Toolkit to support the identification and deployment of a health facility registry service in countries

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About the GHFD initiative

WHO's Geolocated Health Facilities Data (GHFD) initiative is a collaborative effort that provides support to countries who need assistance updating, geolocating, digitizing, and/or openly sharing the health facility master list (HFML) for their country. As a global public good, the final product will be the first central and accessible public directory of health facility names, locations and types.

More specifically, the initiative provides support for developing:

- a georeferenced Health Facility Master List (HFML) per country that is maintained, actively used, and basic information is publicly shared by the Ministry of Health.
- Ministry of Health capacity to leverage geospatial information systems (GIS) for health.
- a global directory containing HFML-related information of importance to the international community.

Please consult the GHFD initiative webpage for more information:
https://www.who.int/data/GIS/GHFD

Acronyms

CGR	Common Geo-Registry
GHFD	Geolocated Health Facilities Data initiative
HFML	Health Facility Master List
HFRS	Health Facility Registry Service
HIS	Health Information System
IT	Information Technology
MFL	Master Facility List
MOH	Ministry of Health
RFP	Request for Proposal
TCO	Total Cost of Ownership
TOR	Terms of Reference

About this toolkit

The objective of this toolkit is to help public health managers and the stakeholders supporting them, to identify and plan the deployment of the Information Technology (IT) solution to serve as Health Facility Registry Service (HFRS)[1] to store, manage and share the country's Health Facility Master list (HFML)[2] and other associated data and information.

The toolkit proposes the following seven-step process to help decision-makers choose the adequate IT solution to serve as HFRS based on requirements and other factors as well as develop associated plans and finally understand and manage the risk associated with this type of project:

- Step 1: Establish a technical working group.
- Step 2: Define expected outcomes.
- Step 3: Assess the current enabling environment.
- Step 4: Define what the HFRS should do.
- Step 5: Find the appropriate IT solution.
- Step 6: Develop the implementation, monitoring and evaluation and communication plans.
- Step 7: Understand and manage risks.

The toolkit is targeted at individuals and organization involved in the deployment of a HFRS. It describes each step and provides guidance and tools to help through this process. Its content builds on and is aligned with WHO/USAID's Master Facility List (MFL) resource package [1]. Its structure process and terminology are inspired by other toolkits [2, 3, 4] and it leverages the content of other documents identified during its development [5, 6, 7, 8, 9, 10].

Deploying and maintaining a HFRS is a key component of the process aiming at establishing, managing, regularly updating and sharing the HFML in a sustainable way in countries. As such, it is expected for certain elements of this process to already be in place at the time of using the present toolkit. This is reflected in the different sections of the present document and readers are often asked to refer to the MFL resource package [1] in this regard.

The definition of the terms used in the present toolkit are included in Annex 1.

Introduction

The availability of a Health Facility Master List (HFML) of quality managed by a governmental entity having the official curation mandate over it is recognized as an essential component of the health information system. For this to be realized, a Health Facility Registry Service (HFRS), a digital platform that can store, maintain and share the HFML to facilitate its use for public health purposes, is a crucial component of the national digital health ecosystem [4, 11].

Benefits of such an asset include better accountability of health resources, more efficient coordination of health intervention within the health sector through an easier flow of information between different health information systems, systematic identification of gaps in the availability and accessibility of health services, as well as better preparedness of the health system to withstand emergencies.

Deploying an HFRS supporting the establishment, maintenance regular update, sharing and use of the HFML can also help address many common limitations found in countries' HFMLs, such as poor data quality, unclear institutional governance and long-term sustainability, lack of efficient updating mechanism and low shareability with all stakeholders - including the public. Deploying a HFRS enables a more effective management of the HFML by providing tools to facilitate the work of the governmental entity in charge of curating and sharing the HFML, and to enable different users to ingest it.

A growing number of efforts are being dedicated by global partners to improve the availability, quality and accessibility of the HFML in countries, including the development of global guidelines (e.g. WHO/USAID MFL resource Package [1], OpenHIE guidelines [7]), as well as direct support provided to these countries to establish or complete the HFML, and introduce a HFRS to store, manage and share it.

Nonetheless, countries continue facing challenges in establishing mechanisms for sustained HFML management. Amongst these challenges, major gaps remain in the adoption of digital tools providing adequate functionalities for optimal management, update and sharing of the HFML. Furthermore, gaps remain to be addressed in existing HFRS solutions and the enabling environment to deploy them.

To address this gap, WHO's Geolocated Health Facilities Data initiative (GHFD) provides a clear framework, guidelines, and tools to ensure that the Ministries of Health of the WHO Members States are in the position to maintain, regularly update, share, and use the HFML for their respective country. The present toolkit is one of the tools developed in the technical sub-working group on health facility registry minimum requirements, co-lead by UNICEF and WHO, which was established under the umbrella of the GHFD initiative.

Step 1 – Establish a technical working group

- Establish a technical working group to implement the rest of the process described in the present toolkit
- Identify and engage the relevant stakeholders in the technical working group

A governance mechanism overseeing the establishment, management and sharing of the HFML should ideally already be in place at the time of identifying which IT solution would be adequate to store, manage, and share such a list. This mechanism should ideally be part of, or be connected to, the broader digital health enterprise [4].

If this governance mechanism is in place, the first step consists in establishing a technical working group (TWG) under this governance mechanism with the task of going through the rest of the process described in the present toolkit.

If an HFML governance mechanism (e.g. steering committee) is not yet in place, it is strongly recommended for such a mechanism be established either before or in parallel to the above-mentioned TWG. Please refer to the MFL resource package for more information regarding the governance mechanism in question [1].

As indicated here above, the primary role of the TWG is to implement the rest of the process described in the present toolkit. At a later stage, the TWG might also be given the responsibility to oversee the development and deployment of the selected HFRS.

The membership of the TWG might therefore evolve depending on the work at hand. At first, it is important that it includes the primary data consumers of the HFML [1] as well as those that will be, or anticipated to be, in charge of the long-term management of the HFRS and of its content as they will contribute to defining the expected outcomes (Step 2), to the assessment of the current enabling environment (Step 3), to what the HFRS is meant to do (Step 4) and to the recommendations of a specific IT solution to be used as HFRS (Step 5).

Starting from Step 5, additional stakeholders might need to be invited to join the TWG or to work in close collaboration with it. This could include representatives from the companies developing the IT solutions considered as candidate HFRS and/or stakeholders to be involved in the development of the implementation plan (Step 6). Local or international consultants might also need to be contracted to support the work of the TWG through these different steps.

The TWG should not only closely coordinate with the HFML governance mechanism but also regularly report to it both to ensure that the HFRS process aligns with the HFML goals and process and for key decisions about the HFRS to be taken in the presence of all concerned stakeholders. The TWG might also coordinate with other MOH entities to ensure the HFRS aligns with the national eHealth strategy.

Terms of Reference (TOR) covering all the above should be developed for the TWG.

Step 2 – Define the expected outcomes

- Define the strategic and technical outcomes expected from the deployment of a HFRS.

Expected outcomes for the deployment and maintenance of a HFRS should be defined at both the strategic and technical level.

At the strategic level, the strategic outcomes can be expressed in terms of the benefits that would be provided to the health sector once a HFRS has been deployed and operationalized.

Here is a non-exhaustive list of such benefits considering that the HFRS, together with the HFML and other data it contains, is meant to serve as a backbone of the digital health system:

- Data standardization and quality: A health facility registry enforces data standardization and, as such, the quality of the information collected and stored in the master list.
- Interoperability: A health facility registry enables data interoperability and sharing between information systems collecting, managing and or analyzing facility level data and information.
- Online access: A standardized health facility registry facilitates online use of information contained in the master list including, when appropriate, the creation of a public-facing portal for users to access basic information about nearby health facilities.
- Data-driven decision making: A well-maintained health facility master list accessible through a registry empowers policymakers, healthcare administrators, and stakeholders with accurate, ideally real-time data and reports. This facilitates evidence-based decision-making, allowing for informed policy formulation, strategic planning, and resource allocation.
- Efficient resource management: By centralizing information about health facilities, the registry first reduces duplication of efforts through the centralized management and regular update of the master list. It then enables efficient resource allocation for better health care access and delivery. It aids in identifying gaps in services, redistributing resources, and strategically planning infrastructure development.
- Optimized public health interventions: Timely access to health facility master list of quality through a registry enables authorities to design and implement targeted public health interventions efficiently.
- Enhanced coordination and collaboration: The sharing and accessibility of up-to-date information across various stakeholders within the healthcare system foster collaboration and coordination not only at the national but also regional and global level. This proves invaluable during emergencies, public health crises, and routine healthcare delivery.
- Transparency and accountability: The transparency offered by a comprehensive health facility master list hosted in a registry fosters accountability among healthcare providers and institutions. It allows for monitoring quality standards, compliance with regulations, and assessing the performance of facilities.

- Innovation and research: Researchers and analysts benefit from the data contained in the registry to conduct studies, analyzing trends, and identifying areas for improvement. This aids in fostering innovation and driving advancements in healthcare practices.

If needed, the above list of anticipated benefits can also be used to make a good case for the deployment and maintenance of a HFRS and help secure funding.

At the technical level, the high-level objectives of a HFRS are included in this concept's definition. As such, a HFRS is anticipated to do the following when it comes to the health facility registry's content:

- Store: Provide the necessary functionalities to ensure the storage, security and scalability of the registry's content in a usable, reliable, cost-effective, and performing environment.
- Manage: Provide the necessary functionalities for the authorized users to effectively manage the content of the registry and ensure its quality and integrity.
- Share: Provide the necessary functionalities to ensure proper access to the registry's content as well as its exchange with other systems and applications as articulated by the national digital health enterprise architecture [4].

These should be considered the business requirements of the HFRS to be deployed, maintained and agreed on by the TWG and the HFNL governance mechanism.

Step 3 – Assess the current enabling environment

- Assess the current maturity level of the country's enabling environment required to establish and sustain a HFRS solution
- Document identified gaps

Deploying and maintaining a HFRS is a long-term investment that can only be sustained if the necessary enabling environment is in place.

One way to look at this is to consider the HFRS and its content, starting with the HFML, as a key component of a geo-enabled Health Information System (HIS). In the framework that supports such geo-enablement – the HIS geo-enabling framework [12] – the enabling environment consists of 7 elements, namely [9, 12, 13, 14, 15]: 1. vision, strategy and plan; 2. governance; 3. policies, 4. human and financial resources, 5. specifications, standards and protocols, 6 technical capacity and 7. technologies.

