Elicitation and prioritization of requirements for electronic health records for oncology in low resource settings: A concept mapping study

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Abstract

Background: Understanding functional and non-functional requirements is essential to successfully implement electronic medical record (EMR) systems. Actual requirements will be different for different contexts. **Objective**: To elicit and prioritize requirements for implementing EMRs in oncology in low and middle income countries (LMICs), and to relate these to requirements from high-income countries. **Participants and setting**: Cancer care stakeholders including oncologists, general doctors, nurses, biostatisticians, information technologists, from different LMICs, were involved. **Methods**: Concept mapping was used. Statements of requirements were obtained during focus group discussions (FGDs) and interviews. Using surveys, the requirements were clustered and ranked on importance and feasibility. Data were analyzed in SPSS using agglomerative hierarchical clustering and multidimensional scaling, to create cluster maps and go-zone maps reflecting the relationships between the requirements and their prioritization. **Results**: Four FGD sessions, with twenty participants, were conducted. In addition, six participants were interviewed. Twenty-two participants clustered the requirements and sixty-three participants ranked them on importance and feasibility. One hundred and sixty requirement statements were generated which were reduced to sixty-four after de-duplication and merging. Nine clusters were obtained encompassing the following domains, in order of importance: Security, Conducive organization, Management/Governance, General EMR functionalities, Computer infrastructure, Data management, Usability, Oncology decision support, and Ancillary requirements. On ranking, the requirements scored between 3.74 and 4.80 on importance, and between 3.55 and 4.46 on feasibility, on a 5-point Likert scale. We generated concept maps for use when communicating with stakeholders. **Conclusion**: For oncology EMRs in LMICs, requirements overlap those from high-income countries but generic EMR functionalities, Infrastructural and organizational requirements are still considered priority in LMICs compared to oncology-specific requirements or advanced EMR features e.g. computerized decision support or interoperability. Concept mapping is a fast and cost-effective method for eliciting and prioritizing EMR requirements in a user-centered manner.

1.   Introduction

Cancer is a major public health challenge globally (1) responsible for more deaths than HIV/AIDS, malaria and tuberculosis combined (1,2). Low and middle income countries (LMICs) bear over 70% of the global cancer burden (1,2). Adoption of electronic medical records (EMR) could contribute to improvement in cancer outcomes in LMICs through improved care coordination, reduction in medical errors, time and costs saving, and enhancement of collection of quality healthcare data to support clinical research and healthcare management (3–8). However, adoption of EMRs in LMICs remains low and many projects end in pilots (9–11). Moreover, most of the published literature on EMR implementations in LMICs comes from implementations in the "traditional" public health areas especially HIV/AIDS care programs (12–14). There are only few reports on EMR use in cancer care e.g. in Rwanda (15) and Kenya (16).

A crucial first step in EMR development and implementation is requirements engineering, i.e. the elicitation, prioritization and documentation of requirements. This is because failure to properly analyze requirements is a key contributor to EMR implementation failure (5,17–20). Requirements of an EMR are the attributes, capabilities, characteristics or qualities that the EMR must have for it to be of value to the user. That is, the services that it is expected to offer (functional requirements), and the socio-technical environment or organizational constraints under which it must operate (non-functional requirements) (21).

Requirements engineering is a costly and time consuming process because it requires iterative approaches or techniques, and involvement of different stakeholders. In addition, several issues have to be considered e.g. business value, cost, technical debt, risk, effort, requirements dependencies, and from perspectives of both clients and vendors (22–24). In development of EMRs, requirements engineering tends to be more challenging because of the complexity of healthcare and the busy schedules of healthcare workers making them unavailable especially for techniques that require them to convene or spend a lot of time in requirements engineering activities (25).

There are several international standards that define EMRs[a] (and related HITs), as well as specifying user and technical requirements and architectures (26), such as the ISO/HL7 10781 - Electronic Health Record System Functional Model (27), and the ISO 18308:2011 Health Informatics – Requirements for an Electronic Health Record Architecture (28). Developed through consensus by stakeholders and national bodies from different countries, these standards are intended to be abstract and comprehensive to apply to different EMR application contexts. The ISO/HL7 10781 standard, for example, describes functions considered essential for electronic health record (EHR) by at least one health care setting. As such, the functions are described at a conceptual level with limited

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[a] Note: In this paper we use EMR as an overarching term for all related health information systems such as electronic health record (EHR) or personal health record (PHR), and for that purpose it is interchangeable with these terms (26, p.16).

granularity and fall and under seven sections: Overarching, Care Provision, Care Provision Support, Population Health Support, administrative Support, Record Infrastructure and Trust Infrastructure (27). The standard forms a superset from which subsets, called functional profiles are derived. The functional profiles are more granular, and are constrained to a given health care context or use case since requirements depend on the context of use of the system (29).

Oncology is considered as one health care context requiring a special EMR functional profile. (30–33). It is complex and information-intensive, care is chronic, multidisciplinary and multimodality, and needs to be personalized. Depending on cancer type, it may involve surgery, radiotherapy, chemotherapy (with complex combinations of drugs which are often very toxic), palliative and survivorship care. Medical errors, e.g. in chemotherapy administration, are common (34). Similarly, differences between exist LMICs and high-income countries with respect to the EMR landscape (9,10) and oncology practice (14,35), e.g. in terms of cancer epidemiology, treatment protocols, regulatory requirements for EMRs, reporting needs, and other health data (re)use requirements. These further constrain the functional profile which may lead to differences in requirements for an oncology EMR suitable for LMICs compared to high income counterparts. Besides, international standards do not give a prioritization of the requirements, yet this is usually necessary particularly in LMICs where technical and financial resources might not permit an expensive, state-of-the-art EMR.

In addition, given that EMR adoption in LMICs is still low, many implementation projects are likely to be at lower stages of the HIMSS EMR Adoption model (HIMSS EMRAM) (36) making some advanced functionalities irrelevant or unfeasible for a contemporary oncology EMR in LMICs. For example, meaningful clinical decision support (HIMSS EMRAM level 4) or health information exchange and data warehousing for analytics (HIMSS EMRAM level 7) are likely to not be possible and hence not prioritized early in EMR implementation process where systems are fragmented.

There are several publications specifying requirements for oncology EMRs in high-income countries such as the US (37) and the UK (38,39). As mentioned above, these specifications are principally constrained subsets of the international standards. They include, for example, the need to support oncology-specific documentation e.g. tumor sizes, location, biological markers, (gen)-omics data, imaging results, risk factors, chemotherapy administration, as well as to support care coordination, clinical decision making and cancer research (37–41). In addition, the Ambulatory Oncology Profile Task Group of HL7 was developing an oncology EHR requirements specification although this has not been completed yet (33). In this draft, it is stated that profile was developed primarily basing on US requirements and input from Europe and Australia was incorporated during the revision. However, there are no explicit specifications of requirements for EMRs in oncology in LMICs.

Williams et al (10) note that technology architectures designed for high-income countries can apply to developing countries' environments, but because of the differing cultural, organizational and environmental factors, it is essential for systems analysts and designers to research into these areas to design equipment pertaining to the needs of these users and settings.

In this study we aimed at eliciting and prioritizing functional and non-functional requirements for an EMR suitable for oncology in LMICs. The study is part of ongoing EMR implementation work at the Uganda Cancer Institute (UCI).

2. Methods

We used the concept mapping methodology for requirements elicitation and prioritization. Developed by Trochim and others (42,43), concept mapping is a structured methodology for eliciting, organizing and presenting concepts or ideas from a group of individuals using both qualitative and quantitative techniques. Focus group discussions (FGDs) and interviews are used for generation of concepts. This is followed by surveys in which the identified concepts are clustered and ranked, allowing the ideas to be represented in a variety of statistically derived visual summaries called concept maps. The maps can be used for understanding the issues at hand and reach agreement on how to proceed.

