuscript. The survey questionnaire and dataset are with TMM; they could be shared with other co-others if needed.

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<sup>1</sup> District.Team. Mobilisation 2.0 des équipes cadres de district. Available from: <http://guinee.district.team/>

<sup>2</sup> Keugoung B, Bello KOA, Millimouno TM, Sidibé S, Dossou JP, Delamou A, et al. Mobilizing health district management teams through digital tools: Lessons from the District.Team initiative in Benin and Guinea using an action research methodology. *Learn Heal Syst.* 2020;5(4):e10244. DOI:10.1002/lrh2.10244

<sup>3</sup> Politique Nationale de Santé, Guinée, 2014

<sup>4</sup> Plan National de Développement Sanitaire, Guinée, 2015-2024

<sup>5</sup> Plan Stratégique de la Direction Nationale de l'Épidémiologie et de la Lutte Contre la Maladie, Guinée, 2022-2026

**6. How was data used to develop analytical skills within the partnership?**

The research has allowed TMM to apply methods he has learned during his MPH study, but also to demonstrate autonomy and rigour in the application of the acquired knowledge (for academic purposes).

**7. How have research partners collaborated in interpreting study data?**

TMM interpreted all the data, but he benefited from inputs from ITM co-authors during the writing of his thesis and BM at different stages of the study.

**8. How were research partners supported to develop writing skills?**

The development of writing skills was supported by research partners mainly through the writing of the thesis and then the paper.

**9. How will research products be shared to address local needs?**

The findings of this study were presented at ITM in the form of a Master thesis defence on 5 July 2022. They were also presented at Guinea's second public health conference held on 25-26 October 2022. In addition, a policy brief will be elaborated to inform policy- and decision-makers about why it is crucial to advance learning within Guinea's health system and how an LHS can be built in Guinea. Finally, a webinar will be organised to broadly disseminate the findings of this study locally by targeting study participants (health committee members, district management teams, regional health inspectors, central level staff, and partners) and a wider public (policy- and decision-makers, practitioners, lecturers, researchers, and students of the Master of Public Health at the Gamal Abdel Nasser University of Conakry/Guinea).

**10. How is the leadership, contribution and ownership of this work by LMIC researchers recognised within the authorship?**

Authors TMM and AD have been recognised as the first and last authors, respectively. Also, the authorship is equally distributed between local researchers (five) and external researchers (five). However, it is noteworthy that the LHS issue is one on which TMM and BM have been collaborating for several years, with a shared passion for the questions raised and the understanding that learning is a priority for health systems strengthening and Guinea. This article marks TMM's ambition to advance the shared agenda on LHS beyond the strict obtention of his MPH degree, and there is a consensus that this work is, first and foremost, TMM's achievement. The partnership and broad authorship reflect the fruitful collaboration between a student and his teachers, on the one hand, and his collaborators in the home country, on the other hand.



**11. How have early career researchers across the partnership been included within the authorship team?**

TMM designed the research protocol, monitored the online survey, analysed and interpreted both the review and survey findings, wrote the thesis and drafted the first manuscript. BSC contributed to the reports' selection and appraisal, the writing of the thesis and the manuscript.

**12. How has gender balance been addressed within the authorship?**

Eight authors are male (TMM, BM, WVP, MG, BSC, SS, AHB and AD) and two authors female (AK and TD)

**13. How has the project contributed to training of LMIC researchers?**

Mainly through the thesis writing

**14. How has the project contributed to improvements in local infrastructure?**

Not applicable

**15. What safeguarding procedures were used to protect local study participants and researchers?**

Regarding study participants, we have considered the issue of safeguarding in the manuscript (cf. ethical considerations). As for local study researchers, the question is not directly applicable, as data collection was conducted online.

**Supplementary file 1** – Developing the review question using the SPICE framework

| <b>Acronym</b> | <b>Meaning</b>                                    | <b>Attribute</b>  |
|----------------|---|---|
| <b>S</b>       | Setting   | - Guinea<br>- January 2014- December 2021                         |
| <b>P</b>       | Perspective (or Population)                       | - Health system (actors at all levels)<br>- Response to outbreaks |
| <b>I</b>       | Intervention (or phenomenon of interest/practice) | Learning  |
| <b>C</b>       | Comparison  | Not applicable  |
| <b>E</b>       | Evaluation  | Learning dimensions   |

## Supplementary file 2 – Search strategy

| Literature type | Database/Engine                                      | Search query (5/3/2022)  |
|-----------------|--|--|
| Peer-reviewed   | PubMed   | ((((((((((("Ebola virus"[Mesh] OR "Hemorrhagic Fever, Ebola"[Mesh]) OR "Lassa Fever/prevention and control"[Mesh]) OR "Measles"[Mesh]) OR "Meningitis"[Mesh]) OR "Yellow Fever"[Mesh]) OR "Poliomyelitis"[Mesh]) OR ("Marburg Virus Disease"[Mesh] OR "Marburgvirus"[Mesh] )) OR ("COVID-19"[Mesh] OR "SARS-CoV-2"[Mesh] )) OR "Pandemics"[Mesh]) OR "Epidemics"[Mesh]) AND "Disease Outbreaks/prevention and control"[Mesh]) OR Preparedness OR Response OR "Lessons learned" OR ("Learning"[Mesh] OR "Learning Health System"[Mesh])) AND "Guinea"[Mesh] |
|                 | Web of Science                                       | ALL=("Lessons learned" AND response AND Ebola OR Measles OR "Yellow fever" OR "Lassa fever" OR Polio OR Meningitis OR "Marburg fever" OR "COVID-19" and 2014 or 2015 or 2016 or 2017 or 2018 or 2019 or 2020 or 2021 (Publication Years) and Tropical Medicine or Infectious Diseases or Social Sciences Biomedical or Political Science or Public Environmental Occupational Health or Multidisciplinary Sciences (Web of Science Categories) and GUINEA (Countries/Regions)  |
|                 | Google Scholar                                       | Guinea learning "Ebola Virus" OR "Hemorrhagic Fever Ebola" OR "Lassa Fever" OR Measles OR "Yellow Fever" OR Poliomyelitis OR Meningitis OR "Marburg Virus Disease" OR "COVID 19" OR "Prevention and Control" OR Response OR "lessons learned" -"Papua New" -"Guinea Bissau" -"Equatorial Guinea"   |
| Grey literature | Google customised search (for websites and webpages) | "Lessons learned" AND response AND Ebola OR Measles OR "Yellow fever" OR "Lassa fever" OR Polio OR Meningitis OR "Marburg fever" OR "COVID-19" AND Guinea  |