These elements are like those mentioned in the MFL resources package [1] when referring to the HFML enabling environment (policies, procedures, leadership, technology, infrastructure, and workforce). They compose the first and second stage of the HIS geo-enabling framework's pyramid [12] and support the establishment and maintenance of master lists together with the

associated hierarchies and geospatial data hosted in a set of registries or a Common Geo-Registry (CGR) depending on the digital health enterprise architecture being implemented in the country.

Assessing where the country stands across the above-mentioned elements is a key exercise to be conducted not only in preparation of the deployment of a HFRS but also the establishment of the HFML in general.

This kind of assessment might have already been conducted as part of the establishment of the HFML as recommended by the MFL resource package [1] or as part of the broader planning and implementation of a digital health enterprise [4]. If this is the case, some or all the information needed about the HFRS might have already been collected (the validity of this information should be evaluated based on when the assessment has been conducted). If this is not the case, or the information is too old to still be valid, the present step provides an opportunity to conduct such an assessment.

In both cases, the questions reported in Annex 2 should at least be answered through this exercise when it comes to the HFRS (extracted and adjusted from [1, 2]).

The answer to the above questions might either support or limit the use of specific IT solutions. This might have an influence when defining requirements (Step 4) and when looking for the appropriate IT solution to serve as HFRS (Step 5). It is recommended to start conducting the assessment as soon as possible as it might take some time if not already performed and it can run in parallel to defining what the HFRS needs to do (Step 4). Conducting this assessment could also allow identifying additional stakeholders to be engaged in the HFRS TWG (Step 1).

At the end of the present step, it is recommended to document the findings from the assessment together with the gaps identified at this stage across the 7 elements of the enabling environment.

These findings should be validated by the TWG members and presented to the HFML governance for approval.

Step 4 – Define what the HFRS needs to do

- Define and document the data ecosystem to be hosted in the HFRS.
- Define and document the task flows and user roles that the HFRS should support.
- Decide on the functional and non-functional requirements that the HFRS is meant to fulfill and prioritize them.
- Define the expected user experience.

Having a clearly documented picture of what the HFRS needs to do is a critical step towards not only being in the position to identify the appropriate IT solution but also to communicate with vendors, and when applicable developers, as well as contract them. A great level of attention should be given to this step to avoid misunderstandings between parties, frustrations, delays, cost overruns and even failure.

In the case of a HFRS, this picture can be obtained by identifying and documenting the following:

1. The data ecosystem to be covered by the HFRS.
2. The task flows and user roles to be supported by the HFRS.
3. The functional and non-functional requirements that the HFRS should fulfill.
4. The expected user experience.

The approach used to identify and document the above should be as inclusive as possible and involve not only the members of the HFRS TWG but also its anticipated users and this across all levels (central to subnational level).

Data ecosystem to be covered by the HFRS

By data ecosystem we mean a detailed description of the data and information that the HFRS is meant to store, manage and share. See Box 1 for more details.

Most of the above is meant to have been defined and agreed upon at the beginning of the process aiming at establishing the HFML as these elements have a direct impact on the HFML content and management. If this is not the case, it is strongly recommended to complete this exercise before moving to the next step described here.

Box 1 – Element defining the data ecosystem meant to be stored, managed and shared though the use of a HFRS.

- The definition of the concept of health facility (for example: A building or physical structure providing health care) which, in some cases, might also require for the clarification of some of the concepts included in that definition (e.g. health care in the example provided here).[9]
- The identification of other types of health-related infrastructures not covered under the health facility definition but which are also expected to be managed in the HFRS (e.g. laboratories, pharmacies, vaccination posts)
- The definition of the hierarchies that should be managed in the HFRS [5, 6, 9, 10]. This concerns not only the hierarchies used to aggregate information geographically (is geographically located within (example: health facility A is geographically located in district B)) but also other types of relationships such as administrative (is reporting to), health-related (covers, provides services to, refers to) or associative (is part of) ones. This exercise will lead to the identification of additional geographic objects for which a master list will also be needed (e.g. administrative or health units).

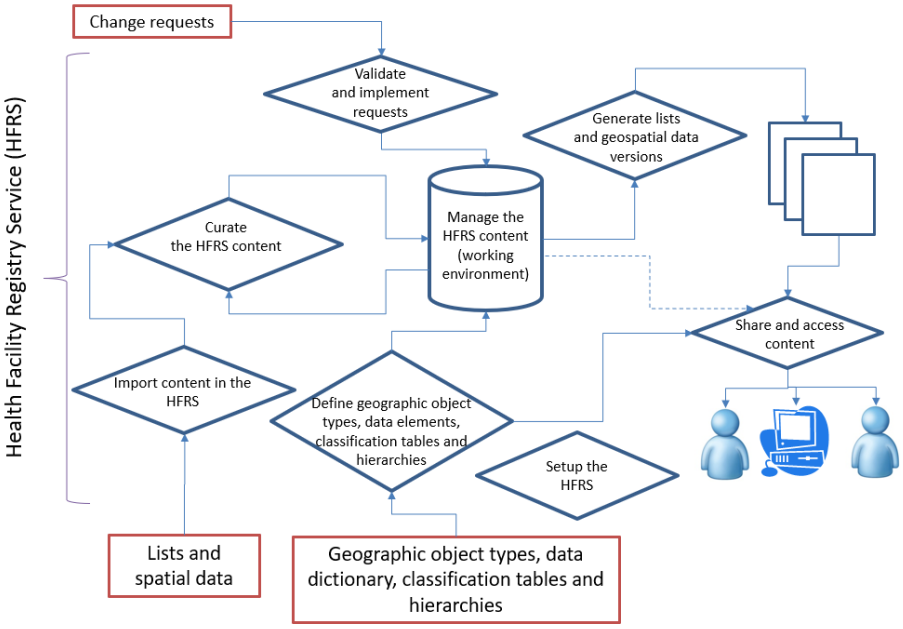
- The data dictionary and associated classification tables for each list to either be stored in the HFRS (e.g. health facilities) or accessed by it from an external registry (e.g. administrative divisions). The data dictionary for each list should contain all the necessary information to characterize all the data elements it contains (code, description, type, size,..) [1, 5, 6, 9, 10]
- The organization (source) having the mandate to provide the values for each data element included in the different data dictionaries. [1, 6, 9, 10]

Task flows and user roles to be supported by the HFRS

The task flows and associated user roles for each of the HFRS business processes need to be defined. They are supporting the high-level objectives, or business requirements, of a HFRS, namely to do the following with the registry's content (see Step 2): store (e.g., manage organizations, roles and users), manage (e.g., define geographic object types, data elements and hierarchies as well as import, visualize, validate, curate, update and document content) and share (e.g., export and exchange content).

These business processes are meant to be connected and interacting with each other as illustrated in Figure 1.

Figure 1 – Organization of business processes in a HFRS (adapted from [9])



Task flows themselves detail the different activities of each of these business processes and the role who performs them [2]. They can be captured in the form of diagrams like the example presented in Figure 1 regarding the submission and treatment of a change request.

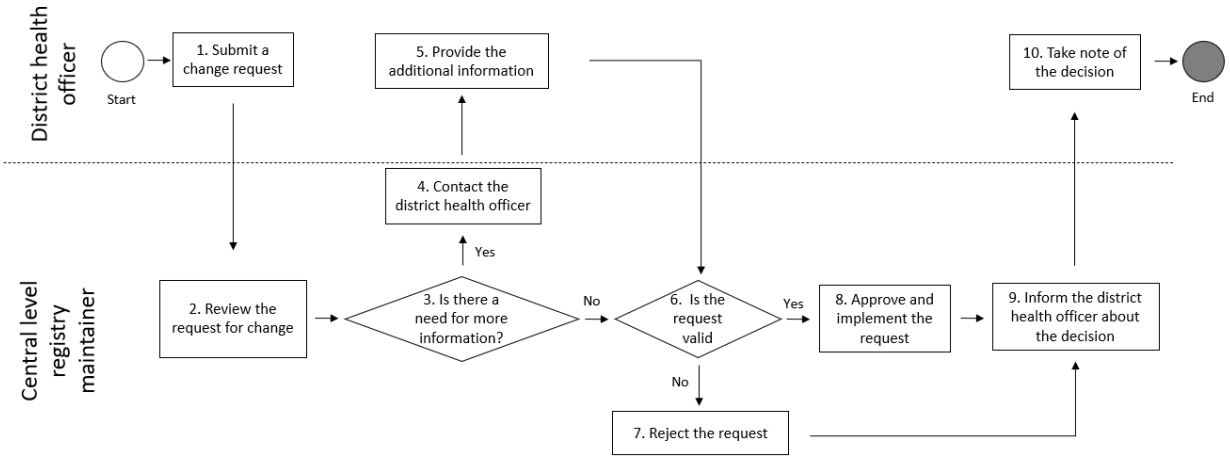


Figure 1 – Example of possible task flow for the submission and treatment of a change request in the HFRS

The way a task flow is represented in these diagrams is standardized to facilitate their readings (indication of the start and end, direction of reading (from left to right or top to bottom), symbols being used to describe actions (rectangles in Figure 1), decisions (diamonds) or sequence (arrows). They should also contain, or be accompanied by, the necessary information to identify who is involved at each step (e.g. who is responsible, taking decision, being informed, or consulted), which data or information is involved, and at which level each step takes place [2] as well as how frequently each task should be carried out [1]. As such, these task flows should allow answering questions such as:

- How will the content of the HFRS be updated?
- What administrative process is required to validate any change request?
- How will new health facilities be integrated in the HFML?

Depending on the current situation, these diagrams might document both the task flows as they are currently being implemented and then how they should ideally be implemented in the HFRS. Doing this can help support the change management that might be required by the deployment of a HFRS or the upgrade of the IT solution currently being used to store the HFML.

This information can also be used to define the roles that the HFRS should support (e.g. system administrator, registry maintainer or curator, registry contributor) as well as document the data governance model (centralized, decentralized, federated) [1, 9]. Table 1 provides an example of the user roles that could result from this exercise with a description of their respective responsibility and rights.