Concept mapping provides a quick and low-cost process for involvement of various stakeholders and target end users of the system which is key in the user centered design (19,20). The method has been used in studying implementation of EMRs (44) and health policies (45).

2.1. Participants and setting

Participants were selected by convenience sampling, but purposively to represent a wide variety of stakeholders in cancer care, and EMR implementation, e.g. those involved in EMR development, those who have used EMR in patient care, and those without EMR experience. Professionally these included oncologists, general doctors, nurses, biostatisticians, medical records personnel, information technology professionals, administrators, lab technicians and palliative care workers (**Table 1**).

FGD participants were recruited from four groups: (i) staff UCI; (ii) delegates to an international conference by UCI and Palliative Care Association of Uganda (Kampala, Uganda, August 2017, (iii) staff who manage cancer patients at Kamuzu Central hospital in Lilongwe, Malawi and (iv) delegates to the Annual OpenMRS Implementers' Conference (Lilongwe, Malawi, December 2017). Participants who could not attend an FGD were invited for one-on-one interviews. Those who could not be reached physically (e.g. residing in another country) were interviewed via phone or email.

The participants invited for clustering included those who took part in the FGDs and interviews, whereas for ranking additional participants were invited from UCI staff and corresponding authors in the abstract book of African Organization for Research and Training in Cancer (AORTIC) 2017 (46) conference that took place in Kigali, Rwanda.

2.2. Concept mapping process

2.2.1. Generation of concepts (FGDs and Interviews)

Given the variability in functional profile and definition of EMR (26), the FGDs and interviews begun by a short description of what we meant by EMR in this study and contextualization with respect to the participants' EMR experience, e.g. by discussing examples

of EMRs that participants had used before or seen being used, and their potential applications in the workflows at the participants' organization. Participants were asked the following focus questions:

1) *What features or functionalities do you need in an electronic medical records system for cancer care in your setting?*
2) *If such an EMR with all the functionalities and features exists, what would you need in your setting to be able to implement and use that system well?*

In the FGD, participants were given about 15 minutes to write down as many ideas as possible in response to the questions. Then, going round, each participant submitted one response at a time. The response was discussed to make sure it was clear to everyone, and then typed and displayed as a statement on a projector or written on a flipchart for all participants to see. All participants removed responses from their lists that were addressed by the displayed statements. The process was repeated until every participant had exhausted their responses. In the interviews, the moderator briefed the interviewee of the findings from the FGDs and asked if the interviewee had any additional ideas or different perspectives.

All FGDs and interviews were moderated by the first author who is a medical doctor and informatician at the UCI, and a member of the OpenMRS community working on developing oncology functionality in OpenMRS. Each FGD last about three hours, whereas the interviews lasted about thirty minutes.

2.2.2. Surveys

The statements from all focus discussions and interviews were merged, and the authors discussed and de-duplicated them by merging similar ones, and paraphrased those that were ambiguous. Statements that described a means of achieving a requirement were removed e.g. "entries in the EMR should be time-stamped" or "there should be clear definitions of key indicators", which are needed respectively to achieve audit trail and dashboards. The final list was then used to create two surveys: one for clustering and one for ranking. In each survey we added general questions about the participants, including their gender, profession, country where they work, EMR experience, and whether they work in cancer care or not (either directly as a healthcare provider or with cancer patients' data).

Clustering was performed using an online card sorting tool (47). The tool presents statements as cards, which participants were asked to cluster into groups of related concepts by drag-and-drop. A discussion by Trochim on reliability of concept mapping states that approximately fifteen participants are sufficient for the clustering (48).

Ranking was performed by a survey in Google Forms. Participants were invited to rank each statement on importance and feasibility on a scale of 1 to 5 (1= "not important" or "not feasible" and 5 = "very important" or "very feasible"). An option for "Do not know/No opinion" was provided as well as a space to give a comment. As discussed in (22) one of the pitfalls in requirements engineering is prioritization of requirements on a single dimension (typically business value). We therefore used feasibility as a second dimension which we defined to participants as meaning "possible, affordable, convenient or practical". In order to reduce chances of participants ranking statements similarly on both dimensions due to ordering effect, we presented them with the list first to rank on importance only, and once finished we presented them with the list to rank on feasibility.

2.2.3. Analysis

We performed the cluster analysis in SPSSv24 by agglomerative hierarchical clustering using Ward's method and squared Euclidean distance between clusters as a measure. We generated cluster memberships and proximity (dissimilarity) matrix. The cluster membership shows statements in each cluster for any given number of clusters. The number of clusters ranges from a minimum of two (i.e. all statements in just two clusters) to a maximum number which equals to the number of statements (i.e. each statement in its own cluster); in our case this was sixty-four.

Using the cluster membership, the authors jointly determined the appropriate number of clusters by discussion and consensus. For every number of clusters we discussed the statements in each cluster and gave an inclusive and unambiguous descriptive name.

Using the proximity matrix, we conducted multidimensional scaling (PROXCAL) to produce a point map. The point map is a graphical representation of the proximity matrix i.e. the similarity or difference between the statements. Theoretically this similarity or difference, and hence the point map, can have infinite dimensions or axes, and the idea of multidimensional scaling is to calculate few but key dimensions (principal components) so as to reduce them to a comprehensible number. For our point map, we limited it to two dimensions in an X,Y-plot (43). The point map therefore is just a two dimensional space to arrange points so that the distance between the points correlates as much as possible with the dissimilarity between the points. Thus, the axes on this plot do not give much mathematical information, but generally statements that were grouped together most of the time during the clustering are closer on the map. The approximation of fewer key dimensions from a large number of dimensions means that some distortion of the similarities occurs. A measure of this distortion is called stress. Stress values range from 0 to 1. Smaller stress value indicating greater conformity of the map to the proximities of the statements, and higher stress values indicating distortion (in this case meaning that there is no two-dimensional arrangement that reflects the similarities between the statements). Stress values less than 0.285 are acceptable (44).

We then plotted the final clusters derived from the cluster membership, onto the point map, thus combining them into a cluster map, which is a higher-order conceptual grouping of the statements.

For each statement we calculated the average importance score and feasibility score across participants and used these to generate the Go-zone map. To check that participants did not consistently score importance and feasibility in the same way (which would suggest that they did not understand the difference between the two dimensions), we calculated the intra-class correlation coefficient (ICC).

ICC less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 indicate poor, moderate, good, and excellent correlation, respectively (49).

2.3. Ethics

The research was approved by the Uganda Cancer Institute Research Ethics Committee, UCIREC# 13-2017, and was registered by the Uganda National Council of Science and Technology, UNCST# HS152ES. All FGD/interview participants had to sign informed consent forms prior to participation. For the surveys (online), participants provided consent by entering their email addresses which was required to submit a response. All responses were processed anonymously.

3. Results

3.1. Participants

We approached a total of 56 participants for the FGDs. Of these, 20 (12 male and 8 female) came for the 4 FGDs sessions (2 sessions in Kampala, and 2 in Lilongwe). We conducted 6 follow-up interviews.

The same 56 participants were invited for clustering, and 24 (42.9%) completed the exercise. Of these, 2 were removed from the analysis because they did not cluster according to understanding of concepts and how related they were, but rather on whether they agree if the statement or requirement was important (they likely mixed up the ranking and clustering exercises), leaving a final number of 22 (15 male, 7 female).

For ranking, a total of 293 participants (including the 56 invited for clustering) were invited. Of these, 63 (21.5%) completed the exercise. Responses of two participants were removed because they mentioned that they did not work in LMICs, leaving a final number of 61 (56% male) participants).

Profession, gender and country distribution of clustering and ranking participants are also shown in **Table 1.** The most represented professional role was general doctor, and majority of the participants were male. Some participants mentioned that they worked in multiple countries, but all LMICs. All participants reported working in cancer care (or with cancer patients' data), either in specialist cancer centers, in palliative care or in HIV clinics where HIV-associated cancers are treated as part of integrated care. In addition, 15 (68%) of clustering participants and 45 (74%) of the ranking participants reported having experience using an EMR.