**Supplementary file 3** – Characteristics of reports included in the synthesis and key lessons learned/recommendations

| Author (year)              | Country | Type of Report       | Study Design/Method            | Outbreak                  | Key Lessons Learned/Recommendations   |
|----------------------------|---------|----------------------|--------------------------------|---------------------------|---|
| Camara S (2020) [43]       | Guinea  | Research article     | Parallel mixed method          | Ebola Virus Disease (EVD) | Community engagement and mobilisation are prominent in outbreak control.  |
| Camara BS (2020) [116]     | Guinea  | Research article     | Cross-sectional                | EVD                       | Preserving communities' values and addressing outbreak-related psychosocial effects.  |
| Lesho EP (2016) [109]      | Guinea  | Editorial commentary | Not Applicable (NA)            | EVD                       | Engaging local providers to collaboratively plan and execute humanitarian medical assistance, with external agents remaining in the background. Banking serum of EVD patients and performing real-time sequencing.  |
| Alessandro A (2018) [121]  | Guinea  | Research article     | Real-time field EVD sequencing | EVD                       | Combining thorough epidemiological and genomic investigations, particularly in low resource settings with a limited epidemiological investigation, as the genetic characterisation can support the outbreak investigation in real-time linking cases (sequencing).  |
| Sidibé S (2018) [101]      | Guinea  | Research article     | Cross-sectional                | EVD                       | Capacity building of healthcare providers for better preparedness and response to outbreaks.  |
| Magassouba AS (2020) [110] | Guinea  | Research article     | Cohort study                   | EVD                       | Better preparedness of the health system to prevent service disruptions during the response to mitigate collateral effects (e.g. Tuberculosis).   |
| Kodish SR (2018) [87]      | Guinea  | Research article     | Qualitative study              | EVD                       | Early community engagement to mitigate outbreak collateral effects (e.g. maternal and child nutrition).   |
| Gsell PS (2017) [118]      | Guinea  | Research article     | Field intervention             | EVD                       | A ring vaccination strategy can be rapidly and safely implemented at scale in response to EVD outbreaks in rural settings.  |
| Kolie D (2018) [111]       | Guinea  | Research article     | Cross-sectional                | EVD                       | Enhancing outbreak preparedness and health system resilience is required to mitigate collateral effects (e.g. Malaria in under-five children).  |
| Fairhead J (2016) [105]    | Guinea  | Review               | Case study                     | EVD                       | Four kinds of local accommodations broke down in responding to the EVD in Forest Guinea—accommodations with hospital practices; accommodations with mines (and extractive economies); accommodations with state authority; and accommodations with sorcerers. Therefore, there is a need to involving anthropologists in outbreak response. |



|                           |                                    |                  |                      |     |   |
|---------------------------|------------------------------------|------------------|----------------------|-----|---|
| Soeters HM (2016) [102]   | Guinea                             | Research article | Descriptive          | EVD | Infection prevention and control (IPC) training and capacity building for frontline healthcare workers (HCWs) proved helpful during the EVD and need to be considered in outbreak response  |
| Delamou A (2017) [114]    | Guinea                             | Research article | Cohort study         | EVD | Maternal and child health indicators significantly declined during the EVD outbreak. There is a need for designing parallel strategies and interventions to counter service disruptions (mitigate collateral effects), particularly developing toolkits for monitoring health service disruptions and adjusting programmes accordingly. |
| Keita M (2017) [96]       | Guinea                             | Research article | Case series          | EVD | Strengthening social mobilisation and the training of HCWs.   |
| Diallo B (2016) [119]     | Guinea                             | Brief report     | NA                   | EVD | Persistence of Ebola virus in a survivor's seminal fluid 531 days after onset of disease causing a new cluster of EVD in Guinea and Liberia; Need for outbreak response to combine field epidemiology with real-time molecular epidemiology and the availability of an up-to-date virus genome repository for the outbreak.             |
| Moisan F (2016) [115]     | Guinea                             | Research article | Descriptive analysis | EVD | The EVD outbreak resulted in a modest decrease in healthcare attendance in Guéckédou, requiring, nevertheless, intervention design to counter service disruptions during future outbreaks.  |
| Leno NN (2018) [112]      | Guinea                             | Research article | Cross-sectional      | EVD | Designing strategies to mitigate outbreak collateral effects (e.g. Prevention of Mother To Child Transmission of HIV).  |
| Bah EM (2019) [120]       | Guinea                             | Case report      | NA                   | EVD | ICP needs to be strengthened for obstetrical surgery in the context of EVD outbreaks.   |
| Plucinski MM (2015) [113] | Guinea                             | Research article | Cross-sectional      |     | Designing strategies to mitigate outbreak collateral effects (e.g. Malaria)   |
| Kpanake L (2019) [126]    | Guinea                             | Research article | Descriptive          | EVD | In a case of need for volunteer recruitment for the response to future outbreaks, a multifaceted motivational approach should be adopted, emphasising motivational messages that refer to patriotic values and moral responsibility.  |
| Baldé T (2015) [89]       | Guinea                             | Research article | Single case study    | EVD | Establishing robust coordination mechanisms for partners and within the ministry of health, departments is needed. Early community engagement is central. Developing clinical research on medicines and vaccines is needed.   |
| Bjorneseth F (2020) [90]  | Guinea (+Liberia and Sierra-Leone) | Policy brief     | NA                   | EVD | Community engagement, crisis communication and countering rumours have proved effective.  |
| Jaye T (2014) [103]       | Guinea (+Liberia and Sierra-Leone) | Policy brief     | NA                   | EVD | Investment priority must target health education, infrastructure and personnel.   |