User role	Role description and rights
System administrator	A user having all the privileges of a registry administrator plus the capability to setup the HFRS as well as manage organizations and registry administrators
Registry administrator	A user having all the privileges of a registry maintainer plus the possibility to manage users
Registry maintainer	A user having all the privileges of a registry contributor plus the possibility to manage the HFRS content
Registry contributor	A user who has a view access to the content of the HFRS as well as the possibility to submit change requests
Registry consumer	A user who has the possibility to consumes HFRS's content (e.g. visualize, query, download,...) for which he has access rights (either through user access or through API to their own systems)

Table 1 – Example of user roles that could be provided by the HFRS (adjusted from [6] and [9])

Functional and non-functional requirements

There are different approaches to defining and documenting functional and non-functional requirements including but not limited to conducting interviews or surveys with current and/or anticipated users, organizing brainstorming workshops or reviewing and analyzing existing documentation.

Each of these approaches presents advantages and disadvantages, the main ones being captured in Table 2. The major risk with any of the approaches included in this table is that some critical functionalities might be forgotten and therefore not captured in the final requirements.

	Advantages	Disadvantages
User survey	- Can potentially reach a larger audience, making it suitable for gathering a broad range of perspectives. - Allows respondents to provide honest feedback without feeling pressured or biased by direct interaction.	- It can be difficult to design and may not provide a deep understanding of the system's requirements. - Low response rates or incomplete responses can impact the quality of gathered data.
Users' interviews	- Can provide detailed insights into stakeholder needs and expectations.	- Responses might be influenced by stakeholders' perspectives, leading to subjective or biased information.

		- Can be time-consuming and expensive, especially if the stakeholders are geographically dispersed.
Brainstorming workshops	- Facilitates collective brainstorming, fostering consensus and buy-in from stakeholders.	- May not be suitable for all stakeholders
Documentation review	- Leverages available documentation for insights into current processes and requirements. - Provides historical data useful for understanding system evolution	- Existing documents may not accurately reflect current stakeholder needs or system functionalities. - Documents might lack comprehensive information, leading to gaps in requirements understanding.

Table 2 – Main advantages and disadvantages of different approaches used to capture functional and non-functional requirements.

Given the above, to leverage the advantages of the different approaches listed in Table 2 and because the business requirements of a HFRS are clearly spelt, the present toolkit proposes for countries to use the approach included in Box 2 to obtain a comprehensive list of functional and non-functional requirements[3].

Box 2- Approach proposed to obtain a comprehensive list of functional and non-functional requirements

1. Use the list of 24 functional and 16 non-functional requirements defined through the documentation review conducted as part of the development of the present toolkit (Annex 2) as the starting point for the process.
2. Organize a survey and/or workshop[4] to get feedback on this initial list based on the potential limiting factors identified during the enabling environment assessment conducted during Step 3 (e.g. data exchange protocols to be supported), the data ecosystem, task flows and user roles that have been defined and documented earlier in the present step. More specifically, this exercise should aim at identifying if:
    a. The criticality level currently included in the list for each requirement should be adjusted. The recommendation is not to change the level for the requirements that are labeled as required as they are core to the concept of HFRS but only to potentially upgrade the level of those that are currently labeled as recommended to required or those labeled as optional to recommended depending on the local context. Annex 3 provides not only a justification for the current criticality level included in Annex 2 but also a description of the reason

that could lead to an upgrade of these levels based on the country's needs and context.

b. The spelling of some of the requirements should be adjusted to facilitate their understanding or be better aligned with the local context (e.g. data governance model for example).
c. Requirements should be added to the list. If this is the case, their description and criticality level should be defined at the same time. The next available unique code following the same structure as the one used in Annex 2 (e.g. RMR F5 for functional requirements and RMR NF 5 for non-functional ones) should also be attributed to each new requirement.

Expected user experience

Defining the expected user experience at this stage in the process consists in:

- Defining a user persona for each user role that the HFRS should support (example in Table 1).
- Documenting user stories specific to each required requirement from the point of view of a specific user persona.

While no standard template exists, the following information can be considered for inclusion in the user persona to be developed in relation to the HFRS:

- Function and responsibilities: Job title and description, list of responsibilities
- Demographic Information: Details such as age, gender, location, education level, occupation, income, etc.
- Technical skills and experience: Level of IT proficiency (beginner, intermediate, advanced), expertise in specific software or systems, previous experience with similar solutions, ability to learn and adapt to new technologies.
- User Environment: Description of their physical environment, time constraints, or any other situational factors that might affect their usage of the HFRS.
- Technology access and constraints: Devices and platforms used (desktop, laptop, mobile, etc.), internet connectivity and bandwidth limitations, potential security and privacy concerns.
- Data and Information needs: types of data they need to access and manage, data analysis, visualization and reporting requirements, information-sharing and collaboration needs.
- Communication Preferences: Understand how they prefer to receive information and communicate including for IT support (emails, phone calls, social media, or other communication channels).

A user story is a documented description of a software functionality seen from the end-user perspective. These stories describe what exactly the user wants the system to do and is usually phrased as follows [1]: "As a [user role] I want to [insert need] so that I can/all the users can [insert why]."

Here are some examples of user stories based on the user roles defined in Table 1:

- As a system administrator I want to have access to an audit trail so that I can control that all the changes operated in the HFRS have been made by authorized users.
- As a registry administrator, I want to attribute user permission to each user so that I can ensure that only authorized users are editing the registry's content.
- As a registry maintainer I want to be able to add a newly opened health facility so that all the users can have access to a complete HFML.
- As a registry contributor I want to be able to submit a change request for incorrect information to be adjusted in the HFML so that all the users can have access to the correct information.

The identification and documentation of these user stories can be performed using one of the approaches listed in Table 2 considering their respective advantages and disadvantages. While it might be possible to conduct this exercise in direct conjunction with the one dedicated to the functional and non-functional requirement, this option should be carefully considered in view of the additional concepts that need to be absorbed and the volume of work this represents. If possible, it might be preferable to conduct this as part of a separate exercise.

The stories should be defined in relation to each specific functional and non-functional requirement. Going through this exercise will help ensure that there is a common understanding among all stakeholders regarding what each requirement entails. This might lead to the need to adjust some of the requirement's wording or even the inclusion of new requirements in the list.

All the information collected during this step should be documented in detail as it will serve as the "blueprint" to select the appropriate IT solution (Step 5), including the identification of the right vendor and guide the development of a custom solution in case this is the approach that is finally chosen.

This document should be validated by the TWG members and presented to the HFML governance for approval.

Step 5 – Find the appropriate IT solution

- Identify the IT solutions that could serve as HFRS.
- Assess how each of the identified solutions complies with the defined functional and non-functional requirements.
- Calculate the total operation cost
- Decide which solution will be used as HFRS.

Now that a technical working group has been established (Step 1), the expected outcomes defined (Step 2), the current enabling environment assessed (Step 3) and what the HFRS should do defined (Step 4), the next step consists in finding the appropriate IT solution to serve as HFRS in the country.

The choice of this solution depends on three main factors:

1. Possible limitations identified during the assessment of the enabling environment.
2. The level of compliance against the requirements that have been determined [2].
3. The total cost of ownership (TCO)[1] [2].

The process that will lead to the choice of the IT solution to be used as HFRS based on these three factors depends on the current situation observed in the country. Figure 2 captures the process in question.

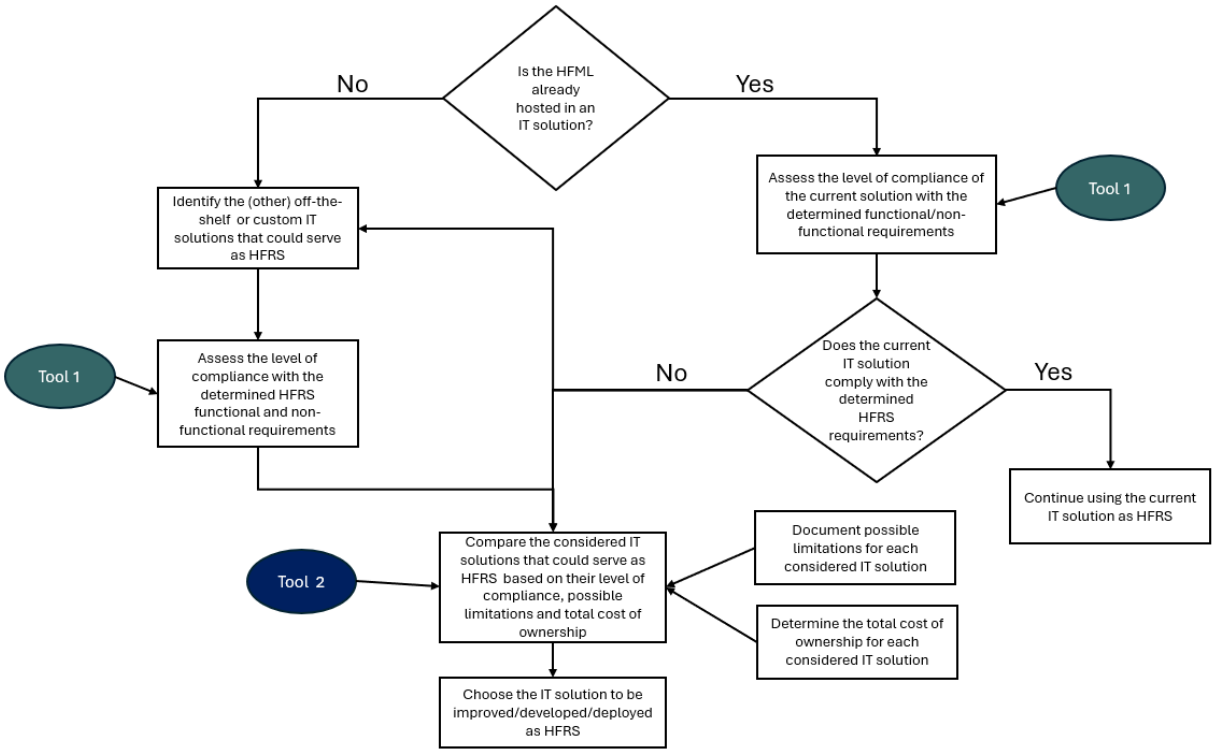


Figure 2 – Process for the selection of the IT solution to be used as HFRS

Two tools have been developed under the form of an MS Excel spreadsheet to support the implementation of the process reported in Figure 2.:

1. Tool 1; Spreadsheet that can be used to assess the level of compliance of a given IT solution against the determined functional and non-functional requirements: https://tinyurl.com/236t4ywa
2. Tool 2: Spreadsheet that can be used to compare different solutions based on their level of compliance to the functional/non-functional requirements, possible limitations, and total cost of ownership: https://tinyurl.com/muh9b3t5

[1] https://digitalsquare.org/blog/2022/12/1/how-much-do-digital-health-interventions-cost-a-new-tool-helps-countries-estimate

Both files must be modified before using them to account for the result of the process conducted during Step 3 of the present toolkit. Annex 5 details what needs to be done in this regard. Once this is done, instructions on how to complete each spreadsheet are provided in the first worksheet of both files.