3.2. Concepts

The initial list consisted of 160 statements from all FGDs and interviews. After removing duplicates and merging similar statements the final list contained 64 statements (**Table 2**).

3.3. Clustering

Clustering results are shown in **Figure 1** (point map) and **Figure 2** (cluster map). Our final number of clusters was nine, covering the following domains in order of importance: Security, Conducive organization, Management/Governance, General EMR functionalities, Computer infrastructure, Data management, Usability, Oncology decision support, and Ancillary requirements.

3.4. Ranking

Ranking results are shown in **Table 2** (ranking of individual statements), **Table 3** (ranking of clusters) and **Figure 3** (go-zone map). The average score for the statements ranged from 3.74 to 4.80 on importance, and 3.55 to 4.46 on feasibility. The intra-class correlation coefficient was 0.441 for raw scores (i.e. for 3904 importance-feasibility pairs for the 61 participants each scoring the 64 statements) and 0.58 for the average scores (i.e. for each of the 64 statements after averaging the score across the 61 participants).

4. Discussion

We involved different stakeholders in oncology in LMICs (oncologists, general doctors, nurses, public health practitioners, Health IT professionals and biostatisticians) from at least eleven different countries to come up with 64 requirements for an EMR for oncology in LMICs. These requirements have varying levels of granularity or abstraction, and represent the seven sections of the functional list provided in ISO/HL7 10781 standard (Electronic Health Record System Functional Model) (27). These requirements are a subset of those listed in standards such as ISO/HL7 10781 (27) and ISO 18308 (28) and, to a high degree, they are similar to those listed for oncology EMRs in high income settings (33,37–39) . However, participants also mentioned other requirements which relate to the organization or environment rather than the EMR system, for example funding, infrastructure (electricity and computer networks), positive attitudes by managers, system usability, and stakeholder involvement. On top of having a system that meets the functional requirements, these environmental requirements are important for the successful implementation and use of the EMR, but in LMICs these can be a major barrier and thus need prioritization (50).

All requirements were considered important and feasible (average score 3.74 and 3.55 respectively on a scale of 1 to 5). The requirements were clustered into 9 umbrella clusters covering the following domains in order of average importance: Security, Conducive organization, Management/Governance, General EMR functionalities, Computer infrastructure, Data management, Usability, Oncology decision support, and Ancillary requirements.

Table 1: Gender, Profession and Countries for participants				
	FGD (n=20)	Interviews (n=6)	Clustering (n=22)	Ranking (n=61)
Gender				
Female	8	1	7	27
Male	12	5	15	34
Profession				
Nurse	7	0	2	6
General Doctor	6	1	4	20
Oncologist	3	4	2	12
Biostatistician/Clerk	1	1	2	5
Informatics/IT	2	0	7	4
Other health workers	1	0	1	11
Research/Administrator	0	0	4	3
Country				
Uganda	13	3	13	35
Kenya	1	2	1	3
Malawi	3	0	1	3
Nigeria	1	0	1	6
Burundi	0	1	0	0
Rwanda	2	0	1	2
Tanzania	0	0	0	4
Cambodia	0	0	0	1
D.R. Congo	0	0	0	1
South Africa	0	0	0	1
Morocco	0	0	0	1
Multiple			5	3