|                           |                                    |                      |                 |     |  |
|---------------------------|------------------------------------|----------------------|-----------------|-----|--|
| Undurraga EA (2017) [104] | Guinea (+Liberia and Sierra-Leone) | Opinion              | Modelling       | EVD | Strengthening the health system by increasing health personnel, bolstering primary and critical healthcare facilities, developing the infrastructure and improving disease surveillance (IDSR).  |
| Bhatnagar NG (2016) [97]  | Guinea (+Liberia and Sierra-Leone) | Scoping review       | NA              | EVD | Improving preparedness by building a strong health system and enhancing community participation.   |
| Vetter P (2016) [106]     | Guinea (+Liberia and Sierra-Leone) | Review               | NA              | EVD | Improving outbreak preparedness through strengthening the health system; Engaging with social scientists in designing and delivering culturally-sensitive approaches to public health.   |
| Wilkinson A (2017) [45]   | Guinea (+Liberia and Sierra-Leone) | Opinion              | NA              | EVD | Engaging with anthropologists to understand social dynamics and design sturdy interventions.   |
| Scott V (2016) [91]       | Guinea (+Liberia and Sierra-Leone) | Debate               | NA              | EVD | Early community engagement for a successful response to outbreaks.<br>Investment priority must be on health personnel; Commitment is required to address the underlying social determinants of the country's vulnerability and weak capacity for successful response to outbreaks.   |
| Karamouzian M (2014) [92] | Guinea (+Liberia and Sierra-Leone) | Letter to the editor | NA              | EVD | Community engagement and mobilisation can reduce fear and stigma; Not deploying armies, especially western armies on the ground, can lower fear in communities and prevent mistrust and violent fatal attacks on healthcare workers and volunteers.  |
| Kekulé AS (2015) [107]    | Guinea (+Liberia and Sierra-Leone) | Essay                | NA              | EVD | Better preparedness and sensitive epidemiological surveillance (including genetic characterisation) are required, as naturally occurring outbreaks do not happen suddenly; Deploying anthropologists is necessary; Treatment centers are the most effective form of emergency aid; In an emergency, only actions/practices will work that have worked already before (necessity to learn). Outbreak control must be fast and flexible. |
| Jalloh MF (2017) [93]     | Guinea (and Sierra-Leone)          | Research article     | Cross-sectional | EVD | Community engagement is a cornerstone for a successful response to outbreaks.  |
| Laverack G (2016) [94]    | Guinea (+Liberia and Sierra-Leone) | Commentary           | NA              | EVD | Community engagement and social mobilisation in outbreak response are prominent.   |
| Delamou A (2017) [98]     | Guinea (+Liberia and Sierra-Leone) | Commentary           | NA              | EVD | Improving community participation and <u>multisectoral collaboration</u> are key to the health system's preparedness for future outbreaks. Learning from the EVD humanitarian assistance and rethinking the  |

|                           |                                    |                  |                               |     |   |
|---------------------------|------------------------------------|------------------|-------------------------------|-----|---|
|                           |                                    |                  |                               |     | humanitarian–researchers’ collaboration is needed. Lessons learned must inform policies and programmes.   |
| Umar I (2016) [99]        | Guinea (+Liberia and Sierra-Leone) | Review           | NA                            | EVD | Multisectoral collaboration is required for major outbreaks such as EVD, including civil society organisations.   |
| Gillespie AM (2016) [86]  | Guinea (+Liberia and Sierra-Leone) | Research article | Case study                    | EVD | Community engagement and social mobilisation are central to outbreak response.  |
| Venables E (2017) [108]   | Guinea (+Liberia and Sierra-Leone) | Research article | Case study                    | EVD | Anthropologists played prominent roles in responding to the EVD outbreak.   |
| Miller NP (2018) [95]     | Guinea (+Liberia and Sierra-Leone) | Research article | Mixed methods                 | EVD | Putting community health workers and other community-level actors at the forefront.   |
| Dhillon RS (2015) [122]   | Guinea (+Liberia and Sierra-Leone) | Perspective      | NA                            | EVD | Community engagement, risk communication, and social mobilisation are central to outbreak response  |
| Govindaraj R (2017) [100] | Guinea (+Liberia and Sierra-Leone) | Book             | NA                            | EVD | A national post-Ebola health system strengthening investment plan (shift from response to resilience) is needed.  |
| Lebel R (2019) [117]      | Guinea                             | Book             | NA                            | EVD | Addressing survivors' emotional reactions is a core element of emergency response.  |
| Keita S (2021) [85]       | Guinea                             | Book             | NA                            | EVD | Lessons:<br>Weak preparedness to respond to a major outbreak: delay in diagnosing the EVD (weak surveillance system); Lack of the necessary infrastructure (laboratory & treatment centres), skilled human resources and financial resources; lack of early community engagement and social mobilisation; WHO guidelines that were followed showed limitations; Weak coordination of actors.<br>Recommendations:<br>Putting a particular focus on health system preparedness and financing; Training human resources for health; Improving infrastructure & equipment; Laboratory capacity building; Emphasising social mobilisation and communication. Establishing a sustainable structure for outbreak response with an autonomous management mandate; Improving governance. |
| Kolie D (2019) [44]       | Guinea                             | Research article | Qualitative explanatory study | EVD | Emphasis on recruitment of HCWs facilitated by the changing practice of development cooperation partners about health financing, especially payment of staff salaries; the availability of remaining funds mobilised by donor countries and institutions for  |

|   |                                    |   |                    |                    |  |
|---|------------------------------------|---|--------------------|--------------------|--|
|   |                                    |   |                    |                    | the response to EVD; the availability of trained HCWs that were contracted across all levels of the health system, especially in underserved areas during the EVD outbreak, and the change of the political perception in health issues or risks.  |
| Pastor Institute (2017) [124]                                       | Guinea (+Liberia and Sierra-Leone) | Webpage   | NA                 | EVD                | Enhanced vigilance and health surveillance are essential.<br><i>"Given the risk of resurgence of the disease, former epidemic foci in Guinea, Liberia and Sierra Leone could suffer new outbreaks."</i><br>Warning issued by scientists.   |
| National Coordination Unit for the Fight against Ebola (2014) [138] | Guinea                             | Strategic plan for "Zero Ebola within 60 days" campaign | NA                 | EVD                | Main issues tackled: surveillance, IPC, dignified and secure burials, case management, communication/reluctance.   |
| Ministry of Health (2015) [127]                                     | Guinea                             | Health System Recovery & Resilience plan (2015-2017)    | NA                 | Post-EVD           | Eradicating EVD (IPC, IDSR, IHR); Improving the performance of the local health system (improving service delivery and strengthening the management system); and enhancing health system governance (management, coordination, accountability, community engagement, regulation).  |
| Keita M (2020) [123]  | Guinea                             | Research article  | Cohort             | EVD                | Setting up the surveillance and alert system for early detection of Ebola resurgence among survivors, modelled on the health system, from the community level to the central level.  |
| Ndjomou J (2021) [130]  | Guinea                             | Research article  | Descriptive        | Post-EVD (2014-16) | Guinea's laboratory capabilities have been built.  |
| Linton NM (2020) [132]  | Guinea                             | Research article  | Modelling          | Measles            | Due to insufficient levels of herd immunity, measles transmission persists in Guinea. Further reproduction number estimation should be performed to help decision-makers and field staff understand outbreak progress and the timing and type of vaccination efforts needed to stop transmission.  |
| Saez AM (2018) [84]   | Guinea                             | Research article  | Randomised control | Lassa Fever        | The chemical treatment effectively controls local rodent populations. It can partly serve as a practical, holistic approach combining rodent trapping, use of local rodenticides, environmental hygiene, house repairs and rodent-proof storage. Engaging with local stakeholders and communities in developing these actions is key to success. |
| Magassouba N (2019) [133]   | Guinea                             | Research article  | Case report (next- | Lassa Fever        | Early identification of viral haemorrhagic fever cases remains challenging in remote areas (e.g. health centres); There is a need for  |