The first spreadsheet is meant to be filled out by local technicians and users in the case of an IT solution already being used in the country or by the vendors of an off-the-shelf solution. The criticality level of each requirement has been removed on purpose in this spreadsheet to avoid for this information to influence the level of self-reported compliance being provided by the respondent.

It is important to check the answers provided before using this information for the next step. It might also be good to check the validity of the compliance level provided by asking for a demonstration and/or documentation of the concerned functionality(ies) and this potentially using the user stories that have been defined for the concerned requirement(s) during Step 3 as reference.

The second spreadsheet can be completed by the members of HFRS TWG using the result of the compliance levels assessment and additional information collected separately. In this spreadsheet:

- The level of self-compliance collected during the assessment for each requirement is captured in the form of tables and radar graphs allowing a direct visual comparison between the different candidate solutions. Annex 6 provides an example of a table and graph obtained for the required functional requirements.
- Separate worksheet allow to manually capture the link to supporting material (e.g. marketing material, website, user manual), possible limitations of the solution related to the enabling environment that have not been captured in the requirements (e.g. non-compliance with a policy of law, not compatible with specific hardware, embedded in an information system (e.g. HMIS)), the cost associated to the development, deployment and running of the solutions and this across the pilot, scale up and sustain phases and questions for vendors

While the spreadsheets have been primarily designed to compare already existing solutions that could serve as HFRS (already in use or off-the-shelf), it can also be used to store the information for custom solutions if this is an option that is being considered.

Once the comparison worksheet is completed for all the solutions, its content can be analyzed to identify which one(s) are appropriate to serve as HFRS. When doing this analysis, it is important to remember that:

1. It might not be possible to overcome some of the limitations coming from the enabling environment and this despite the broader process being implemented for the establishment and maintenance of the HFML.
2. Even if it is decided not to enable them right from the beginning of the implementation the required requirements defined during Step 3 should either already be fulfilled by the

chosen IT solution or there should not be any limitation towards the expansion of the solution's capabilities to cover them in the future.

3. Additional cost might be identified during the development of the implementation plan (Step 6)

These findings should be validated by the TWG members and presented to the HFML governance for approval and, when applicable, the decision on the final IT solution to be implemented as HFRS.

The following sub-sections provide more information regarding the three main factors to influence the choice of the IT solution to serve as HFRS.

Possible limitations

There might be some limitations to using a particular IT solution. For example, it might not comply with the data security and privacy law, not be in the position of supporting the network or data exchange protocols to be followed or be incompatible with the hardware currently used in the country.

These limitations are meant to be identified during Step 3 and some of them captured in the requirements defined during Step 4 (e.g. data exchange protocols to be supported). Any other potential limitations not captured until now must be identified and documented during the present step.

Level of compliance against requirements

The limitations mentioned in the previous sub-sections is the reason why it is recommended to start by assessing the IT solution currently hosting the HFML, if any, to see how well it complies with the determined requirements and if any potential gaps could be filled. Doing so might address some of the limitations mentioned earlier, limit costs and facilitate stakeholders' buy-in.

Incentives might have to be identified for adopting and contributing to the IT solution to serve as HFRS in case the one currently used is finally identified as not being adequate.

If there is currently no IT solution being used to host the HFML, or if the gap to be filled for such a solution to comply with the requirements is too substantial, then different software models are possible, each of them with their own benefits and risks as presented in Annex 4 (extracted from [2]).

At that point, it makes sense to look at what other countries have been doing and the IT solutions they have been using to store, manage and/or share their own HFML and to assess by yourself to what extent one, or more, of these solutions could fit your own country's needs and serve as HFRS.

While it is not the purpose of the present toolkit to promote a particular IT solution over another, the inventory of existing frameworks, guidelines, good practices, and tools supporting the deployment and management of a health facility registry in countries conducted under the umbrella of the GHFD initiative could be used as a starting point for identifying some of these countries and the tools they have been using.

In this case, this would mean that a developer company, or a set of companies, will have to be identified and asked to submit a request for proposal (RFP) based on the functional and non-functional requirements developed under Step 3. The proposal(s) should also allow filling the different worksheets of the solution comparison spreadsheet. In that regard, the proposal must include (adjusted from [2]):

- A profile of the company including its type, working language(s), technical and organization capabilities including number of employees, past and present projects that are the most relevant for this work.
- A description of the proposed solution and the details of the requirements that will be fulfilled from the list being provided.
- A description of how the solution will be implemented in your context.
- An implementation work plan with timeline, methodology, roles, and responsibilities.
- The total cost of ownership to develop, deploy and operate the solution across the different phases (pilot, scale, sustain) and level of effort, including the effort required from MOH staff.

Total cost of ownership

When it comes to costing, the toolkit developed by WHO and PATH to help public health managers plan an information system project [2] provides a detailed list of cost drivers as well as a matrix that can be used to estimate the TCO.

If you receive a proposal from different software development companies, you will have to evaluate each of them to retain the one, or those, corresponding to the defined needs. The above-mentioned toolkit [2] provides recommendations and some tools to go through this process.

A profile together with any useful material and the total cost of ownership will also be needed from the vendors of the considered off-the-shelf solutions to complete the solutions comparison worksheet. Such a cost should include the development effort to address the gaps in requirements identified during the assessment.

Step 6 – Develop the implementation, monitoring and evaluation and communication plans

- Draft and finalize the implementation plan including timeline and potential budget adjustment
- Develop the monitoring and evaluation and communication plans

Developing not only an implementation but also a monitoring & evaluation and communication plan are key to ensuring a successful HFRS investment.

The development of the implementation plan might go through a few iterations before being finalized and this to account for the finalization of some activities such as the nomination of the project manager, the hiring of local and/or international consultants or the negotiation and finalization of the contract with the vendor(s).

It is also important for that plan to be integrated and therefore aligned with the overall HFML [1] and the digital health enterprise implementation plans [4]. In addition to that, several of the activities included in the HFML plan will have a direct influence on the HFRS one. This for example concerns but is not limited to:

- The definition of the HFML data dictionary and associated classification tables as these will influence the data type, formats, and standards that the HFRS will need to be able handling (e.g. UTF-8 for character encoding)
- The availability of the first version of the HFML that should be uploaded and used into the HFRS during user testing.
- Potential HFML-related data collection exercise which would provide an opportunity for bulk data import into the HFRS.
- HFML-related training that could provide an opportunity to train relevant staff on the use of the HFRS at the same time.
- The definition and documentation of the HFML updating mechanism that should be operationalized in the HFRS.

An example of an implementation specific to the different phases linked to the planning, development, and deployment of a HFRS is provided in Annex 7 (modified from [2]). While the planning phase included in this plan, which is the focus of the present toolkit, should remain the same independently from the IT solution being finally chosen, the development and deployment phase might have to be adjusted to account for that choice. In addition to that, the timeline in this example is expressed in terms of milestones and not the duration of each activity as such a duration will differ from one project to another.

Activities linked to addressing potential gaps in the enabling environment as identified during Step 3 should themselves be integrated into the overall HFML and, if existing, digital health

enterprise implementation plan(s) to avoid dissociating the technology from the content related aspects.

When monitoring and evaluation, it is important to conduct and communicate periodic evaluations to assess the impact and effectiveness of the HFRS.

Indicators that directly align with the HFRS business objectives (Step 2) and therefore the health system's strategic priorities and goals should be defined. Like for any other projects, they should be specific, measurable, achievable, relevant, and time-bound (SMART).

Examples of indicators might include data completeness rate, timeliness of data entry, or utilization of specific registry features. It is important to determine the data collection method that will be used for each indicator, considering frequency, data sources (e.g., registry system, surveys, administrative records), and responsible personnel.

For more information, please refer to WHO's practical guide for monitoring and evaluating digital health interventions [16].

An effective communication plan is crucial for ensuring successful deployment, adoption, and sustained use of a health facility registry service.

It is important to consider the following key elements when developing such a plan:

- Objectives: Clearly define the objectives of the communication plan. This will help in identifying the key messages that need to be communicated. This can include but not be limited to increased awareness and understanding of the HFRS, manage expectations and address concerns: Build trust and buy-in or solicit feedback.
- Target audience: Identify the target audience for the communication plan. This may include government officials, development partners, donors and other stakeholders. Categorize stakeholders based on their roles, interests, influence, and communication preferences.
- Key messages: Develop a set of key and tailored messages that will be communicated to the target audience. These messages should be clear, concise, and easy to understand.
- Communication channels: Identify the communication channels that will be used to reach the target audience. This may include email, social media, or other forms of communication.
- Timeline: Include communication activities in the HFRS implementation plan. This will help ensure that the key messages are communicated promptly.
- Monitoring and evaluation: Include communication-related indicators in the monitoring and evaluating plan to measure the effectiveness of the communication plan. This may involve collecting feedback from the target audience and analyzing the results.
- Adaptation: Use the results of the monitoring and evaluation activities to adapt the communication plan to changing needs and circumstances.

Adequate resources for M&E and communication activities, including personnel, technology, and funding should be allocated and therefore included in the final budget.

Step 7 – Understand and manage risks

- Identify potential risk factors that might lead to project failure.
- Define if and how the identified risks can be managed.

Implementing the 6 previous steps should lower the risks to the minimum but not necessarily eliminate all of them.

Common risk factors associated with the development and deployment of any IT solutions in the health sector include [2]: lack of overarching digital health enterprise plan, lack of governance, poor management, development, deployment, and operational risks.

The 6 steps process reported in Box 3 can be implemented to identify, understand and try to manage the risk as soon as possible.

Table 8.1 of the toolkit developed by WHO and PATH to help public health managers plan an information system project [2] provides an example of a table that can support steps 1 to 3 of the above process.