| Table 2: Clusters, number of statements in each cluster, average importance and feasibility of cluster (basing on the statements in the cluster).					
Cluster name	Statements in Cluster (n)	Average Importance	Importance rank	Average Feasibility	Feasibility rank
Security	3	4.65	1	4.39	1
Conducive organization	9	4.46	2	4.08	6
Management/Governance	6	4.43	3	4.21	2
General EMR functionalities	12	4.43	4	4.20	3
Computer infrastructure	5	4.37	5	3.97	8
Data management	10	4.32	6	4.12	4
Usability	7	4.25	7	4.08	7
Oncology decision support	9	4.25	8	4.11	5
Ancillary requirements	3	4.07	9	3.96	9
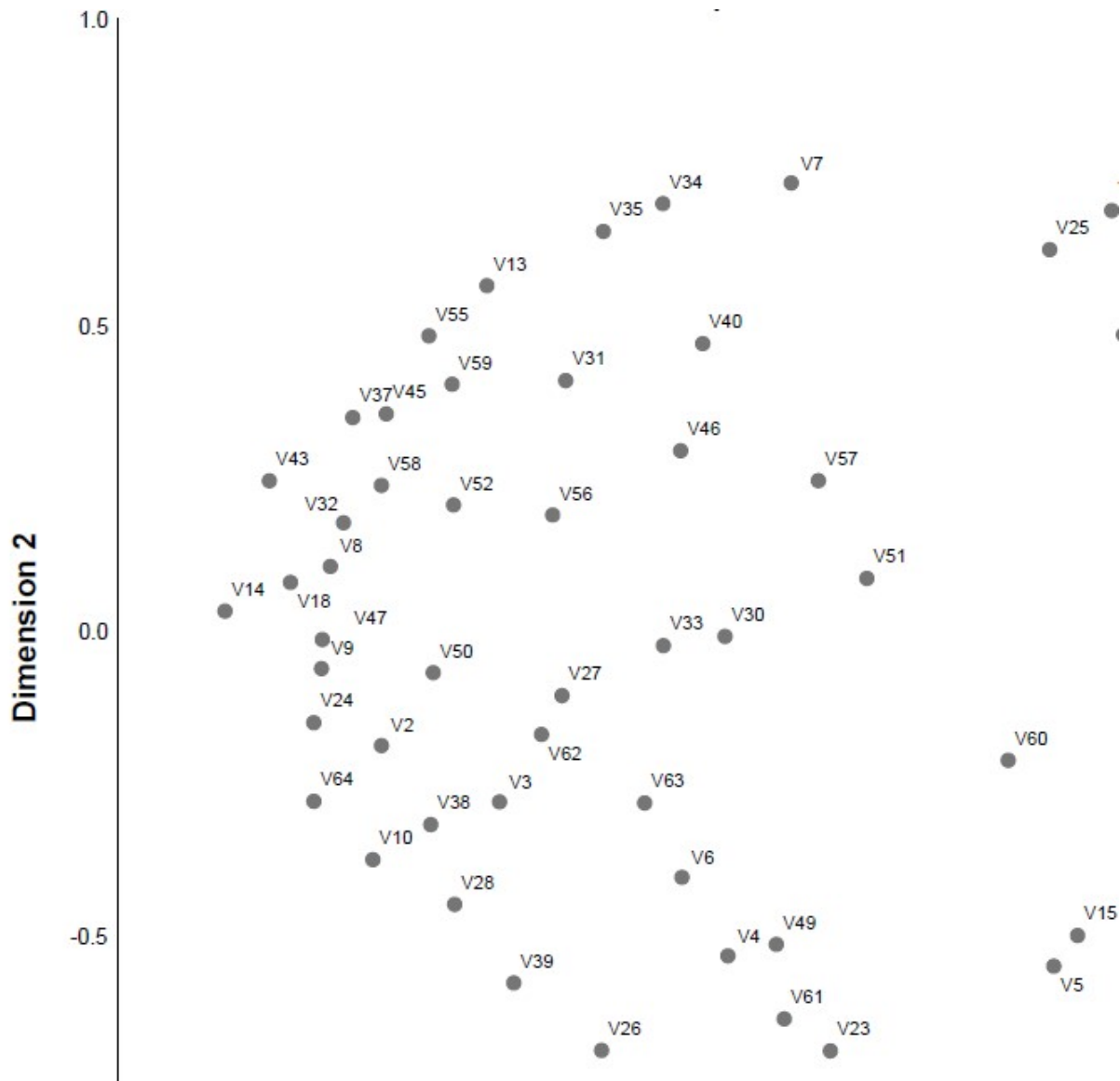
Figure 1: The point map representing the relationship between the statements scaled down to two dimensions. The closer the points (statements) on the map, the more similar or related they are. The normalized raw stress for our two-dimensional map was 0.0695. Full names of the points can be found in **Table 2**, but they are abbreviated here as V1: Stakeholder involvement; V2: CDS; V3: Dashboards; V4: Backup; V5: Computer configuration; V6: Intuitive flow; V7: Legislation; V8: Labs; V9: Patient follow-up; V10: Patient portals; V11: Access points; V12: Funding; V13: Data quality control; V14: Scheduling; V15: Familiar software & hardware (UX); V16: Positive attitude; V17: M&E of implementation; V18: Oncology documentation; V19: Human resource; V20: Policies; V21: Computer infrastructure; V22: Phased roll-out; V23: Data entry options; V24: Order sets; V25: Workflow optimization; V26: Easy data entry; V27: Links to medical knowledge; V28: Structured and free-text data; V29: User friendly; V30: Interoperability; V31: PACS and multimedia data storage; V32: Fit with workflow/patient journey; V33: ETL & Data warehousing; V34: Human resource management; V35: Billing; V36: Training on policy; V37: Unique identifiers; V38: Allow printing; V39: Real-time data entry; V40: restrict changes; V41: EMR usage training; V42: Tech support; V43: Routine clinical documentation; V44: Computer accessories; V45: Parsimonious data models; V46: Health information exchange; V47: Medication order management; V48: Steady electricity; V49: Secure online access; V50: Facilitate triage; V51: Offsite access; V52: Inventory management; V53: Advocacy about EHR; V54: Continuous improvement; V55: Standardized terminologies; V56: Cancer treatment protocols; V57: Accessible to entire care team; V58: Chemotherapy management; V59: Track paper charts; V60: Incorporate SOPs & reference materials; V61: Authentication and access control; V62: Flexibility (allow exceptions); V63: Distribute data entry burden; V64: Reminders
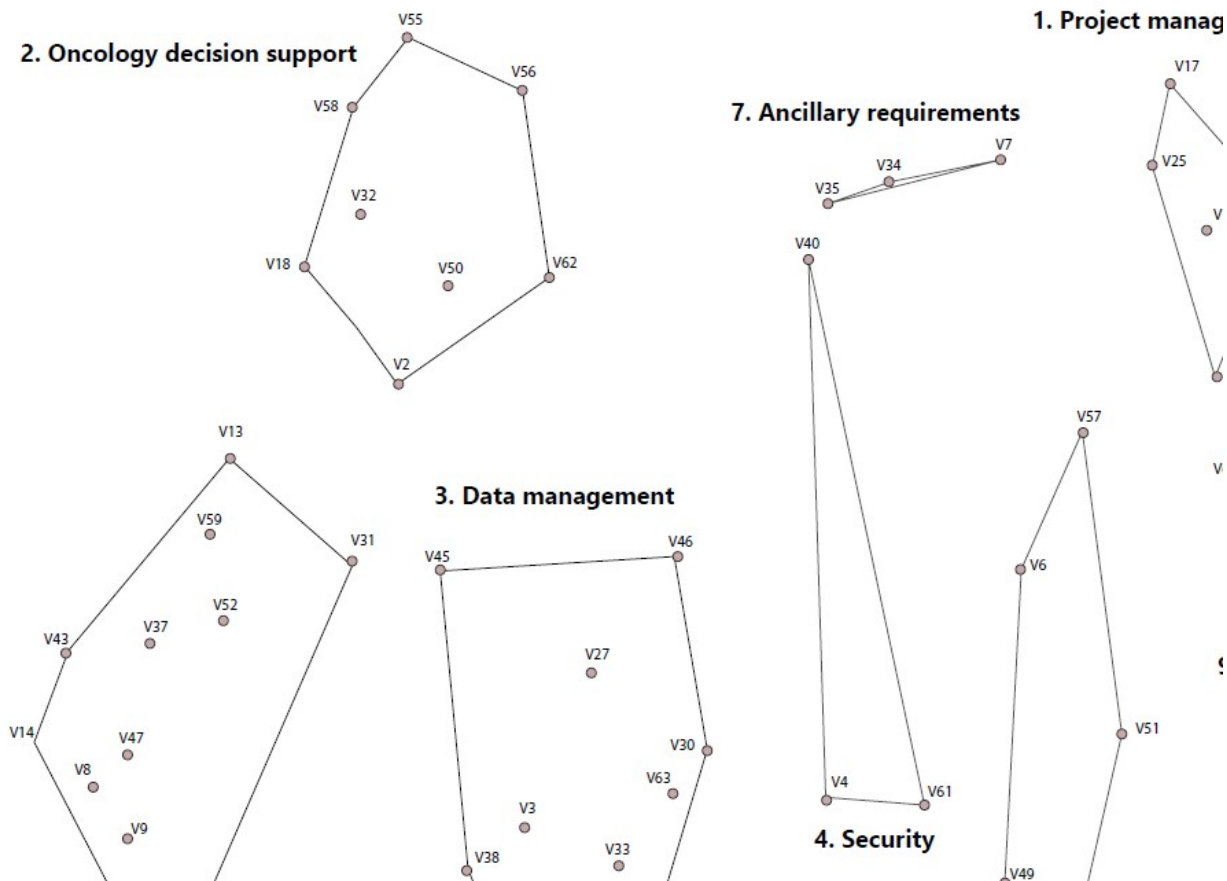
Figure 2: The cluster map which is derived from combining the point map and cluster membership. Some clusters overlay others in a two-dimensional plane; therefore they have been slightly displaced in this cluster map for clear visibility.

Security ranked highest on both average importance and feasibility. The security cluster encompasses concepts of authentication (password protection), access control (restriction to changes to information), and backing-up of data. Other high-ranking clusters included management and governance of EMR implementation (optimization of workflows prior to EMR roll out, phased roll out, involvement of all stakeholders, etc.) and Conducive organization (technical support, funding, steady electricity). Some individual statements in clusters General EMR functionality (tracking patient follow-ups, routine clinical documentation) and Usability (easy data entry features such as point-and-click or pull-down menus) were also ranked highly on both dimensions even though the scores of whole clusters were moderate. The clusters are important for summarizing the many requirements to ease communication and distribution of tasks among stakeholders (e.g. all requirements in the security cluster can be assigned to a security expert in the EMR development team).

The ranges for the average cluster rankings were narrow, i.e. 4.07 to 4.65 for importance, and 3.96 to 4.39 for feasibility. However, requirements are independent of each other even if they are in the same cluster, and can be each fulfilled without the other. Therefore prioritization is based on individual requirements. For example, access control and backing-up of data (security cluster) can each be fulfilled independent of the other.

The ICC was 0.441 for raw scores, and 0.58 for the averaged scores. These ICC values are moderate to poor which suggests that participants did not score statements as important just because they are feasible, or vice-versa.

Interestingly, requirements around oncology decision support (cancer treatment protocols, order sets for chemotherapy, etc.) did not rank as the highest. This might be because EMR adoption is still in early phase in this setting and therefore the focus is still on basic functionalities as well as socio-technical, organizational and management issues. Similarly, issues related to data management such as interoperability standards, ontologies and terminologies to enable analytics were not in the go-zone, probably for the same reason or because the participants were mostly clinical and less familiar with the technical concepts. Advanced features like computerized decision support and health information exchange are in higher levels (level 4 - 7) of the HIMSS EMR Adoption model (HIMSS EMRAM) (36) as opposed to basic and overarching EMR requirement such as security and usability (27).