|   |  |  |                        |                  |   |
|---|--|--|------------------------|------------------|---|
|   |  |  | generation sequencing) |                  | regular awareness training to facilitate the implementation of improved field surveillance and early detection.   |
| Mariën J (2020) [134]                                   | Guinea                                   | Research article                               | Spatial analysis       | Lassa Fever      | The risk of Lassa virus spillover is heterogeneously distributed within Guinea's villages; Viral eradication in one specific village is unlikely if rodents are not controlled in neighbouring villages.  |
| National Agency for Health Security (ANSS) (2019) [135] | Guinea                                   | Management guide of priority zoonotic diseases | NA                     | Zoonotic disease | "One Health" approach; nine diseases retained: EVD, Lassa Fever, Dengue, Brucellosis, Avian Influenza, Yellow Fever, Rabies, Anthrax/charcoal, and Rift Valley Fever. Strengthening capacity of multisectoral actors in IDSR.   |
| Delamou A (2020) [144]                                  | Guinea (+Liberia and Sierra-Leone)       | Correspondence                                 | NA                     | COVID-19         | For more success in responding to outbreaks, the health system needs to rethink the governance of the outbreak response by prioritising internal resource mobilisation and creating better synergy between national institutions to pool existing strengths and gain support from communities. To this end, national institutions tasked with each response pillar should be identified and provided with the required resources (e.g. local budget lines) under the coordination of the MoH or the designated institution. When doing so, the path for long-term capacity building of local actors with support from developing partners could be established. |
| Delamou A (2021) [145]                                  | Guinea                                   | Research article                               | Cross-sectional        |                  | The COVID-19 pandemic jeopardised efforts to achieve Millennium Development Goals for maternal and child health in urban settings in Guinea. For the country's health system to be resilient to crises such as COVID-19, there is a need for interventions to ensure the continuity of maternal and neonatal care.  |
| Maxmen A (2020) [143]                                   | Guinea (+Liberia and Sierra-Leone)       | News in focus                                  | NA                     | COVID-19         | Political unrest can contribute to the rapid spread of an outbreak, jeopardising the response plan's implementation.  |
| Millimouno TM (2021) [140]                              | Guinea (+Mali, Senegal and Burkina Faso) | Viewpoint                                      | NA                     | COVID-19         | Political unrest can contribute to the rapid spread of an outbreak, jeopardising the response plan's implementation. Learning from past experience, strengthening contact tracing and early community engagement for rapid outbreak control.  |
| Kolie D (2021) [142]                                    | Guinea                                   | Commentary                                     | NA                     | COVID-19         | Governance mechanisms, diagnostic capabilities, and international support need to be improved.  |
| Adote KA (2020) [141]                                   | Guinea (+Liberia and Sierra-Leone)       | Review   | Case study             | COVID-19         | Outbreak preparedness is still suboptimal (e.g. insufficient detection and response capabilities). National public health emergency   |

|                                 |                                    |  |  |            |  |
|---------------------------------|------------------------------------|--|--|------------|--|
|                                 |                                    |  |  |            | response plan and International Health Regulations (IHR) simulation exercises need to be improved.   |
| Impouma B (2021) [139]          | Guinea (+Liberia and Sierra-Leone) | Research article   | Cross-sectional                          | COVID-19   | The introduction of rapid readiness and response measures was probably due to the lessons learned from the EVD outbreak. Some health system weaknesses persist, and the unique nature of COVID-19 continues to challenge control efforts.  |
| Ministry of Health (2020) [136] | Guinea                             | National Preparedness and Response Plan                          | NA                                       | COVID-19   | It includes the following components: epidemiological surveillance, laboratory, IPC, information and communication, logistics, coordination, and technical assistance (community engagement, risk communication, treatment centres, resuscitation, Go.Data, etc.)  |
| ANSS (2020) [137]               | Guinea                             | Community Response Strategic Plan "Stop COVID-19 within 60 days" | NA                                       | COVID-19   | It includes community engagement and social mobilisation, contact tracing, Testing, Home case management and lockdown, case referencing, Food and financial support to households, and sanitary control around lockdown areas.   |
| Keita AK (2021) [149]           | Guinea                             | Research article   | Case report (next-generation sequencing) | EVD (2021) | In-country sequencing and capacity building enabled a timely characterization of Ebola virus strains in the 2021 outbreak. The Ebola virus can persist in survivors' body fluids for five years. Therefore, adequate healthcare measures for survivors are needed. Additionally, there is an urgent need for further research into potent antiviral agents that can eradicate the latent virus reservoir in patients with EVD and into efficient vaccines that provide long-term protection. |
| Ministry of Health (2021) [146] | Guinea                             | Response Plan to the EVD outbreak 2021                           | NA                                       | EVD (2021) | 16 pillars: Epidemiological surveillance; Laboratory; Medical management; Risk communication, social mobilisation and community engagement; IPC and WASH; Psycho-Social care; Information management; EVD and epidemic-prone diseases vaccination management; Survivors care; Nutrition; Protection; Prevention of sexual exploitation and abuse (PSEA); Strengthening governance/Coordination; Security; Logistics; Administration and finance.   |
| WHO (2021) [147]                | Guinea                             | Webpage (End of EVD 2021)  | NA                                       | EVD (2021) | Outbreak controlled within four months. Success factors were related to incorporating experience and lessons learned from the 2014-16 EVD outbreak. These include strengthened epidemiological surveillance, deployment of skilled Guinean professionals trained during the 2014-16 EVD at all response pillars,   |