Box 3 – Six steps process to identify, understand and try to manage the risk as soon as possible

1. Identify potential risks:
   - Stakeholder Involvement: Engage stakeholders, including developers, clients, and end-users, to identify potential risks at various stages of the project.
   - Risk Categories: Categorize risks into areas such as technical, operational, organizational, and external factors to ensure comprehensive identification.
   - Brainstorming and Documentation: Conduct brainstorming sessions and document identified risks along with their potential impact and probability.
2. Assess, analysis and priorities the identified risks:
   - Impact Assessment: Evaluate the potential impact of each identified risk on project objectives, timelines, budget, and quality.
   - Probability Analysis: Analyze the likelihood of each risk occurring based on historical data, expert opinions, and project-specific factors.
   - Risk Prioritization: Prioritize risks based on their severity, combining impact and probability, to focus on high-priority risks.
3. Develop risk Mitigation Strategies:
   - Risk Avoidance: If possible, eliminate or avoid high-risk elements by altering project scope, technology choices, or methodologies.
   - Risk Transfer: Consider outsourcing or obtaining insurance to transfer specific risks to third parties capable of managing them effectively.

- Risk Reduction: Implement strategies to reduce the probability or impact of identified risks through process improvements, redundancies, or early issue detection mechanisms.
- Risk Acceptance: Acknowledge and accept certain risks deemed acceptable within defined thresholds, with contingency plans in place if they materialize.

4. Monitoring and control continuously:
   - Regular Reviews: Conduct regular reviews to reassess identified risks, update risk registers, and incorporate new risks that may arise during the project.
   - Mitigation Plan Execution: Implement and monitor the effectiveness of mitigation plans to address identified risks.
   - Communication: Maintain open communication channels to keep stakeholders informed about potential risks, mitigation strategies, and their impact on the project.
5. Develop a contingency plan:
   - Develop Contingency Plans: Create contingency plans for high-priority risks, outlining predefined actions to be taken if these risks materialize.
   - Resource Allocation: Allocate resources and budget for contingency plans to ensure preparation for unforeseen events.
6. Learn from experiences:
   - Post-Project Evaluation: Conduct a comprehensive review after project completion to analyze the effectiveness of risk management strategies.
   - Documentation and Learning: Document lessons learned and best practices to enhance risk management in future software development projects.

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Annex 1 - Glossary of terms

Term	Definition used in the present document with reference
Business requirement	High-level objectives that a system must achieve to meet the needs of the stakeholders (e.g., store the health facility master list and associated data, manage the health facility master list and associated data).
Classification table	Table organizing and categorizing data elements according to predefined criteria. [8]
Common Geo-Registry	IT solution that allows the simultaneous hosting, management, regular update and sharing of master lists as well as associated hierarchies and geospatial data for the geographic objects core to development in general and public health in particular. [8, 13]
Criticality level	Level of importance of a functional or non-functional requirement towards achieving the HFRS business objectives.
Data dictionary	A collection of names, definitions, and attributes about data elements that are being used or captured in a database or information system. [5, 8]
Data element	Fundamental data structure in a data processing system. Any unit of data defined for processing is a data element. For example: Full name, Type, Address, etc. are each separate data element. A data element is defined by its size (in characters) and type (alphanumeric, numeric only, true/false, date, etc.). [5, 8, 13]
Digital health ecosystem	The combined set of digital health components representing the enabling environment, foundational architecture and ICT capabilities available in a given context or country. [15]
Digital health enterprise	The business processes, data, systems and technologies used to support the operations of the health system, including the digital health applications, point-of-service software applications, other software, devices, hardware, standards, governance and underlying information infrastructure (such as the digital health platform) functioning in a purposeful and unified manner
Enabling environment	Attitudes, actions, policies and practices that stimulate and support effective and efficient functioning of organizations, individuals and programmes. The enabling environment includes legal, regulatory and policy frameworks and political, sociocultural, institutional and economic factors. [12]
Functional requirement	Product features or functions that developers must implement to enable users to accomplish their tasks (e.g. The system shall support the ability to create, define, and maintain data elements).
Geographic feature	Naturally and artificially created features on the Earth. Natural geographical features consist of landforms and ecosystems.

	Natural geographical features include terrain types and physical factors of the environment. Artificial geographical features include human settlements or other engineered forms. [8, 13]
Geographic object	Computer representation of a geographic feature (e.g. point, line, polygon). [8]
Health Facility Master List (HFML)	Also referred to as Master Facility List (MFL), complete, updated, authoritative listing of health facilities in a country. [1]
Health Facility Registry Service (HFRS)	A platform for storing, managing, and sharing the health facility master list and associated data and information. (Modified from [1])
Hierarchy	An arrangement or classification of things according to relative importance or inclusiveness. [8]
Interoperability	Interoperability is the ability of different applications to access, exchange, integrate and use data in a coordinated manner through the use of shared application interfaces and standards, within and across organizational, regional and national boundaries, to provide timely and seamless portability of information and optimize health outcomes.. [15]
Master list	Unique, authoritative, complete, up-to-date and uniquely coded list of all the active (and previously active) records for a given type of geographic feature/object (e.g. health facilities, administrative divisions, villages) officially curated by the mandated agency. [5, 8, 13]
Metadata	Information that describes the content, quality, condition, origin, and other characteristics of data or other pieces of information. [8]
Non-functional requirements	Requirements describing how a system should perform. (e.g. performance, scalability, security, usability, maintainability)
Registry	An IT solution that allows storing, managing, validating, updating and sharing of the master list for a specific geographic object. It is the “container” for the master list. [5, 8, 13]
Requirement	A documented physical and/or functional prerequisite that a system must have to be operational. It is a statement that identifies an attribute, capability, characteristic, or quality of a system that is necessary for it to have value and utility for a data consumer. [1]
Service domain	Basic information on the service capacity of a facility. It provides a listing of available services and facility capacity (e.g., number of beds) that is essential for health systems planning and management. [1]
Signature domain	A set of identification items for each facility that serves to uniquely identify the facility, thereby preventing duplication or omission of facilities from the health facility master list [1]

Total Cost of Ownership (TCO)	Cost of the initial investment and the costs to scale and sustain the system over three to five years after implementation. [2]
Unique identifier	Data element in a relational database that is unique for each record [5, 8, 13]
Use case	A description of all the ways an end-user wants to “use” a system [5]
User story	Tool used in Agile software development to capture a description of a software feature from an end-user perspective [8]
User persona	A generic aggregate description of a person involved in or benefiting from a health programme. [15]

Annex 2- Questions to answer during the assessment of the current enabling environment (extracted and adjusted from [1, 2]).

- Vision, strategy and plan
    - Is an eHealth, digital health enterprise and/or HIS vision, strategy and/or plan in place or being developed?
- Governance
    - Is the HFML governance mechanism well established and active?
    - Is a HIS-related governance mechanism in place/ If yes, is the HFML one connected to it?
- Policies
    - Are there policies in place that could support, guide or limit the establishment and maintenance of a HFRS? Such policies could include but not be limited to:
        - Attributing the mandate over the management, regular update of the HFML.
        - Guiding where and/or how the HFML should be hosted.
        - Data sharing policies (e.g. national open data policy).
        - Data protection laws or other governmental regulations that regulate data security and privacy.
        - The use of certain technology infrastructure (e.g. use of cloud services)?
- Resources
    - Are financial resources that could support the establishment and maintenance of a HFRS in the short and/or long term already available?
- Specifications, standards and protocols
    - What is the data governance model used, or planned to be used, to maintain the HFML (centralized, decentralized, federated [1])?
    - What are the network and data exchange protocols standards (e.g. HL7 FHIR, Geo-JSON, Mobile Care Services Discovery) or architectural best practices (e.g. OpenHIE) already utilized or that should be followed?
- Human resource capacities
    - Are the currently existing human resources capacities trained on the use of specific technology stack (e.g. programming languages, frameworks, databases, front-end and back-end tools, and APIs)? Are there currently existing human resources trained and certified in informatics. interoperability standards and enterprise architecture (e.g. TOGAF)?
    - Are there mechanisms to ensure the consistent training of human resources in the technical skills that ensure continuity in light of staff turnover?
- Technologies
    - What is the hardware to be used and the network and data exchange protocols to be followed?
    - Are any technology barriers observed in the country (i.e., reliable electrical power, servers, internet connectivity and bandwidth, and computers)?
    - Is an IT solution already being used to store the HFML? If yes:
        - What is the IT solution in question?

        - Is the solution specifically dedicated to storing the HFML or embedded in an information system (e.g. HMIS)?
        - Who developed it?
        - Since when has it been in use and by whom?
        - What are the HFML-related functionalities currently provided?
        - What workflows exist to use and update the HFML?
        - What challenges have been encountered when using the solution?
        - What is the process for the solution to receive updates, including bug and security fixes?
            - If it is a commercial product, does the vendor still support it?
            - If it is open source, are there developers actively contributing to it?
    - Are any existing information systems meant to synchronize with the HFRS? If yes, which type(s) of data exchange format(s) and protocol(s) can these systems handle?
    - Are any infrastructure updates planned soon?

Annex 2 – Propose list of HFRS functional and non-functional requirements

Functional requirements

New requirement code	New requirement wording	New requirement type	Criticality level
RMR F1	Organization management: Manage different organizations (create, invite, edit, inactivate)	Functional requirement (organizations management)	Recommended
RMR F2	User roles management: Support the ability to create roles and assign permissions to the roles. Example roles would be system administrator, registry administrator, maintainer and contributor	Functional requirement (users management)	Required
RMR F3	User management: Support the ability to set up, assign to an organization and a role, invite, manage and inactivate users	Functional requirement (users management)	Required
RMR F4	Data elements management: Support the ability to create, define (type, uniquity, necessity, sensitivity, access), document (metadata) and evolve the data elements based on the master list data dictionary	Functional requirement (data elements management)	Required
RMR F5	Data dictionary management: Create and view the data dictionary describing the HFML's data elements and make it available with the HFML, including during export	Functional requirement (data elements management)	Recommended
RMR F6	Classification tables management: Create, edit, inactivate, and export the classification tables associated with the defined data elements	Functional requirement (data elements management)	Recommended
RMR F7	Hierarchies management: Support the ability to create, define, document (metadata), maintain, visualize, use (e.g. provide operations for moving facilities from one hierarchy node to another) and export multi hierarchies of facilities and related geographic objects considering that all of these hierarchies are subject to change over time	Functional requirement (hierarchies management)	Required