Our list of requirements can be considered the functional profile (26,27,33) that is relevant for the context of oncology in LMICs according to the stakeholders involved in this study. Functional profiles can change with changing needs of the users (26), e.g. when

new legal constrains are imposed on EMRs, or when the range of clinical services changes. The list of requirements is therefore not intended to be complete, but rather evolving. For instance, previous publications on oncology EMR requirements focusing on high-income countries such as the US and UK (37–41) mention requirements that are similar to the ones we elicited, e.g. security, data standards for interoperability, usability, support for thorough routine and oncology specific documentation (e.g. tumor staging, chemotherapy management and toxicity tracking), order sets and clinical decision support based on established guidelines. However, some requirements highlighted for oncology EMRs in high income countries (33,37–39) were not mentioned in our study. These include support for clinical trials, capturing of chromosome and tumor biomarkers data, and patient reported outcomes. We anticipate that these and more will become increasingly relevant in LMICs, resulting into different functional profiles as the range of oncology services evolves and these use cases become commonplace, and as EMR implementation and adoption increase. We also anticipate that infrastructural requirements (e.g. electricity and computer infrastructure) will become less of an issue, whereas interoperability, health information exchange, need to capture patient reported outcomes and computerized clinical decision support will become more important cancer care data accumulates, and cancer services improve.

A strength of our study is that we included participants from different stakeholder groups and several countries to get generalizable findings. We were able to harness the benefits of both qualitative and quantitative methods. This was achieved in relatively short time and with little resources, and in a user-centered manner as compared to alternative methods of requirements engineering such as document review, onsite observation, or prototyping (22–24).

A weakness of the study is that most participants were clinicians, albeit with EMR experience. This means that different clustering and ranking might be achieved if more participants from technical and administrative or policy-maker roles were included. In addition, we did not do a primary comparative analysis with high-income settings, and we did not include all LMICs, but rather mostly African countries. This could limit generalizability of the findings to other LMICs.
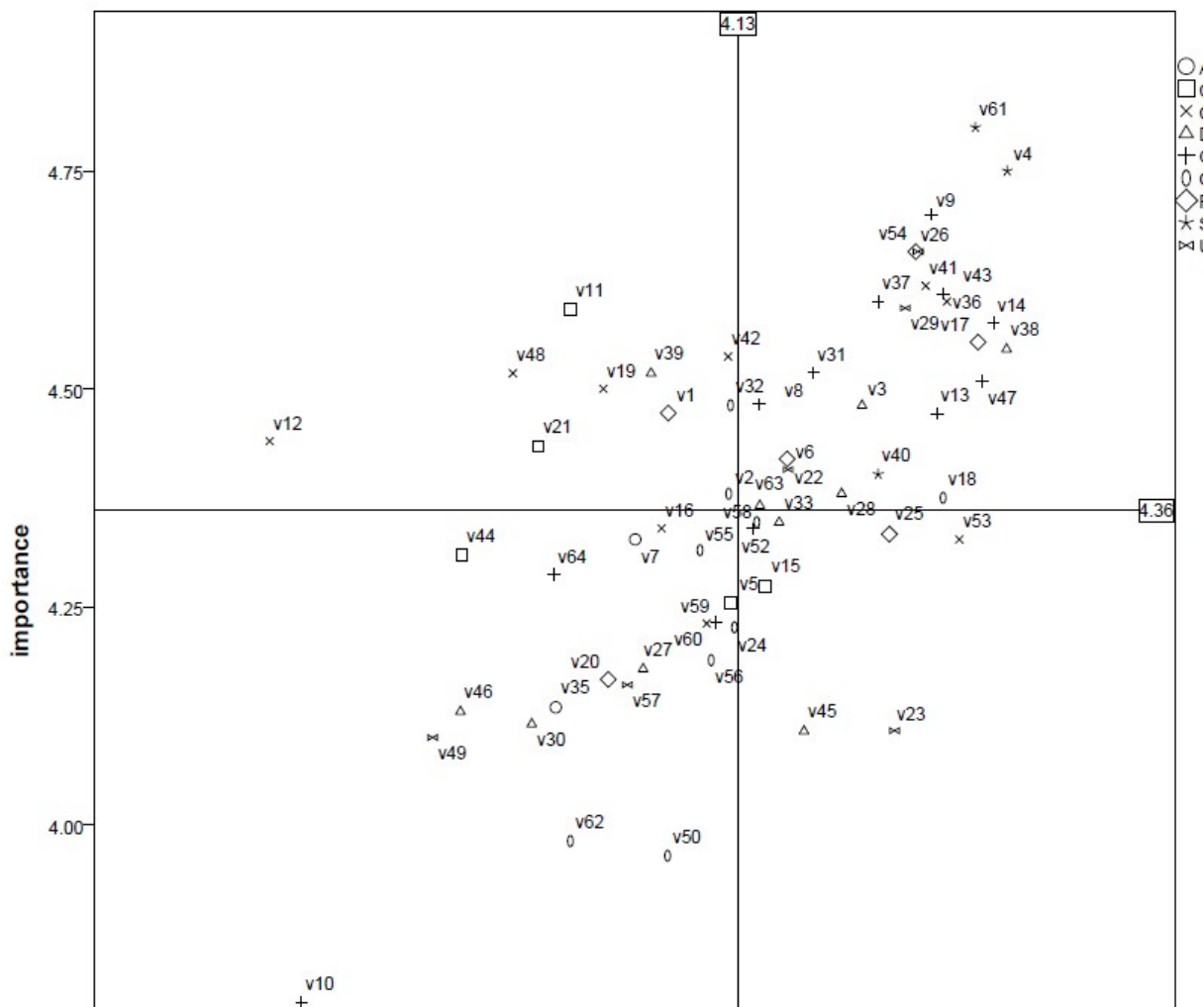

Figure 3: Go-zone map. The upper right quadrant is the ***go-zone area***. Requirements in this zone scored above the mean importance and feasibility, and are the considered most important and most feasible and should be prioritized.

ID	cluster	Statement	Import-ance	Import-ance rank	Feasibi-lity	Feasibility rank
		Table 3: Statements, their clusters, importance, and feasibility; and rank. Statements in bold are those in the Go-zone area (see Figure 2)				
v61	Security	**The EMR has proper security and authentication mechanisms – usernames and passwords, clearance/access levels, etc**	4.80	1	4.42	6
v4	Security	**The EMR backs up data e.g. frequently send backup copies of the data to an offsite storage server**	4.75	2	4.46	1
v9	General EMR functionalities	**The EMR facilitates tracking of patients follow ups**	4.70	3	4.37	12
v26	Usability	**The EMR has quick and easy data entry features – point-and-click, pre-populated menus with checkboxes, dropdown lists**	4.66	4	4.35	14
v54	Management/ Governance	**The system is continually improved**	4.66	5	4.35	15
v41	Conducive organization	**There is initial and periodic training of users on how to use the system**	4.62	6	4.36	13
v43	General EMR functionalities	**The EMR allows thorough routine clinical documentation (patient identification and demographics, medical history, treatment plans etc)**	4.61	7	4.38	9
v36	Conducive organization	**There is training on usage policies such as security (passwords and logging out after use) and confidentiality/privacy of patient information**	4.60	8	4.38	8
v37	General EMR functionalities	**The EMR facilitates proper and thorough identification of patients – unique identifiers (master patient index across all departments or using larger national identification databases) with biometrics, details contact information**	4.60	9	4.30	19
v29	Usability	**The system is user friendly (ease of log in, password timeouts, password complexity, must-enter fields that can be skipped if information isn't available at the moment with reminders to enter it later)**	4.59	10	4.33	16
v11	Computer infrastructure	Computer access points are available at all relevant clinical work places (doctors' offices, labs, wards)	4.59	11	3.92	52
v14	General EMR functionalities	**The EMR facilitates scheduling of patients' appointments and care events (e.g. when to return for chemo, follow up checks)**	4.58	12	4.44	3
v17	Management/ Governance	**There should be monitoring and evaluation of system implementation and use**	4.55	13	4.42	5
v38	Data management	**The EMR allows printing out (of prescriptions, clinical notes)**	4.55	14	4.46	2
v42	Conducive organization	Technical support is available	4.54	15	4.11	37
v31	General EMR functionalities	**The EMR has functionality for tracking and documentation/storage of imaging results (Picture Archiving and Communication Systems (PACS)**	4.52	16	4.22	23
v39	Data management	Data entry occurs immediately at point of collection/generation of the data	4.52	17	4.02	45
v48	Conducive organization	Steady electricity supply is available	4.52	18	3.85	58
v47	General EMR functionalities	**The EMR allows thorough recording of medications – all current and past medications, when they are prescribed, dispensed or discontinued, tracking of cumulative doses**	4.51	19	4.43	4
v19	Conducive organization	Adequate and appropriately skilled human resource is available	4.50	20	3.96	51
v8	General EMR functionalities	**The EMR has functionality for tracking and documentation of laboratory results (in computable formats not PDFs)**	4.48	21	4.15	30
v32	Oncology decision support	EMR workflow follows patient's journey/care timeline – links/allows documentation and communication between all the cancer care teams or departments and sections of EMR are arranged according to patient's journey	4.48	22	4.12	34
v3	Data management	**The EMR provides dashboards and reports with summaries of key performance indicators (e.g. overviews of demographics of patients, survival, adverse events/drug reactions, etc)**	4.48	23	4.28	21
v1	Management/ Governance	All stakeholders (clinicians, managers, data personnel) are involved and regular feedback collected	4.47	24	4.04	42