|                      |        |  |             |                            |   |
|----------------------|--------|--|-------------|----------------------------|---|
|                      |        |  |             |                            | good coordination and synergy of partners' actions, community engagement, and ring vaccination.   |
| ANSS (2021) [148]    | Guinea | 90 days Strengthened Surveillance Plan | NA          | Post-EVD (2021)            | Maintaining and strengthening community-based surveillance through the "One Health" platforms; Ensuring vaccination of health staff, corpse washers, traditional healers, red-cross staff, and survivors' relatives in the region of N'zérékoré; Strengthening the survivors' monitoring programme (clinical, biological and psychological monitoring, surveillance and vaccination around survivors, research).  |
| Keita M (2022) [125] | Guinea | Research article                       | Case report | COVID-19, Lassa fever, EVD | The case clarifies the need to expand disease-specific surveillance to areas surrounding the outbreak's known geography. In this case, the extension of Ebola surveillance into neighbouring districts allowed to identify and diagnose a Lassa fever index case, facilitating prompt declaration of a Lassa fever epidemic and rapid implementation of control measures to limit the virus' spread in Guinea and Liberia.  |
| ANSS (2021) [150]    | Guinea | Response Plan                          | NA          | Marburg                    | It includes the following components: coordination, epidemiological surveillance, IPC, case management, risk communication, social mobilisation, community engagement, laboratory, and logistics.   |
| WHO (2021) [151]     | Guinea | Final Report                           | NA          | Marburg                    | Outbreak controlled within 42 days, with only one confirmed case/death.<br>The rapid implementation of response activities, coupled with the experience of the affected prefecture in fighting against viral haemorrhagic diseases, played a central role in controlling the epidemic's spread to other regions. The source of the epidemic is still unknown, and the wife of the index case could not be found, which constitutes a significant risk for the resurgence of cases: investigations and research are ongoing. |
| WHO (2021) [153]     | Guinea | Webpage (End of Marburg)               | NA          | Marburg                    | <i>"Without immediate and decisive action, highly infectious diseases like Marburg can easily get out of hand. Today we can point to the growing expertise in outbreak response in Guinea and the region that has saved lives, contained and averted a spill-over of the Marburg virus,"</i> said the WHO Regional Director for Africa.   |
| WHO (2021) [152]     | Guinea | Webpage (End of Marburg)               | NA          | Marburg                    | The training and vigilance of HCWs in the surveillance of epidemic-prone diseases were essential to the early detection of the case.  |

|                           |        |                      |    |         |  |
|---------------------------|--------|----------------------|----|---------|--|
|                           |        |                      |    |         | <i>"We immediately informed the prefectural health authorities so that they could take a sample."</i> Stated the lead of the health centre of Koundou.   |
| Aborode AT (2022)<br>[88] | Guinea | Letter to the editor | NA | Marburg | Rapid control based on experience and knowledge from the response to the EVD outbreak (e.g. effective contact tracing, community engagement and social mobilisation); Request for support of 10 experts from WHO for outbreak investigation, rapid emergency response and improvement in disease surveillance and testing; Improvement of border disease surveillance. |



**Supplementary file 4 – Participants' characteristics**

| <b>Informants' home organisations</b> | <b>Specification of the organisation</b>   | <b>Number of informants</b> | <b>Informants' function</b>                           |
|---------------------------------------|--|-----------------------------|---|
| Ministry of Health (MoH)              | National Agency for Health Security (ANSS)   | 1                           | Representative  |
| Health regions                        | Conakry, Faranah, Mamou, Boké and Labé   | 5                           | Regional Health Director                              |
| Health districts                      | Dixinn, Ratoma, Kaloum, Matam, Matoto, Dalaba, Dinguiraye, Kouroussa, Mandiana, Forécariah, Dubréka, Guéckédou and Coyah | 13                          | District Medical Officers                             |
| Health committees                     | Mangala (Guéckédou), Konso (Dabola), Konindou (Dabola), Banko (Dabola), Madina (Kissidougou)                             | 5                           | Community representatives and Heads of health centres |
| MoH's partners                        | WHO, UNICEF, USAID, UNFPA, CRS, Jhpiego and Amref Health Africa  | 9                           | Representatives                                       |
| Total number of informants            |  | 33                          |   |

**Supplementary file 5** – Learning at the central, regional and district levels during the response to outbreaks in Guinea, 2014 -2021.

(NB: for the central level, all the quotes are from the ANSS representative, a male; all regional health inspectors (RHIs) in Guinea were male at the time of the study)

| Learning dimension | Learning aspect | Description and illustrative quotes   |  |   |
|--------------------|-----------------|---|--|---|
|                    |                 | Central level   | Regional level   | District level  |
| Levels             | Individual      | <p>The ANSS staff has learned through data collection, compilation and interpretation and gained tacit knowledge through experience and interpretation of these knowledge inputs.</p> <p><i>“I managed databases, some of which I designed; I coordinated data collection, compilation and interpretation activities at the devolved levels; prepared reports for decision-makers.”</i></p> | <p>RHIs have learned through diverse ways such as across the process of data collection, analysis and interpretation; across experience; and outbreak alert, investigation and response.</p> <p><i>“During the responses to Ebola disease [2014-16], Lassa fever and COVID-19 outbreaks in my region, I have learned through data entry, production of tables and graphs, interpretation and follow-up of contacts, production of databases for cases and contacts.”</i> (RHI #2)</p> <p><i>“In my region during the response to COVID-19, I have learned community engagement’s importance.”</i> (RHI #1)</p> | <p>District medical officers (DMOs) or their team members have learned across data collection, and gained tacit knowledge through experience and interpretation of these knowledge inputs.</p> <p><i>“We determined the target according to the Measles and Polio notified cases; ordered target vaccines, set micro-planning, mobilised and trained staff.”</i> (DMO, male #6)</p>   |
|                    | Team            | <ul style="list-style-type: none"> <li>Learning at the team level took place across meetings for data harmonisation and committees to elaborate epidemiological situation reports.</li> </ul>   | <ul style="list-style-type: none"> <li>In some health regions (3/5), epidemiological surveillance data were first interpreted by an individual (the one tasked with epidemiological surveillance), then by the team during either crisis, daily or weekly coordination meetings.</li> <li>In others (2/5), data were interpreted by the regional team for health, led by the person in charge of epidemiological surveillance.</li> <li>In either scheme, the team interpreted data and shared a common understanding of issues, and collectively found approaches to address them.</li> </ul>                 | <ul style="list-style-type: none"> <li>In most health districts (9/13), information was at once interpreted by the district health management teams (DHMTs).</li> <li>Only in a few health districts that an individual (the data manager or the responsible for epidemiological surveillance) perform the preliminary interpretation before the team interpretation for a shared understanding of issues to find tackling ways.</li> <li>The data manager or the responsible for epidemiological surveillance interpreted data daily and made a daily synthesis.</li> </ul> <p><i>“The interpreted data are discussed during weekly coordination meetings and through the development of a newsletter.”</i> (DMO, male #3)</p> |