New requirement code	New requirement wording	New requirement type	Criticality level
RMR F8	Data Import: Support data import to enable the bulk addition of facility information	Functional requirement (data import)	Required
RMR F9	Data pulling: When applicable, support data pulling from other systems (e.g. hierarchies information and/or other signature domain data elements when managed in a different registry)	Functional requirement (data import)	Optional
RMR F10	Signature domain: Allow authorized users to maintain, edit, and update the following data elements: unique identifier, name, type, operational status, ownership/managing authority, location (physical address, administrative structure, geographic coordinates with the indication of the data collection method and accuracy) and contact information	Functional requirement (records management)	Required
RMR F11	Service domain: All authorized users to maintain, edit and update the following data elements: Type of Services offered (Lab, HIV, TB, etc.), human resource for health, numbers by cadre, opening and closing times, details on Infrastructure (Power, Water, etc.)	Functional requirement (records management)	Optional
RMR F12	Records search, filtering, selection, and retrieval: Provide robust search, filtering, sorting, selection, and retrieval functionalities that enable users to find and visualize records in the list for a given date and/or based on the data elements included in the list	Functional requirement (records management)	Recommended
RMR F13	Lists management: Manage the lists hosted in the registry including the definition of their characteristics (ownership, authoritativeness, access right) and metadata	Functional requirement (lists management)	Required
RMR F14	Geospatial data management: Manage the geospatial data hosted in the registry (e.g. health facilities geographic coordinates or other geospatial data) including their characteristics (ownership, authoritativeness, access rights,..) and metadata	Functional requirement (geospatial data management)	Recommended

New requirement code	New requirement wording	New requirement type	Criticality level
RMR F15	Comprehensive time management and data preservation: Provide comprehensive time management and data preservation functionalities, including effective dating, historical data retention and time-based reporting	Functional requirement (time dimension management)	Required
RMR F16	Data validation and quality control: Implement data validation checks to ensure alignment with defined standards, prevent the entry of inaccurate or incomplete information as well as data quality control including but not limited to identifying missing and/or out-of-date information, cross-referencing, deduplicating, data cleansing and ensuring data consistency through time to maintain the high quality of the HFRS' content	Functional requirement (quality control)	Required
RMR F17	Basic reporting and analytics: Provide basic reporting and analytics that facilitate data curation and allow users to have a general overview of the master list's content for a given date (e.g. number of health facilities by type)	Functional requirement (reporting & analytics)	Recommended
RMR F18	Advanced reporting and analytics: Provide advanced reporting and analytics features that allow users to generate standard and customized reports, charts, and graphs based on the content of the master list, including trend analysis for decision-making, planning or research	Functional requirement (reporting & analytics)	Optional
RMR F19	Geographic visualization: Provide geospatial mapping capabilities to visually represent the locations of health facilities for a given date on a map together with other layers of information (e.g. administrative boundaries, satellite imagery)	Functional requirement (reporting & analytics)	Recommended
RMR F20	Spatial analytics: Provide spatial analytics capabilities including the possibility to measure distances or location-based queries (e.g. selection of health facilities located within a given administrative unit).	Functional requirement (reporting & analytics)	Optional

New requirement code	New requirement wording	New requirement type	Criticality level
RMR F21	Updating mechanism: Operationalize the updating mechanism that has been defined to support the curation and regular update of the health facility master list content (closures, openings, data element changes)	Functional requirement (updating mechanism)	Required
RMR F22	Versioning: Support version control system that allows users to view and compare different versions of the HFML for a given date, facilitating effective tracking of data changes.	Functional requirement (versioning)	Recommended
RMR F23	Notification and alerts: Provide a notification system to alert users about updates and/or changes in the health facility master list based on their specific needs	Functional requirement (notification)	Optional
RMR F24	Data Export: Support data export to an Excel spreadsheet to enable the bulk extraction of facility information with the associated data dictionary and metadata in an Excel spreadsheet and other format as needed (e.g. .csv) as well as the associated geospatial data when applicable	Functional requirement (Data export)	Required

Non-functional requirements

New requirement code	New requirement wording	New requirement type	Criticality level
RMR NF1	Access security features: Implement encryption, access control, and intrusion detection systems to ensure data security and protect against unauthorized access.	Non-functional requirement (security)	Required
RMR NF2	Audit trail and logging: Maintain detailed logs of data modifications, including who made the changes, when they were made, and what was modified, and user activities for auditing, monitoring, and accountability purposes	Non-functional requirement (security)	Required
RMR NF3	Data archiving: Provide data archiving process to ensure that older records do not hinder system performance while remaining accessible for historical reference.	Non-functional requirement (performance)	Optional
RMR NF4	Scalability: Accommodate the possible expansion of the data dictionary, the addition of new health facilities or newly collected bulk data as well as an increased number of users and integrations with other systems or applications without major disruptions including a significant decrease in performance.	Non-functional requirement (scalability)	Recommended
RMR NF5	Feedback mechanism: Provide a way for users to provide feedback and report issues, which can help improve the system's functionality over time (e.g. using a cloud-based service for software development)	Non-functional (maintainability)	Recommended
RMR NF6	Cost-effective maintenance: Facilitate cost-effective system maintenance and updates, considering factors such as software licenses, hardware maintenance, and personnel cost	Non-functional requirement (maintainability)	Recommended
RMR NF7	Data backup and recovery: Implement automated data backup and disaster recovery mechanisms to ensure data integrity and availability in the event of system failures or data loss.	Non-functional requirement (reliability)	Required

New requirement code	New requirement wording	New requirement type	Criticality level
RMR NF8	User-friendly interface: Provide an intuitive, user-friendly interface that allows authorized users to navigate the system and perform tasks efficiently.	Non-functional requirement (usability)	Recommended
RMR NF9	User training resources: Provide user documentation, training materials, and support resources to help users learn to use the system effectively.	Non-functional requirement (usability)	Recommended
RMR NF10	Public access: Allow public access to view data that is relevant and accessible to the public.	Non-functional requirement (usability)	Recommended
RMR NF11	Mobile access: Provide the capacity to access the HFRS for consultation and the submission of change requests while in the field	Non-functional requirement (usability)	Optional
RMR NF12	Language localization: Support full language localization of the platform (screens, prompts, tooltip help, pick lists, metadata field names, and messages (except unanticipated system-level error messages) should be available in the user's default language to the extent translations are available.	Non-functional requirement (localization)	Required
RMR NF13	Governance model: Support the HFML's data governance models in place (centralized, decentralized, federated)	Non-functional requirement (localization)	Recommended
RMR NF14	Hosting model: Support the preferred hosting model for the health facility master list (cloud or locally hosted)	Non-functional requirement (localization)	Recommended
RMR NF15	Accessibility: Support accessibility features available in the operating environment as described in level A of the W3C Web Content Accessibility Guidelines v. 2.0	Non-functional requirement (localization)	Optional
RMR NF16	Data exchange: Provide flexible standards-based APIs (e.g. RESTful API, HL7 FHIR) for data exchange and this in alignment with the in-country existing information system architecture	Non-functional (interoperability)	Recommended

Annex 3 - Justification for the criticality level attributed to each requirement

Functional requirements

New requirement code	New requirement wording	Criticality level	Justification of the criticality level	What can lead to an upgrade of the criticality level
RMR F1	Organization management	Recommended	While most HFRS implementations will be single organization-based, it is useful to store and edit the organization's metadata in one single place for integration in different products, including during the export. This functionality will also allow for the solution to handle multiple organizations in the future if needed	The need to manage more than one organization within the HFRS right from the start of the implementation
RMR F2	User roles management	Required	Managing user roles is key to data security and integrity, data quality and maintenance, collaboration, and information sharing. It also facilitates the customization of workflows and improves user experience. On some case this might also support regulatory compliance	NA
RMR F3	User management	Required	Managing users is key to data security, privacy, integrity and quality, controlled data access and collaboration, auditing and accountability, role-based access, user experience and customization as well as the HFRS's administration	NA
RMR F4	Data elements management	Required	Data elements constitute the HFML's building blocks. Managing them is key to ensuring data quality and consistency, flexibility and adaptability, integration and interoperability, analysis and reporting, governance and compliance, maintenance and reuse. Their management is also central to specific use cases (e.g. health information exchange and research)	NA
RMR F5	Data dictionary management	Recommended	By providing a clear and concise view over all the data elements included in the HFML, the data dictionary is a key element facilitating its use	A large number of data elements making it difficult for the users to manage and use the HFML without the data dictionary

New requirement code	New requirement wording	Criticality level	Justification of the criticality level	What can lead to an upgrade of the criticality level
RMR F6	Classification tables management	Recommended	Several data elements such as health facility type or ownership are based on a specific classification. Providing the capability to manage these classifications not only contributes to the standardization of the HFML's content but also facilitates its use, including for research, as well as the use of certain HFRS's functionalities (e.g. searching and filtering). They also contribute to interoperability and data exchange and in some case ensure compliance with national or international standards	The need to manage data elements for which the values are based on a classification table
RMR F7	Hierarchies management	Required	Hierarchies do not only enable data aggregation and analysis but also support specific use cases (e.g. supply chain management, surveillance) and facilitate information exchange and interoperability by providing standardized data structure. As they change through time, being able to manage them enables to accommodate to health system and administrative changes and facilitate new use cases	NA
RMR F8	Data Import	Required	Data import is key to the initial population of the registry and supports ongoing data maintenance and updates and integration with other systems when applicable. Depending on the functionalities implemented in the HFRS, it can also support data quality improvement by identifying errors and enforcing standardization. All of this supports cost-effectiveness and efficiency.	NA
RMR F9	Data pulling	Optional	Data pulling can contribute to enhancing data completeness and accuracy by having access to external authoritative sources of information. Implementing these functionalities requires ensuring a proper data governance structure, data standards and interoperability between sources and a common data exchange protocol.	The possibility to access authoritative sources of data that are stored in a separated registry accessible by the HFRS (e.g. administrative units master list)