ID	cluster	Statement	Importance	Importance rank	Feasibility	Feasibility rank
v13	General EMR functionalities	**The EMR has data quality control mechanisms – clearly labeled fields and sections, placeholders in entry fields to provide hints on required data, enforcing mandatory/required fields to not be left blank, checking for invalid entries (e.g. text where numbers are expected or invalid values such as age of 120 years)**	4.47	25	4.37	11
v12	Conducive organization	Sufficient funding	4.44	26	3.55	64
v21	Computer infrastructure	There is sufficient computer and network infrastructure (PCs, Fast Internet, Servers, Firewalls, Backup systems)	4.43	27	3.88	56
v22	Management/ Governance	**Roll out is phased to allow smooth transition from paper to electronic**	4.42	28	4.19	26
v6	Usability	**The EMR has simple and intuitive information flow and presentation – logical flow mirroring clinical encounter (registration -> history & physical - >diagnosis, etc), and related information is presented together (e.g. all lab results on one screen)**	4.41	29	4.19	25
v40	Security	**The EMR restricts changes to information or rules (e.g. guidelines/protocols) in the system to only authorized personnel (e.g. only consultants), and keep an audit trail/log if and when such changes are allowed**	4.40	30	4.30	20
v2	Oncology decision support	The EMR offers computerized clinical decision support (basing on protocols/guidelines) – alerts and warnings during prescription, scheduling, assigning diagnosis or stage, etc (e.g. enforce a rule to not prescribe without providing a diagnosis)	4.38	31	4.12	36
v28	Data management	**EMR allows both free-text and structured data entry (free-text details about structured information e.g. details about presenting complaints/problem list, or a structured summary of detailed clinical history)**	4.38	32	4.25	22
v18	Oncology decision support	**The EMR allows for oncology specific documentation (cancer diagnosis and stage, tumor measurements/descriptions, cancer risk factors, chemo/radiotherapy details including side effects)**	4.38	33	4.38	10
v63	Data management	**Data entry burden is distributed to all care team members (doctors, nurses, lab, imaging, palliative care team)**	4.37	34	4.15	29
v33	Data management	The EMR has ETL (Extract, Transform, Load) and data warehousing functionalities to support analytics and research.	4.35	35	4.18	27
v58	Oncology decision support	EMR has chemotherapy safety checks e.g. for maximum or ceiling doses, infusion duration, contraindication basing on diagnosis or co-morbidity, requiring countersigning by doctors/nurses/pharmacist	4.35	36	4.15	31
v16	Conducive organization	Hospital managers/administrators have a positive attitude and support (buy-in)	4.34	37	4.03	44
v52	General EMR functionalities	The EMR keeps/tracks inventory of drugs, supplies, equipment, and other assets including available stocks (and gives feedback to prescribers) or faults of equipment, usage patterns and prediction of stock-outs	4.34	38	4.15	32
v25	Management/ Governance	A review and/or optimization of hospital workflow and processes (e.g. documentation) is done prior to implementation of the EMR to minimize inefficiency	4.33	39	4.31	18
v7	Ancillary requirements	The EMR adheres to legislations and provide a legal health record – e.g. ability to print out a longitudinal summary of key findings during the cancer care journey of the patient	4.33	40	4.00	47
v53	Conducive organization	Advocacy and sensitization of users (doctors, nurses, patients, administrators) about benefits of electronic medical records is done	4.33	41	4.40	7
v55	Oncology decision support	The EMR incorporates/uses standardized concept dictionaries and ontologies or structured and well defined variables (e.g. ICD10 for diagnoses, Proper staging systems such as AJCC or FIGO or Risk stratifications for Leukemias)	4.31	42	4.08	41
v44	Computer infrastructure	There are sufficient computer accessories for handling data besides the text directly in the EMR system (e.g. printers and scanners for lab/imaging reports, Dictaphones for audio data)	4.31	43	3.79	59
v64	General EMR functionalities	The EMR gives reminders to patients on follow ups/appointments	4.29	44	3.90	55

Table 3: Statements, their clusters, importance, and feasibility; and rank. Statements in bold are those in the Go-zone area (see Figure 2)

ID	cluster	Statement	Import-ance	Import-ance rank	Feasibi-lity	Feasibility rank
		Table 3: Statements, their clusters, importance, and feasibility; and rank. Statements in bold are those in the Go-zone area (see Figure 2)				
v15	Computer infrastructure	There is consistence - use of hardware and software interfaces that users are familiar with	4.27	45	4.16	28
v5	Computer infrastructure	Computer systems are properly configured to prevent misuse (restricting only to EMR use e.g. by removing games and music player software)	4.25	46	4.12	35
v59	General EMR functionalities	The EMR has functionality to track other clinical documents and information such as paper chart movements – who took the file, when it was taken or returned, where it is located	4.23	47	4.10	38
v60	Conducive organization	Standard operating procedures, job aids and quick reference material on system usage are available	4.23	48	4.09	40
v24	Oncology decision support	The EMR has order sets for drugs and investigations e.g. automatic generation of prescription for chemotherapy and premedication, or generation of imaging or lab requests for a particular clinical scenario (e.g. all staging work up for new patients)	4.23	49	4.12	33
v56	Oncology decision support	The EMR has cancer care/treatment protocols and guidelines incorporated in it	4.19	50	4.09	39
v27	Data management	The EMR links to medical knowledge bases for health worker to reference or learn	4.18	51	4.01	46
v20	Management/ Governance	Governance policies are in place that support implementation of electronic medical records	4.17	52	3.97	50
v57	Usability	The EMR is accessible by all the different care teams/members	4.16	53	3.99	48
v35	Ancillary requirements	The EMR has billing functionality	4.13	54	3.90	54
v46	Data management	The EMR allows communication with other facilities (other hospitals, clinics, labs, imaging centers) to share patient information and documents e.g. patient summaries, referrals, etc	4.13	55	3.78	60
v30	Data management	Interoperability and health information exchange (integration with other systems) is supported - sharing of data with other systems such as cancer registry, DHIS 2 (HMIS reporting), EMRs or lab information systems at other health centers	4.12	56	3.87	57
v23	Usability	The EMR has various data entry options e.g. keyboards, touch screens, voice input, barcode readers, etc	4.11	57	4.32	17
v45	Data management	Data collection is parsimonious (collect only the information that is needed for a specified purpose e.g. clinical decision making instead of trying to collect all details)	4.11	58	4.21	24
v49	Usability	The EMR allows for secure (e.g. VPN) remote/offsite access via the web or mobile devices for clinicians to access while at home or during outreaches	4.10	59	3.75	61
v62	Oncology decision support	The EMR allows exceptions and overriding of the rules and clinical decision support recommendations (EMR should not dictate what the clinician does but rather suggest)	3.98	60	3.92	53
v50	Oncology decision support	The EMR facilitates triage and prioritization of patients basing on their clinical condition, investigation results (e.g. if patient has concerning labs) or where they are in cancer care journey	3.96	61	4.04	43
v10	General EMR functionalities	The EMR provides patient portals (e.g. via a web interface) where patients can interact and participate in their care (view and/or make appointments, get care instructions or general cancer information, report symptoms/side effects)	3.80	62	3.59	63
v34	Ancillary requirements	The EMR has human resource management functionality to monitor staff – clocking in and out, leave, timetables and duty schedules	3.75	63	3.98	49
v51	Usability	Remote/Offsite access to the EMR e.g. by doctors while they are at home, is possible	3.74	64	3.61	62

The last step in concept mapping is utilization of results in which the concept statements (requirements) and maps are used as a basis for discussion with the target end users to make implementation decisions. Our findings have been disseminated to the EMR implementation team at the Uganda Cancer Institute to guide selection and/or customization of the EMR, as well as to the OpenMRS community which is currently working on developing oncology support in OpenMRS, particularly in the chemotherapy ordering module (51,52).