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|  | <p>Organisation/<br/>cross-<br/>organisation</p> | <ul style="list-style-type: none"> <li>○ The ANSS integrated the routine learning process by establishing guidelines (and situation reports) taught during the Field Epidemiology Training Programme (FETP) and formulation of verbal recommendations during meetings for epidemiological information.</li> <li>○ Learning was institutionalised by applying integrated learning regularly to bring about improvements throughout the ANSS and by sharing/transmitting integrated and institutionalised learning to all the ANSS teams, including the local governing bodies.</li> <li>○ Learning was also institutionalised through the FETP by the elaboration of normative documents.</li> <li>○ Learning that took place through others' experiences (partners) was applied by putting in place several mechanisms, such as Public Health Emergency Operation Centre (COU-SP), Prefectural Epidemic Alert and Response Team (EPARE), Communal Epidemic Alert and Response Team (ECARE), Regional Epidemic Alert and Response Team (ERARE), Rapid Response Teams for Immunisation (EIRaV), Epidemiological Treatment Centre (CT-Epi) and a training unit.</li> </ul> | <ul style="list-style-type: none"> <li>○ The RHIs integrated learning generated by interpreting knowledge as a routine practice through formalising rules and procedures, elaborating guidelines, and making verbal recommendations. For instance, they set guidelines for using rapid diagnostic tests, constantly reviewed and simulated ERARE operations, and developed contingency and district intervention plans.</li> <li>○ They reported that the integrated learning was institutionalised along the different epidemics.</li> <li>○ An RHI asserted that to ensure that learning is institutionalised, they trained health professionals on procedures and guidelines developed and monitored them in the field. <i>"After training, we performed a post-training follow-up of agents in the field."</i> (RHI #4)</li> <li>○ Others reported that learning that was applied regularly to bring about improvements throughout the region, was also shared with peers. <i>"We shared procedures and guidelines developed about outbreak surveillance and response with regional peer directors of health."</i> (RHI #3)</li> <li>○ The RHIs have learned the epidemiological surveillance, investigation, prevention, management of cases, social mobilisation and rapid response to outbreaks from partners.</li> <li>○ They applied what they learned from peers or partners by upgrading teams and deploying the gained knowledge in the field.</li> </ul> | <p>DHMTs integrated learning generated by interpreting knowledge as a routine practice through formalising rules and procedures, elaborating guidelines, and making verbal recommendations.</p> <p><i>"After analysing this information, rules and procedures are defined in order to improve the shortcomings identified in the outbreak surveillance process."</i> (DMO, male #1)</p> <p>Most DMOs (9/13) reported that the integrated learning was institutionalised along the different epidemics, the majority of which (7/9) applied the integrated learning to drive improvements in the health districts.</p> <p><i>"In the health district, thanks to supporting from the ANSS, two health workers were trained as field epidemiologists. The weekly surveillance bulletin is produced to respond effectively in case of an outbreak."</i> (DMO, male #1)</p> <p><i>"When we take the infection control and prevention, the guidelines document is available in all health facilities. We train healthcare workers, and then we assess them regularly to maintain best practices."</i> (DMO, female #12)</p> <p>The remaining DMOs reported that, beyond applying the integrated learning to drive improvements in their health districts, they shared or transmitted the integrated and institutionalised learning with/to peers (other DMOs) or other organisations.</p> <p><i>"We hold regular cross-border meetings with Sierra Leone where experiences are shared."</i> (DMO, male #7)</p> <p>DMOs have learned the epidemiological surveillance, the "one health" concept, the importance of collaboration, the use of DHIS2, contact tracing and investigation, prevention, management of cases, social mobilisation and</p> |
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|       |             |  |   | <p>rapid response to outbreaks from partners, e.g. CDC, WHO, Unicef and Amref Health Africa.</p> <p><i>"We have learned a lot with support from partners. For example, regarding Ebola, we did not know many things, but thanks to the WHO and CDC, we learned how to map contacts, do contact tracing, and develop a situation report. It was new for us; it was a new epidemic."</i> (DMO, female #10)</p> <p><i>"We have acquired skills in outbreak response, especially in the investigation, thanks to the WHO's transfer of expertise and experience."</i> (DMO, female #11)</p> <p>They applied what they learned from peers or partners by deploying the gained knowledge in the field or during future outbreaks.</p> <p><i>"What we have learned during Ebola, we applied it locally during COVID-19. We put it into practice through weekly meetings, contact tracing, entering data into the DHIS2, producing situation reports."</i> (DMO, female #10)</p> |
| Means | Information | <ul style="list-style-type: none"> <li>○ ANSS sources of information in response to different outbreaks were paper-based reports and the district health information system (DHIS2).</li> <li>○ The frequency of information transmission from the field to ANSS was daily and weekly.</li> <li>○ The collection, processing, use and dissemination of information enabled the ANSS to measure the success and failure: <i>"we monitor trends."</i></li> <li>○ Learning through information enabled the ANSS to anticipate trends and discover new approaches to solving the problems encountered, as reported.</li> </ul> | <p>The RHIs have learned through information. The sources of information of health regions during the response to different outbreaks were paper-based reports and DHIS2. Usually, information transmission from health districts to the regions includes phone calls and emails.</p> <p><i>"The health districts call the region as soon as there is a suspected case and send by email the summary of the investigation and the reports. The case is entered in the template designed for this purpose."</i> (RHI #2)</p> <p><i>"The daily reports and the DHIS2 informed us about the indicators in our region."</i> (RHI #1)</p> <p>The frequency of information transmission from health districts to regions is daily, weekly or monthly, depending on circumstances and the type of information.</p> | <p>DHMTs have learned through information. The sources of information for health districts during the response to different outbreaks were paper-based reports, DHIS2, community feedback and research data. Information was conveyed from the field/health centres to DHMTs through calls and emails.</p> <p><i>"We learn through analysis of reports sent by health centres, information collected in the community, and primary data collected during household surveys."</i> (DMO, male #4)</p> <p>The frequency of information transmission to DHMTs is daily, weekly or monthly, depending on circumstances and the type of information.</p> <p><i>"During an outbreak, as soon as the community liaison officer is informed of a case of illness or death, he reports the information directly to his</i></p>   |