New requirement code	New requirement wording	Criticality level	Justification of the criticality level	What can lead to an upgrade of the criticality level
RMR F10	Signature domain	Required	The data elements considered as being part of the signature domain are the building blocks necessary for the proper management of any other data elements, including those part of the service domain or any other programmatic data. Prioritizing the signature domain data elements help ensure their quality and this through time	NA
RMR F11	Service domain	Optional	While service domain data elements provide a comprehensive understanding of healthcare services, their management requires specific considerations including but not limited to data governance (data managed by different MOH entities), specific data life cycle (e.g. data collection method, updating frequencies) and sensitivities including in regard to data sharing (e.g. human resources data). This is why it is recommended for these data elements to either be managed in a separated registry (e.g. human resources registry) or only in the HFRS if their management can be clearly and completely separated from the management of the signature domain data elements.	The clear separation between the management of the signature and service domain data elements in the HFRS and when the questions of governance and data sensitivities have been addressed
RMR F12	Records search, filtering, selection, and retrieval	Recommended	Records search, filtering, selection and retrieval enhance data accessibility and usability and as such user experience. Users can efficiently find specific facilities based on various criteria, saving time and effort which helps promote adoption and effective use of the HFRS.	The need to manage a large number of records in the HFML
RMR F13	Lists management	Required	The HFRS is ideally meant to provide users with a picture of the HFML at different points in time. In addition to that, different stakeholders might be interested in custom variations of the HFML tailored to their needs (e.g. subset of data element of health facility types). Finally, the HFRS might allow storing different versions of the same list. All this calls for the possibility to not only manage but also characterize and document each of them separately	NA

New requirement code	New requirement wording	Criticality level	Justification of the criticality level	What can lead to an upgrade of the criticality level
RMR F14	Geospatial data management	Recommended	While the location of a health facility is generally stored as geographic coordinates in the HFML (signature domain-related data elements), this kind of information can sometimes be sensitive and require separate access rights from the other data elements. In addition to that, some countries might want to capture the health facility's building footprint (polygon) and/or handle other geospatial data in the HFRS (e.g. administrative unit boundaries). When this is the case, specific functionalities allowing to store, manage and visualize geospatial data are required	The need to treat the access to geographic coordinates in a different way than the other data elements in the HFML and/or manage more than the geographic coordinates of the health facility in the HFRS and/or when operationalizing geographic visualization and/or spatial analytics
RMR F15	Comprehensive time management and data preservation	Required	Effective management of the time dimension within the registry is essential to maintain a comprehensive historical record of health facility data. These features enable tracking the evolution of health facilities, compliance with historical regulations, and the ability to analyze trends and changes over time	NA
RMR F16	Data validation and quality control	Required	Data validation and quality control are key to ensuring data reliability, maintaining data integrity, and facilitating data interoperability and sharing. This is critical to enhance trust and accountability and support evidence-based decision-making, planning, and resource allocation.	NA
RMR F17	Basic reporting and analytics	Recommended	Basic reporting and analytics support the identification of errors and inconsistencies, enhance data accessibility and understanding by visualizing key data points and facilitating exploration and discovery	The need to manage a large number of health facilities and/or rapidly create some basic statistics for monitoring or reporting
RMR F18	Advanced reporting and analytics	Optional	While advanced reporting and analytics are important to inform decision-making, planning and research they require specific functionalities that might not only be difficult to develop and maintain but also already provided in other	The implementation of all the other requirements classified as required or recommended

			external tools specifically dedicated to performing this kind of tasks	
New requirement code	**New requirement wording**	**Criticality level**	**Justification of the criticality level**	**What can lead to an upgrade of the criticality level**
RMR F19	Geographic visualization	Recommended	Geographic visualization improves the understanding of health facility distribution and can help identify and correct errors in facility location data, improving overall data quality and reliability.	The availability of geographic coordinates in the HFML
RMR F20	Spatial analytics	Optional	While spatial analytics are important to inform decision-making, planning and research they require specific functionalities that might not only be difficult to develop and maintain but also already provided in other external tools specifically dedicated to performing this kind of tasks	The implementation of all the other requirements classified as required or recommended
RMR F21	Updating mechanism	Required	Operationalizing the updating mechanism is key to keeping the HFRS's content up-to-date and therefore of quality, preventing outdated and inaccurate information that can hinder proper healthcare delivery. A robust update mechanism demonstrates the registry's commitment to data quality and fosters trust in its information, leading to more effective use of the system.	NA
RMR F22	Versioning	Recommended	Versioning provides the ability to revert to previous versions of the HFML for a given date, facilitating error correction and data recovery without compromising overall integrity.	
RMR F23	Notification and alerts	Optional	While real-time notifications ensure users are immediately aware of updates relevant to their work, this functionality depends on other requirements to be implemented in the HFRS (e.g. updating mechanism) as well as an HFML of quality to be relevant	The implementation of all the other requirements classified as required or recommended
RMR F24	Data Export	Required	The possibility to export data in an appropriate format and accompanied by accurate metadata and data dictionary is key to allowing its use outside of the HFRS.	NA

Non-functional requirements

New requirement code	New requirement wording	Criticality level	Justification of the criticality level	What could lead to an upgrade of the criticality level
RMR NF1	Access security Features	Required	Access security features are key to prevent unauthorized modifications and maintain data integrity and trust.	NA
RMR NF2	Audit trail and logging	Required	Auditing helps identify and address unauthorized or malicious activities within the system. It enhances transparency and accountability, improves security, streamlines troubleshooting and error tracking, and in some cases, supports compliance with regulations as well as facilitates investigation and audits	NA
RMR NF3	Data archiving	Optional	Archiving inactive or historical data can free up storage space and improve system performance, optimizing current operations. At the same time, archives can serve as a backup in case of system failures, data corruption, or security breaches	A significant increase in data volume affecting the HFRS's performances
RMR NF4	Scalability	Recommended	It is important to anticipate growth and expansion of the HFRS's content and of its use. Scalability can help optimize resource utilization and avoid costly infrastructure upgrades as needs change. Scalable systems are often more resilient to disruptions and can handle unexpected surges in demand.	An anticipated rapid increase of the number of health facilities, users and/or integration with other systems or apps
RMR NF5	Feedback mechanism	Recommended	The availability of a feedback mechanism is important to support continuous improvements, understand users' needs and expectations, transparency and openness, early problem detection and resolution as well as increased adoption and utilization	An important volume of development to be performed (custom development or upgrade of an existing solution)

New requirement code	New requirement wording	Criticality level	Justification of the criticality level	What could lead to an upgrade of the criticality level
RMR NF6	Cost-effective maintenance	Recommended	Cost-effective maintenance is important for long-term sustainability and maintenance, optimization of resource allocation, reduction of the dependence on external funding, improved return on investment, increased system uptime and availability, scalability and future growth as well as attracting and retaining expertise and enhancing public perception and trust	The deployment of a HFRS in a resource-scarce environment
RMR NF7	Data backup and recovery	Required	Data backup and recovery are key to protecting the HFRS's content, ensuring business continuity and preserving data integrity	NA
RMR NF8	User-friendly interface	Recommended	A user-friendly system enhances accessibility and adoption, improves data quality, promotes efficient use and reduces training costs and support burden. It also improves users' satisfaction and trust	The deployment of an HFRS in a resource-scarce environment, users with a low level of technology literacy
RMR NF9	User training resources	Recommended	Adequate training and support improve system adoption and utilization, enhance system efficiency and minimize errors, data inputs issues and inconsistencies, reduce support burden and promote user autonomy and confidence in using the HFRS, fostering a sense of ownership.	The deployment of an HFRS in a resource-scarce environment, users with a low level of technology literacy
RMR NF10	Public access	Recommended	Providing public access to the HFRS's content ensures its largest use possible which contributes to reducing duplication of efforts and increases data interoperability. At the same time, this promotes transparency and public cost, supports research and public health initiatives as well as fosters innovation and collaboration	The promotion of an open-data policy by the government. Supporting data sharing

New requirement code	New requirement wording	Criticality level	Justification of the criticality level	What could lead to an upgrade of the criticality level
RMR NF11	Mobile access	Optional	Focusing on the core functionalities in desktop or web-based access might be prioritized over mobile access, especially if resources are limited. Mobile access can raise security and data privacy concerns due to increased vulnerability to theft, malware, and network breaches. Developing and maintaining a secure and user-friendly mobile application requires additional resources and expertise, which might not be readily available	The need to able to consult and/or contribute to the HFRS's content from a mobile application
RMR NF12	Language localization	Required	Language localization is key to ensuring the accessibility and usability of the HFRS, enhancing data quality by reducing potential data entry errors, strengthening trust and user's engagement, and compliance with regulatory and ethical standards.	NA
RMR NF13	Governance model	Recommended	Supporting the data governance model in place minimizes disruption and facilitates seamless integration with current data management practices, respects local ownership and control, leverages existing expertise and infrastructure and encourages scalability and sustainability	The need to support a specific data governance model
RMR NF14	Hosting model	Recommended	While each hosting model has its advantages and disadvantages, certain factors might influence the need to follow a specific one including specific data privacy and security regulations, cost or technical capacity	The need to comply with specific national regulations
RMR NF15	Accessibility	Optional	Supporting accessibility features can promote inclusiveness and equity and improve user experience for all. In some cases, there might be a need to comply with accessibility regulations	The need for the HFRS's content to be accessible to specific population groups
RMR NF16	Data exchange	Recommended	Supporting and adhering to flexible standards-based APIs supports interoperability and integration, enables flexible integration with new systems or services as they arise, facilitates innovation and collaboration promotes a more sustainable approach to system development and maintenance	The need to support specific standard-based APIs for data exchange

Annex 4 - Benefits and risks of different software models (extracted from [2]).

Model	Benefits	Risks
Custom-developed Software - Build a software system from scratch	• You have control over technology, functionality, and design. • The development experience creates ownership and improves sustainability. • It is possible to engage the local IT industry.	• Custom development tends to be difficult to manage within time and budget. • Control over design does not guarantee satisfaction with the end product, as that depends on the capabilities of the technical team. • Long-term support depends on the continued availability of individuals. • Adaptive maintenance can be resource intensive, such as updating or replacing library dependencies due to newly discovered security vulnerabilities
Commercial off-the-shelf software - Buy a commercially available product)	• The lead time from selection to implementation is normally shorter. • You can evaluate it before buying. • The product is maintained and upgraded (at a cost). • It has normally been tested and refined in other implementations.	• Often expensive and sold with unclear and complex fee structures, for example, a fee-per-server processor. • Commercial off-the-shelf software is not often designed for implementation in low-resource settings. • Custom development might be difficult and limited to what the product is designed to do within the configurability options that are available
Free packaged software - Software developed by a donor organization or technical agency. Alternatively, a system developed by a neighboring country)	• Shorter lead time. • Possibility to evaluate. • No upfront cost (but maintaining or customizing it may require investment).	• There is often no contract, so service and warranty for bug-fixing depends on goodwill of one or two individuals and there is no institutional support. • Many implementation and running costs are hidden.