5.   Conclusion

Requirements for EMRs to be used for oncology in LMICs overlap with those in high-income countries. However, basic infrastructural and contextual requirements need to be fulfilled in LMICs before more advanced functionalities can be achieved (50). As oncology and EMR adoption rapidly evolves in LMICs, continuous user-centered evaluation and further development of EMRs in this setting is essential.

Concept mapping is a suitable method for eliciting and prioritizing EMR requirements in a user-centered manner. Using this method, we were able to quickly and cheaply involve stakeholders from different geographical location and professional roles to elicit a comprehensive list of requirements, and using statistical methods we prioritized and grouped these requirements into graphical maps that are easier to interpret and communicate.

Summary points

What was already known on the topic?
- Understanding of requirements is crucial for successful EMR implementation
- Requirements are context-dependent, and requirements engineering is costly and time-consuming
- Oncology is chronic, complex, multi-disciplinary and multi-modality care with specific requirements for the EMR.
- Elicitation and prioritization of requirements for the EMR can be difficult, time consuming and costly

What this study added to our knowledge
- Functional and nonfunctional requirements for an EMR for oncology in LMICs, with their prioritization
- For oncology EMRs in LMICs, requirements overlap those for high-income countries, although basic infrastructural and contextual requirements appear to still be key, as opposed to advanced or oncology-specific EMR functionality
- Concept mapping is an efficient method for requirements engineering in a user-centered manner.

References

1.   World Health Organization. WHO | Cancer [Internet]. WHO. World Health Organization; 2018 [cited 2018 Apr 13]. Available from: http://www.who.int/mediacentre/factsheets/fs297/en/

2.   Moten A, Schafer D, Farmer P, Kim J, Ferrari M. Redefining global health priorities: Improving cancer care in developing settings. J Glob Health [Internet]. 2014 Jun [cited 2016 Jun 29];4(1):010304. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24976959

3.   Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, et al. Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care. Ann Intern Med [Internet]. 2006 May 16 [cited 2016 Jun 28];144(10):742. Available from: http://annals.org/article.aspx?doi=10.7326/0003-4819-144-10-200605160-00125

4.   Campanella P, Lovato E, Marone C, Fallacara L, Mancuso A, Ricciardi W, et al. The impact of electronic health records on healthcare quality: a systematic review and meta-analysis. Eur J Public Health [Internet]. 2016 Feb [cited 2016 Jul 4];26(1):60–4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26136462

5.   Sligo J, Gauld R, Roberts V, Villa L. A literature review for large-scale health information system project planning, implementation and evaluation. Int J Med Inform [Internet]. 2017;97:86–97. Available from: http://dx.doi.org/10.1016/j.ijmedinf.2016.09.007

6.   Boonstra A, Versluis A, Vos JFJ, Abramson E, McGinnis S, Edwards A, et al. Implementing electronic health records in hospitals: a systematic literature review. BMC Health Serv Res [Internet]. 2014 Dec 4 [cited 2016 Jul 27];14(1):370. Available from: http://bmchealthservres.biomedcentral.com/articles/10.1186/1472-6963-14-370

7.   Van Ginneken AM. The computerized patient record: Balancing effort and benefit. Int J Med Inform. 2002;65(2):97–119.

8.   Blaya JA, Fraser HSF, Holt B. E-health technologies show promise in developing countries. Health Aff [Internet]. 2010;29(2):244–51. Available from: http://content.healthaffairs.org/content/29/2/244.long

9.   Fraser HSF, Biondich P, Moodley D, Choi S, Mamlin BW, Szolovits P, et al. Implementing electronic medical record systems in developing countries. Inform Prim Care [Internet]. 2005;13:83–95. Available from: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.135.1906

10.   Williams FM, Austin S, Mha B, Williams FM, Austin S, Mha B. The role of the electronic medical record (EMR) in care delivery development in developing countries: a systematic review. Inform Prim Care [Internet]. 2008;16:139–45. Available from: http://www.himssanalytics.org/emram/emram.aspx

11.   Luna D, Almerares A, Mayan JC, González Bernaldo de Quirós F, Otero C, Otero C. Health Informatics in Developing Countries: Going beyond Pilot Practices to Sustainable Implementations: A Review of the Current Challenges. Healthc Inform Res [Internet]. 2014 Jan [cited 2015 Jul 3];20(1):3–10. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24627813

12.   Seebregts CJ, Mamlin BW, Biondich PG, Fraser HSF, Wolfe BA, Jazayeri D, et al. Human factors for capacity building: lessons learned from the OpenMRS implementers network. Yearb Med Inform [Internet]. 2010;13–20. Available from:

http://www.ncbi.nlm.nih.gov/pubmed/20938564%5Cnhttp://www.schattauer.de/index.php?id=1268&L=1&pii=meme1001001 3&no_cache=1

13. Lewis T, Synowiec C, Lagomarsino G, Schweitzer J, World Health Organization. E-health in low- and middle-income countries: findings from the Center for Health Market Innovations. Bull World Health Organ [Internet]. 2012 May 1 [cited 2015 Jul 26];90(5):332–40. Available from: http://www.who.int/bulletin/volumes/90/5/11-099820/en/

14. Pesec M, Sherertz T. Global health from a cancer care perspective. Futur Oncol [Internet]. 2015 Aug [cited 2016 Jun 21];11(15):2235–45. Available from: http://www.futuremedicine.com/doi/10.2217/fon.15.142

15. Tapela NM, Mpunga T, Hedt-Gauthier B, Moore M, Mpanumusingo E, Xu MJ, et al. Pursuing equity in cancer care: implementation, challenges and preliminary findings of a public cancer referral center in rural Rwanda. BMC Cancer [Internet]. 2016 [cited 2016 Aug 18];16:237. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26992690

16. Strother RM, Asirwa FC, Busakhala NB, Njiru E, Orang'o E, Njuguna F, et al. AMPATH-Oncology: A model for comprehensive cancer care in sub-Saharan Africa. J Cancer Policy [Internet]. 2013 Sep 1 [cited 2014 Dec 1];1(3–4):e42–8. Available from: http://linkinghub.elsevier.com/retrieve/pii/S2213538313000052

17. Orenzi NAML, Ovak LALN, Eiss JABW, Add CYSG, Nertl KIMMU, Lorenzi NM, et al. Crossing the Implementation Chasm : A Proposal for Bold Action. J Am Med Inform Assoc [Internet]. 2017 [cited 2019 Mar 18];15(September):290–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18308985

18. Kaplan B, Harris-Salamone KD. Health IT success and failure: recommendations from literature and an AMIA workshop. J Am Med Inform Assoc [Internet]. 2009 Jan [cited 2016 Feb 18];16(3):291–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19261935

19. Mao J-Y, Vredenburg K, Smith PW, Carey T. The state of user-centered design practice. Commun ACM [Internet]. 2005 Mar 1 [cited 2015 Sep 30];48(3):105–9. Available from: http://dl.acm.org/ft_gateway.cfm?id=1047677&type=html