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|              |   |  | <p><i>“Reporting is daily for all suspected and positive cases and even instantaneous; Situation reports are daily, epidemiological surveillance reports are weekly, DHIS2 reports are monthly.” (RHI #2)</i></p> <p>The collection, processing and use of information have enabled the RHIs to measure outbreak response success and failure by monitoring performance indicators.</p> <p><i>“We monitor the incidence of the disease, the case fatality rate, the spread and contacts.” (RHI #2)</i></p> <p><i>“We review the trends of the epidemic curve to examine whether they are decreasing or increasing.” (RHI #5)</i></p> <p>Learning through information enabled RHIs to anticipate trends and discover new approaches to solving problems.</p> <p><i>“As soon as you see the alert threshold is reached, you go down to investigate on the ground with the epidemic team.” (RHI #5)</i></p> <p><i>“It allowed adapting awareness messages to the population.” (RHI #3)</i></p> | <p><i>health centre manager, who in turn reports the information to the district health management team, which reacts directly by sending a team to the field. However, when there are no outbreaks, reports are made every weekly.” (DMO, female #10)</i></p> <p><i>“Transmission is daily for notifiable disease data and weekly for epidemic thresholds, to monitor weekly trends.” (DMO, female #2)</i></p> <p>The collection, processing, analysis and interpretation of information did not allow DHMTs to measure the success and failure of the response; however, it enabled them to anticipate trends and find new approaches of solving problems.</p> <p><i>“For example, for the COVID-19 vaccination, thanks to the data, we were able to identify the poorly vaccinated areas and increased awareness in these areas to mobilise the population to come and get vaccinated.” (DMO, female #13)</i></p> <p><i>“The information reported was not only about the disease but also cases of reluctance. When we had to go to a locality and were informed that there was reluctance, we took measures to manage these cases. We used lobbying strategies, for example. If there is a native of this locality in the city centre here or Conakry, we will go through him to help sensitise the locality.” (DMO, female #10)</i></p> |
| Deliberation | <ul style="list-style-type: none"> <li>○ The processes of dialogue and reflection to link past actions, the effectiveness or impact of those actions, and future actions were made through team meetings and conferences (face-to-face or online).<br/><i>“We organised weekly epidemiological briefings and</i></li> </ul> | <p>The RHIs have learned through various deliberation acts:</p> <ul style="list-style-type: none"> <li>- Team meeting (all the regions): daily staff meetings</li> <li>- Peer and non-peer engagements, including consultations with stakeholders, engagement with multisectoral coordination and authorities at all levels (3/5 regions)</li> </ul> | <p>DHMTs have learned through various deliberation acts:</p> <ul style="list-style-type: none"> <li>- Team meeting (all the districts): daily staff meetings</li> <li>- Peer and non-peer engagements, including consultations with stakeholders, engagement with multisectoral coordination and authorities at all levels (7/13 districts)</li> <li>- Research collaborations (3/13 districts)</li> </ul>  |  |



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|        |  | <i>strategic epidemic response committee meetings.”</i>  | <ul style="list-style-type: none"> <li>- Research collaborations (2/5 regions)</li> <li>- Conferences (2/5 regions)</li> </ul>   | <ul style="list-style-type: none"> <li>- Conferences (5/13 districts)</li> </ul> <p><i>“After noticing the reluctance of the population to apply barrier measures, to be tested and to accept their results when they were positive, we started to organise community meetings to include all community actors in the response.”</i> (DMO, female #13)</p> <p>Some deliberations, including peers and non-peers, took place outside health districts.</p> <p><i>“After the outbreak, UNICEF brought us together to learn from the response. What worked and why? Is it because we used this strategy? The other one did not work because we did not use that strategy. So we have drawn lessons. This workshop which brought together all those who participated in the Ebola response [2014-16], took place in Kindia.”</i> (DMO, female #10)</p> |
| Action | <ul style="list-style-type: none"> <li>○ Learning produced through actions and practice has been repeated and ended up with guidelines elaboration.<br/><i>“We adapted newsletters and situation reports plans.”</i></li> <li>○ Learning through actions was shared with other actors within and outside the ANSS.</li> <li>○ However, learning generated by the stakeholder consultations has not been captured and codified (translated) into information for future application.</li> </ul> | <p>Learning was produced through iteration of tasks (4/5 regions), then specific technical sheets (guidelines) were developed and routinely followed in practice (4/5 regions).</p> <ul style="list-style-type: none"> <li>○ Learning through actions was shared with other actors within and outside the health regions.<br/><i>“We share learning through action with multisectoral coordination and the hierarchy.”</i> (RHI #2)<br/><i>“We share learning through action via online conferences.”</i> (RHI #3)</li> <li>○ Some RHIs (2/5) reported having captured and codified (translated) learning generated by the stakeholder consultations into information for future application.<br/><i>“We translated lessons learned from the responses to outbreaks into information to tackle future outbreaks effectively.”</i></li> </ul> | <p>DMOs learned through repetition of tasks (13/13 districts) and projects (5/13 districts) and codified information into guidelines (9/13 districts)</p> <p><i>“Every time we wanted to carry out a response activity in a locality, we organised community-based meetings beforehand to be accompanied by all the community players.”</i> (DMO, female #13)</p> <p><i>“In our health district, there were projects born after the COVID-19 epidemic based on lessons learned from the response and supported by IOM and other partners. These projects were born because we learned that there were weaknesses in surveillance before the epidemic.”</i> (DMO, female #10)</p> <p>A few DMOs (2/13) shared learning produced through action with other actors within and outside the health districts in diverse ways, such as information meetings and educational talks in health facilities or places of worship.</p> |  |