Open-source software - the source code as well as the software product is freely available. Often, a community has been formed to support the open-source software)	• You have the right to make changes to the software. • You can engage the local IT industry. • Benefit from communities and share development costs with other organizations.	• Can end up with a poorly supported product. • A loosely knit community might not be able to provide the business relationship you need. • Some of the implementation and running costs are hidden.
Software as a service (SaaS) - Database and application hosted on remote servers, and software is sold (or offered freely) as a service that can be contracted per user and per month or year	• Highly feasible to implement and maintain. • Clarity about the cost to implement and run a SaaS application. • Investment in improved software can easily be shared among customers.	• Data hosted on remote servers: not always in agreement with national policy. • Ministries of health are not often well positioned to pay a regular service fee. • Custom development might be difficult and limited to what the product is designed to do within the configurability options that are available

Annex 5 – Adjustments to be made in the spreadsheet developed to support the identification of the IT solution to serve as HFRS

Spreadsheet to assess the level of compliance of a given IT solution against the determined functional and non-functional requirements

The following should be adjusted in both the *Functional requirements* and *Non-functional requirements* worksheets before the use of the spreadsheet:

1. In case some modifications have been made on the original list of requirements reported in Annex 6 during the implementation of Step 3 of the present toolkit:
    a. Reflect any modification in the requirements' wording.
    b. Add any new requirement(s) (complete description) at the bottom of the list together with its category and unique ID. Please make sure that there are no duplicates of unique ID in the list after that.
2. Delete the remaining empty lines at the end of the list.

Spreadsheet to compare the level of compliance of different solutions considered for use as HFRS

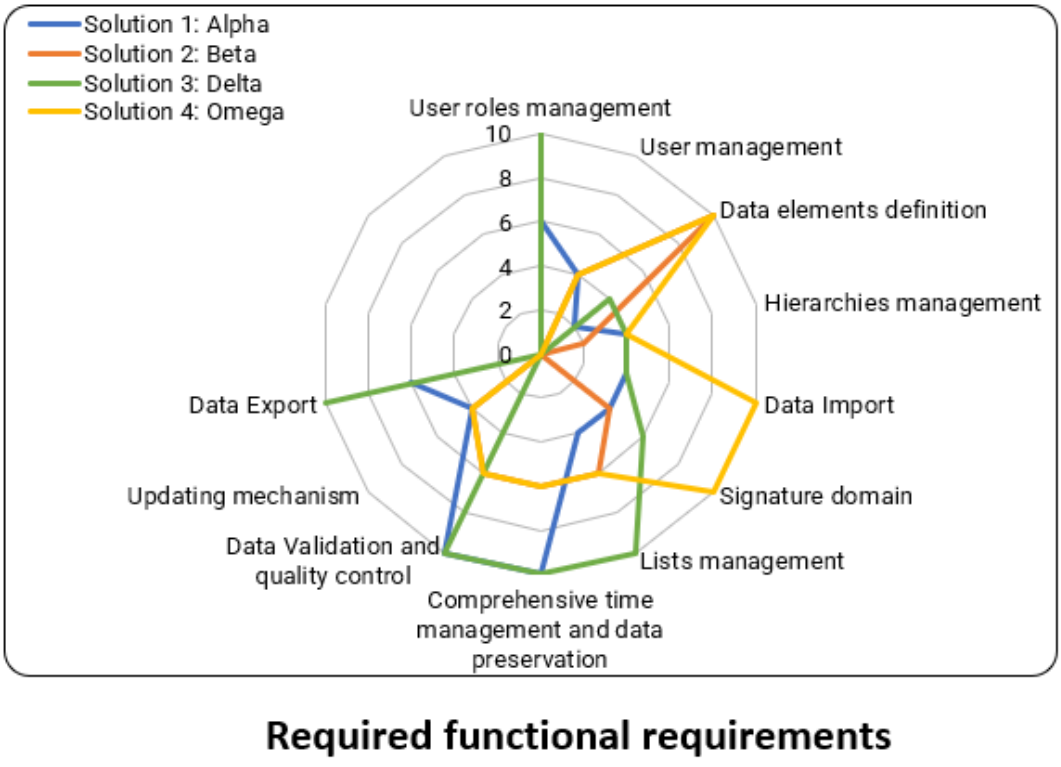
The following should be adjusted before the use of the spreadsheet:

1. In the *Functional by solution* and *Non-functional by solution worksheets*:
    a. In case some modifications have been made on the original list of requirements reported in Annex 6 during the implementation of Step 3 of the present toolkit:
        i. Reflect any modification of requirements' wording.
        ii. Reflect any modification of requirements' critical level.
        iii. Add any new requirement(s) (complete description) at the bottom of the list together with its category and unique ID. Please make sure that there are no duplicates of unique ID in the list after that.
    b. Delete the remaining empty lines at the end of the list.
    c. Highlight in grey the cells containing the requirements' category, ID, description and criticality level to remember that the content of these cells should not be modified anymore

2. In the *Dashboard functional* and Dashboard *non-functional* worksheets:
    1. In case some modifications have been made on the original list of requirements reported in Annex 6 during the implementation of Step 3 of the present toolkit:
        a. Any modification of the critical level of a requirement would require for the line containing the category, ID and label of the requirement in question to be moved from the table where it currently resides to the one corresponding to the new criticality level (use the control X and control V).
        b. Any new requirement together with its category, unique ID and label (not the complete description) needs to be added at the bottom of the table corresponding to the criticality level that has been attributed to it.
    2. Delete the remaining empty lines at the bottom of each table.

Annex 6 – Example of table and graph obtained for the required functional requirements when using the solution comparison spreadsheet

HFRS Required functional requirements						
Requirement Category	**Requirement ID**	**Requirement description**	**Solution 1: Alpha**	**Solution 2: Beta**	**Solution 3: Delta**	**Solution 4: Omega**
Functional requirement (users management)	RMR F2	User roles management	6	0	10	0
Functional requirement (users management)	RMR F3	User management	4	4	0	4
Functional requirement (data elements management)	RMR F4	Data elements definition	2	10	4	10
Functional requirement (hierarchies management)	RMR F7	Hierarchies management	4	2	4	4
Functional requirement (data import)	RMR F8	Data Import	4	0	4	10
Functional requirement (records management)	RMR F10	Signature domain	4	4	6	10
Functional requirement (lists management)	RMR F13	Lists management	4	6	10	6
Functional requirement (time dimension management)	RMR F15	Comprehensive time management and data preservation	10	6	10	6
Functional requirement (quality control)	RMR F16	Data Validation and quality control	10	6	10	6
Functional requirement (updating mechanism)	RMR F20	Updating mechanism	4	4	0	4
Functional requirement (Data export)	RMR F23	Data Export	6	0	10	0



Annex 7 – Example of implementation plan

#	Activity	Milestones								
		1	2	3	4	5	6	7	8	9
1	PLANNING									
1.1	Establish a technical working group	X								
1.2	Define expected outcomes	X								
	Milestone review	X								
1.3	Assess the current ~~supporting~~enabling environment		X							
1.4	Define what the HFRS should do		X							
1.5	Find the appropriate IT solution		X							
1.6	Develop draft implementation plan		X							
1.7	Understand and manage risk		X							
	Milestone review		X							
1.8	Hire and/or obtain technical assistance			X						
1.9	Negotiate/finalize vendor contract(s)			X						
1.10	Finalize implementation, monitoring & evaluation and communication plans			X						
	Milestone review			X						
2	MANAGEMENT AND COMMUNICATION									
	Schedule the following items…									
2.1	Project manager progress reports	X	X	X	X	X	X	X	X	X
2.2	HFRS TWG meetings	X	X	X	X	X	X	X	X	X
2.3	Reporting to the HFML governance mechanism	X	X	X	X	X	X	X	X	X
2.4	Communication to the organization		X	X	X	X	X	X	X	X

3	**DEVELOPMENT**									
	Schedule the following depending on the IT solution selected to serve as HFRS									
3.1	Hold project kickoff meeting				X					
3.2	Expand functionalities of the already existing solution				X					
3.3	Develop the custom solution starting with the implementation of the required requirements				X					
3.4	Install and configure server environment				X					
3.5	Test the solution using real data as much as possible and check compliance with defined functional and non-functional requirements and alignment with captured user stories				X					
3.6	Prepare user acceptance testing script				X					
3.7	Design, obtain approval and finalize training strategy, plan, and preliminary material				X					
	Milestone review				X					
3.8	Setup user feedback mechanism					X				
3.9	Train used meant to perform user testing									
3.10	Perform user acceptance testing					X				
3.11	Resolve high- and medium level issues					X				
	Milestone review					X				

4	**DEPLOYMENT**									
4.1	If needed, adjust the training plan and/or material to cover all the user roles involved in the management of the HFRS and its content (e.g. develop SOPs for each user roles)						X			
4.2	Executive communication plan at the levels to be involved in the management, and use of the HFRS's content						X			

4.3	Identify the information systems that should be synchronized in priority with the HFRS						X			
4.4	Select the geographic area over which the pilot will be implemented						X			
	Milestone review						X			
4.5	PILOT									
4.5.1	Prepare implementation checklist							X		
4.5.2	Train users in charge of managing the HFRS solution (e.g. system administrators) and those in charge of managing its content at the central level (e.g. registry administrators and maintainers)							X		
4.5.3	Train users in charge managing the HFRS's content at the subnational level for the pilot area (e.g. registry contributors)							X		
4.5.4	Pilot test processes captured in the defined SOPs and capture suggestions and issues through the established feedback mechanism							X		
4.5.5	Resolve high- and medium-level issues, modify configuration as necessary							X		
4.5.6	Establish backup procedures							X		
4.5.7	Revise implementation checklist and training material if needed							X		
	Milestone review							X		
4.6	SCALE									
4.6.1	Train users in charge managing the HFRS's content at the subnational level for the rest of the country (e.g. registry contributors)								X	

4.6.2	Pilot test processes captured in the defined SOPs and capture suggestions and issues through the established feedback mechanism								X	
4.6.3	Operationalize the synchronization with the selected information system								X	
4.6.4	Validate the synchronization by health programs using the selected information systems								X	
4.6.5	Resolve high- and medium-level issues, modify configuration as necessary								X	
4.5.6	Revise training material if needed								X	
	Milestone review								X	
4.7	SUSTAIN									
4.7.1	Implement monitoring process and tools									X
4.7.2	Ensure long-term financial sustainability									X
4.7.3	Finalize service-level agreements and maintenance contracts									X
4.7.4	Monitor use and maintenance needs									X
4.7.5	Evaluate system performance									X
	Milestone review									X