20. Ratwani RM, Fairbanks RJ, Hettinger AZ, Benda NC. Electronic health record usability: analysis of the user-centered design processes of eleven electronic health record vendors. J Am Med Inform Assoc [Internet]. 2015 Jun 6 [cited 2015 Sep 13]; Available from: http://www.ncbi.nlm.nih.gov/pubmed/26049532

21. Sommerville I. Software requirements. Softw Eng [Internet]. 2004;115–41. Available from: http://www.comp.lancs.ac.uk/computing/resources/IanS/SE7/SampleChapters/ch6.pdf

22. Ramesh B, Cao L, Baskerville R. Agile requirements engineering practices and challenges: an empirical study. Inf Syst J [Internet]. 2010;20(5):449–80. Available from: http://doi.wiley.com/10.1111/j.1365-2575.2007.00259.x

23. Daneva M, Van Der Veen E, Amrit C, Ghaisas S, Sikkel K, Kumar R, et al. Agile requirements prioritization in large-scale outsourced system projects: An empirical study. J Syst Softw [Internet]. 2013;86(5):1333–53. Available from: http://dx.doi.org/10.1016/j.jss.2012.12.046

24. Zamudio L, Aguilar JA, Tripp C, Misra S. A Requirements Engineering Techniques Review in Agile Software Development Methods. In Springer, Cham; 2017 [cited 2019 Jan 4]. p. 683–98. Available from: http://link.springer.com/10.1007/978-3-319-62404-4_50

25. Tang T, Lim ME, Mansfield E, McLachlan A, Quan SD. Clinician user involvement in the real world: Designing an electronic tool to improve interprofessional communication and collaboration in a hospital setting. Int J Med Inform. 2018;110(November 2017):90–7.

26. Sinha PK (Pradeep K, Sunder G, Bendale P, Mantri M, Dande A. Electronic health record : standards, coding systems, frameworks, and infrastructures. 343 p.

27. Dickinson G, Janczewski M, Mon D, Ritter J, Stevens-love H, Dyke P Van, et al. ISO/HL7 10781:2015(en), Health Informatics — HL7 Electronic Health Records-System Functional Model, Release 2 (EHR FM). Iso [Internet]. 2015 [cited 2019 Jun 8];35(1). Available from: https://www.iso.org/obp/ui/#iso:std:iso-hl7:10781:ed-2:v1:en

28. International Organization for Standardization. ISO 18308:2011 Health Informatics – Requirements for an Electronic Health Record Architecture. ISO [Internet]. 2011 [cited 2019 Jun 8];2011. Available from: https://www.iso.org/standard/52823.html

29. Elms T. Context of Use within usability activities. 2001;

30. Warner J, Hochberg E. Where is the EHR in oncology? JNCCN J Natl Compr Cancer Netw. 2012;10(5):584–8.

31. Clauser SB, Wagner EH, Aiello Bowles EJ, Tuzzio L, Greene SM, Clauser SB, et al. Improving modern cancer care through information technology. Am J Prev Med [Internet]. 2011 May [cited 2016 Jul 4];40(5 Suppl 2):S198-207. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21521595

32. Yu PP. The evolution of oncology electronic health records. Cancer J [Internet]. 2011;17(4):197–202. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21799325

33. HL7Wiki. Oncology EHR Functional Profile - HL7Wiki [Internet]. 2010 [cited 2019 Dec 6]. Available from: https://wiki.hl7.org/Oncology_EHR_Functional_Profile

34. Elsaid KA, Garguilo S, Collins CM. Chemotherapy e-prescribing: opportunities and challenges. Integr Pharm Res Pract [Internet]. 2015 [cited 2018 Feb 5];4:39–48. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29354518

35. Tapela NM, Mpunga T, Karema N, Nzayisenga I, Fadelu T, Uwizeye FR, et al. Implementation Science for Global Oncology : The Imperative to Evaluate the Safety and Efficacy of Cancer Care Delivery. J Clin Oncol [Internet]. 2016;34(1):43–52. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26578617

36. HIMSS. EMRAM | HIMSS Europe [Internet]. [cited 2018 Jun 6]. Available from: https://www.himss.eu/healthcare-providers/emram

37. American Society of Clinical Oncology (ASCO), National Cancer Institute (NCI). Clinical Ocology Requirements for the EHR (CORE) White Paper [Internet]. 2009. Available from: https://www.asco.org/sites/default/files/oct_2009_-

_asco_nci_core_white_paper.pdf

38. Poulter T, Bath PA, Informatics H, Poulter T, Bath PA. The use and usability of EPR systems in oncology. In: Studies in Health Technology and Informatics. 2012. p. 398–402.

39. Poulter T, Gannon B, Bath P a. An analysis of electronic document management in oncology care. Health Informatics J [Internet]. 2012;18(2):135–46. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22733681

40. Yu P, Artz D, Warner J. Electronic Health Records (EHRs): Supporting ASCO's Vision of Cancer Care. Am Soc Clin Oncol Educ B [Internet]. 2014;34:225–31. Available from: http://meetinglibrary.asco.org/content/114000225-144

41. Schreiber JA, Editor A. Electronic Health Records: Current Issues in Oncology. Oncol Nurs Forum [Internet]. 2013;40(1). Available from: https://www.ncbi.nlm.nih.gov/pubmed/23269763

42. Trochim W, Kane M. Concept mapping: An introduction to structured conceptualization in health care. Int J Qual Heal Care. 2005;17(3):187–91.

43. Kane M, Trochim WMK. Concept mapping for planning and evaluation [Internet]. Sage Publications; 2007 [cited 2017 Aug 9]. 200 p. Available from: https://www.socialresearchmethods.net/research/epp1/epp1.htm

44. Joukes E, Cornet R, de Bruijne MC, de Keizer NF, Bruijne MC De, Keizer NF De. Eliciting end-user expectations to guide the implementation process of a new electronic health record : A case study using concept mapping. Int J Med Inform [Internet]. 2016;87:111–7. Available from: http://dx.doi.org/10.1016/j.ijmedinf.2015.12.014

45. Kuunders TJM, van Bon-Martens MJH, van de Goor IAM, Paulussen TGWM, van Oers HAM. Towards local implementation of Dutch health policy guidelines: a concept-mapping approach. Health Promot Int [Internet]. 2017;1–13. Available from: https://academic.oup.com/heapro/article/3045088/Towards

46. AORTIC. 11th International Conference on Cancer in Africa - Abstract Publication. Available from: http://aorticconference.org/wp-content/uploads/2017/10/2017-AORTIC-Abstracts.pdf

47. Proven By Users [Internet]. Available from: https://provenbyusers.com/index.php

48. Trochim WMK. Reliability of Concept Mapping [Internet]. [cited 2018 Jun 13]. Available from: https://socialresearchmethods.net/research/Reliable/reliable.htm

49. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J Chiropr Med [Internet]. 2016 Jun [cited 2019 Jan 6];15(2):155–63. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27330520

50. Sood SP, Nwabueze SN, Mbarika VWA, Prakash N, Chatterjee S, Ray P, et al. Electronic Medical Records: A Review Comparing the Challenges in Developed and Developing Countries. In: Proceedings of the 41st Annual Hawaii International Conference on System Sciences (HICSS 2008) [Internet]. IEEE; 2008 [cited 2019 Dec 6]. p. 248–248. Available from: https://ieeexplore.ieee.org/document/4438952/

51. Oncology Module for OpenMRS | GitHub [Internet]. 2018. Available from: https://github.com/openmrs/openmrs-module-oncology

52. Kabukye JK, Casaceli AM, Ball E, De Armas M, Cornet R. Towards an Open-Source Oncology Electronic Medical Records System for Low-Resource Settings: Development of Chemotherapy Management in OpenMRS. Stud Health Technol Inform [Internet]. 2019 Aug 21 [cited 2019 Dec 6];264:634–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31438001