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|  |  |  | <ul style="list-style-type: none"> <li>○ Some RHIs (2/5) asserted to have taken advantage of “District.Team” experience to respond to outbreaks in their regions. <ul style="list-style-type: none"> <li>“Yes, especially in terms of engagement with the different actors.” (RHI #1)</li> <li>“We trained some young people online who were very active in the outbreak response.” (RHI #2)</li> </ul> </li> </ul> | <p>“We shared our experience with the other district health managers during meetings; for example, we carried out a COVID-19 vaccination campaign strategy targeting mosques, churches and big crossroads. Moreover, many have copied this and adapted it in their areas of intervention to achieve a result like ours.” (DMO, female #12)</p> <p>“The community-based meetings approach was developed and put into practice by us, and we shared it with the other district health management teams.” (DMO, female #13)</p> <p>Some DMOs (4/13) reported having captured and codified (translated) learning generated by the stakeholder consultations into information for future application.</p> <p>“When we code our weekly results, we put this information into a report with recommendations for future application.” (DMO, female #11)</p> <p>“If the follow-up of contacts was reserved for only the district health management team in the past, after the training, we decentralised it; we trained the actors at the base. Every time there was a suspected case, they managed it, and we only came for supervision.” (DMO, female #10)</p> <p>Some DMOs (6/13) asserted to have taken advantage of “District.Team” experience to respond to outbreaks in their districts.</p> <p>“We have learned from District.Team an experience of good collaboration and sharing, which we implement in outbreak response.” (DMO, female #13)</p> <p>“In our district, we implemented a corollary experience that has benefited the district in the context of maternal deaths.” (DMO, male #4)</p> |
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| Loops | Single loop | <ul style="list-style-type: none"> <li>○ Everyday routines and practices in terms of outbreak response within the ANSS were adjusted by adapting the integrated disease surveillance and response (IDSR) guide to national needs and developing the concepts of operations (ERARE/EPARE/ECARE employment guide and COU-SP guide).</li> </ul>  | <ul style="list-style-type: none"> <li>○ The regional health teams adjusted normal routines and practices in epidemic response.</li> <li>○ Some examples of how they performed corrections or adjustments were applying guidelines from the central level, training, activation of the emergency operations centre in response mode, Handwashing and infection control and prevention (ICP) compliance.</li> </ul>  | <p>Customary routines and practices in outbreak response were adjusted within the DHMTs. Some examples of how they performed corrections or adjustments in regular actions and routines were adapting the integrated disease surveillance and response (IDSR) guide to the national context, routine vaccination, investigations, contact identification and tracking, and effective communication.</p> <p><i>"At the very beginning of the Public Health Emergency Operation Centre's meetings, there was a lack of analytical and interpretative capacity. Over time, there were better organised and more problem-specific recommendations to solve."</i> (DMO, male #7)</p> <p><i>"Each case was treated differently, but we knew what to do when we came across a case we had already encountered. For Ebola and COVID-19, for example, we targeted water points near the home of a confirmed case, and all those who came to draw water were considered contact cases. This new approach allowed us to quickly identify contact cases, most of whom tested positive."</i> (DMO, female #13)</p> |
|       | Double loop | <ul style="list-style-type: none"> <li>○ During the response to outbreaks, assumptions around problems encountered have been questioned to find the underlying root causes.<br/><i>"We conducted a survey on persistence factors in measles outbreaks in 2017."</i></li> <li>○ Assumptions around solutions to the problems were questioned, and the correction plan to the identified factors was developed. Assumptions about the problems and their solutions have been tested.</li> </ul> | <ul style="list-style-type: none"> <li>○ Double-loop learning occurred in health regions; however, only one health region fully implemented this aspect of learning.</li> <li>○ The RHIs reported having questioned assumptions to the problems encountered to find the underlying root causes. In some cases, assumptions about the problems and their solutions were tested.<br/><i>"During Ebola disease (2014-16), COVID-19 and measles outbreaks in my region, we questioned communities' belief in false rumours."</i> (RHI #3)<br/><i>"In the course of outbreak investigations, assumptions are made and verified."</i> (RHI #4)</li> </ul> | <p>Double-loop learning occurred in health districts. Almost all DMOs reported having questioned assumptions around the problems encountered.</p> <p><i>" Each problem encountered during the various activities was analysed in-depth to see the possible underlying causes, and we tried to find hypotheses for solving that problem. For example, regarding the COVID-19 vaccination, the craze at the vaccination sites was due to political pressure because as soon as this stopped, attendance dropped. We set up mobile teams and conducted awareness campaigns in mosques and churches to mobilise</i></p>   |

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|  |  | <p><i>"We observed a decrease in measles cases in locations where the plan has been implemented."</i></p> <ul style="list-style-type: none"> <li>○ Learning through hypothesis testing has influenced practices and frameworks, leading to changes in objectives and approaches.</li> </ul> <p><i>"We adapted the content of the Field Epidemiology Training Programme."</i></p> | <ul style="list-style-type: none"> <li>○ Then, only one director questioned assumptions around solutions to problems.</li> </ul> <p><i>"We interpreted solutions to problems."</i> (RHI #5)</p> <ul style="list-style-type: none"> <li>○ In contrast, the other directors did not question solutions; they were limited to questioning problems.</li> <li>○ In some regions (3/5) and in some cases, assumptions about the problems and their solutions were tested.</li> </ul> <p><i>"For instance, regarding the Lassa fever in my region, we formulated many hypotheses and verified; in the end, it was an isolated case of Lassa fever. (RHI #2)"</i></p> <ul style="list-style-type: none"> <li>○ In some regions (2/5), learning through hypothesis testing has influenced practices, frameworks and models, leading to changes in objectives and approaches.</li> </ul> <p><i>"We changed response strategies to outbreaks over time by adapting response plans."</i> (RHI #3)</p> | <p><i>communities to get vaccinated."</i> (DMO, female #12)</p> <p><i>"During COVID-19 in our health district, contact cases were giving wrong information; this was due to the stigmatisation of Covid cases by communities."</i> (DMO, male #9)</p> <p>However, not all assumptions around problems were questioned during responses to outbreaks in health districts.</p> <p>Most DMOs (10/13) asserted to have questioned assumptions about solutions to the problems.</p> <p><i>"In our health district, having more than 70% of children who had measles because they were not vaccinated made us question the vaccination coverage that the centres send each month through their activity reports."</i> (DMO, male #4)</p> <p>In most health districts (9/13), assumptions about the problems and their solutions were tested.</p> <p><i>"We hypothesised that if more than 95% of children are actually vaccinated measles will have been prevented, which was the case."</i> (DMO, male #4)</p> <p><i>"During the COVID-19 outbreak in our health district, when we identified the problems, we hypothesised the causes and proposed solutions. When these solutions were implemented, we saw an improvement in results that had been worsening before."</i> (DMO, female #12)</p> <p>In half of the health districts (7/13), learning through hypothesis testing has influenced practices, frameworks and models, leading to changes in objectives and approaches.</p> <p><i>" Learning through hypothesis testing has enabled us to have regular communications through rural radio, which led to community</i></p> |
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|  |             |  |                 | <p><i>adherence to outbreak control measures."</i><br/>(DMO, female #6)</p> <p><i>"Vaccination provision monitoring in our health district is a strategy that has proven results [end of measles] and for which we have redefined policies to achieve objectives."</i> (DMO, male #4)</p> |
|  | Triple loop | Triple-loop learning was missing at the ANSS level. The very basis (frameworks and assumptions) through which single and double-loop learning occurred was not questioned to influence it to change. Therefore, the ANSS did not improve how it was learning, as learning structures and processes remained identical. | It was missing. | It was missing.   |